

Advanced Gas and Solid Handling Pump for Unconventional Gassy and Sandy Well Challenges

ACE PLUS™ Gas Handler

Lyon Hong and Vishal Gahlot

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An aerial photograph of a forest. The left side of the image is dominated by a dense stand of dark green evergreen trees. The right side shows a mix of deciduous trees, some with bright yellow autumn foliage and others that are bare and greyish. The overall scene is a high-angle view of a diverse woodland.

Project Background

Problem Statement and Objectives

- For unconventional wells, the high gas volume fraction (GVF) and solid abrasives in the production fluid become challenges because the wear in pump stages from the abrasives and the gas locking of pumps cause unwanted interruptions to productions and reduction of the pump life dramatically.
- Develop an advanced multiphase helico-axial and abrasion resistant pump to meet the increasingly difficult conditions found in unconventional gassy and sandy well environments and the technology allows operators to reliably process up to 75% free gas without gas locking at extremely low intake pressure conditions and ride through gas slugging smoothly and significantly enhance the pump life.



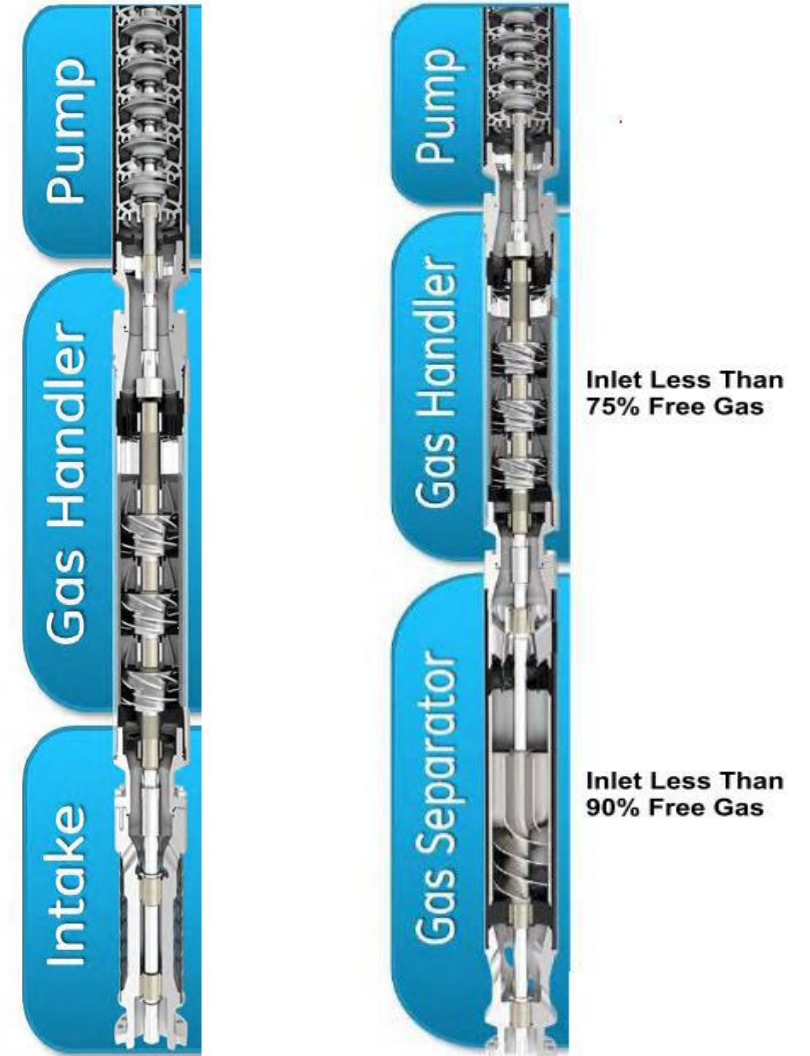
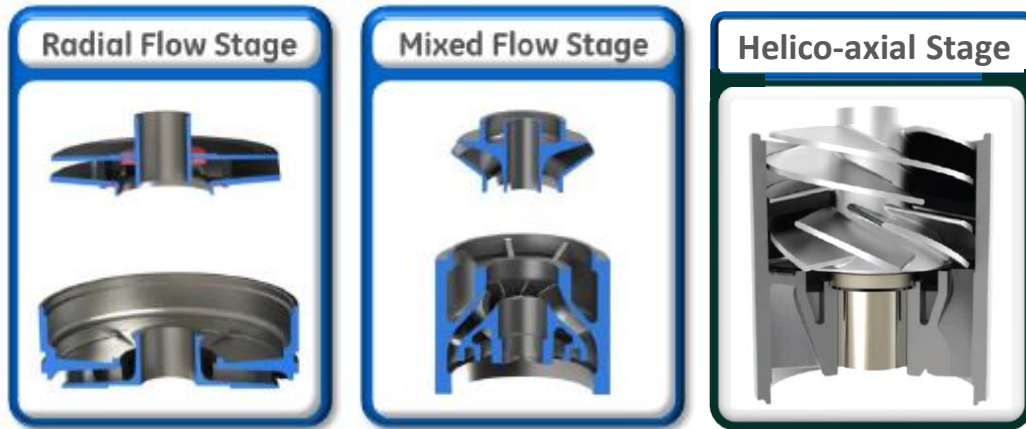
An aerial photograph of a forest. The left side of the image shows a dense stand of dark green evergreen trees. The right side shows a mix of trees, including many bare, greyish-brown deciduous trees and some bright yellow-green trees, suggesting a transition or a different forest type. The text 'Gas Management' is overlaid in white on the left side.

Gas Management

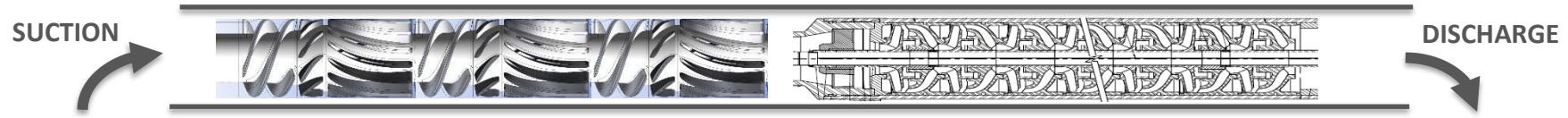
ACE PLUS™ Gas Handling Pump

Gas Handlers are used in extremely gassy wells or in wells that cannot be vented to annulus

- Radial stages can handle +/-10%
- Mixed flow stages +/- 20%
- Helico-axial stages up to 75%



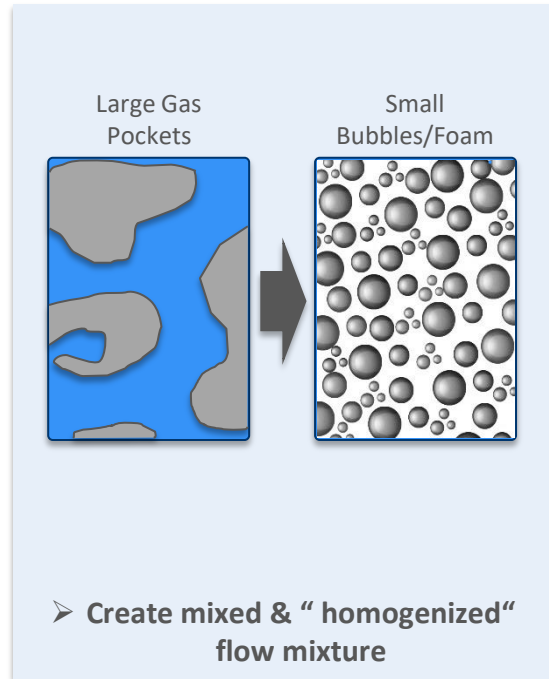
Multiphase Gas Handlers: Working Principle



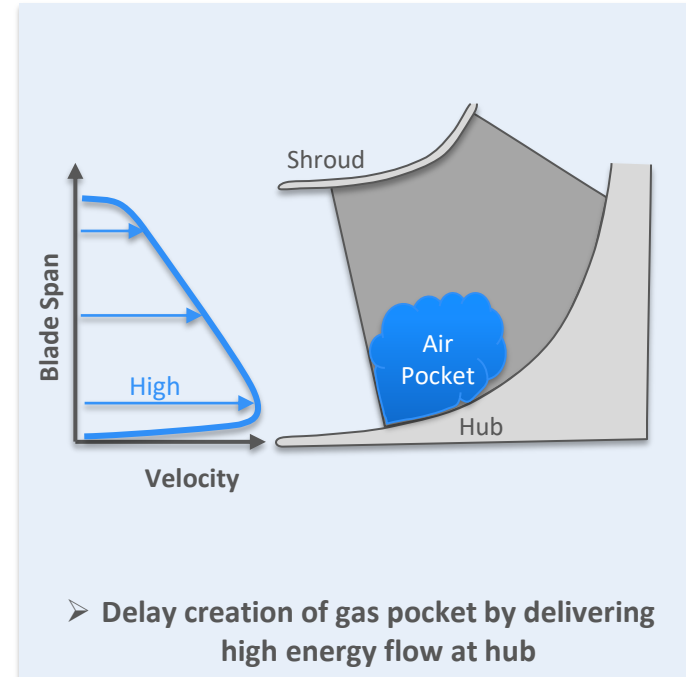
Helical Axial Stages

Mixed Flow Stages

PHASE MIXING



VELOCITY PROFILE



Pump Stage CFD Verification and Validation

Tools & Systematic Design...

Developed **physics-based** tools from 0D to 3D CFD to understand and design **pump stages** for **best-in-industry performance and range**

0D

Early Design

- Geometry Definition

1D

Detailed Design

- Geometry Manipulation
- Meanline
- Throughflow
- Design parameter optimization

2D

3D

Detailed Verification

- CFD

M.S.

Multistage Performance

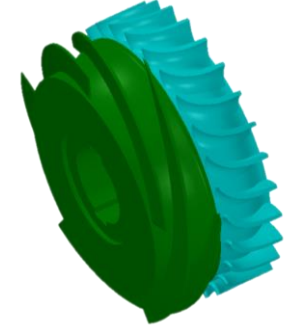
- Pump Maps

TEST

Design Validation

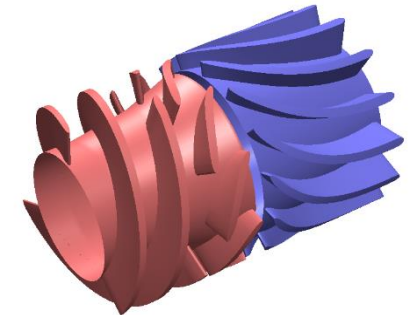


Multiphase Pump



6000rpm • 13.5"

Multiphase Gas Handler

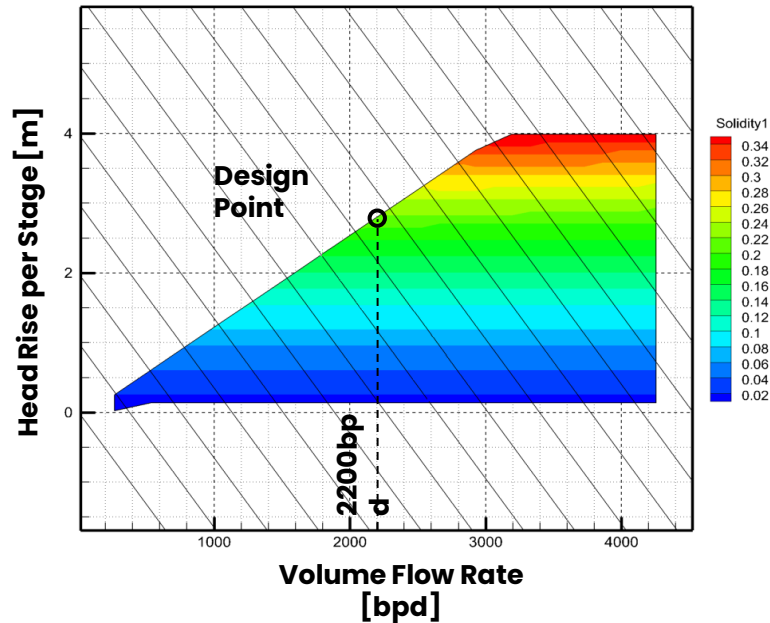
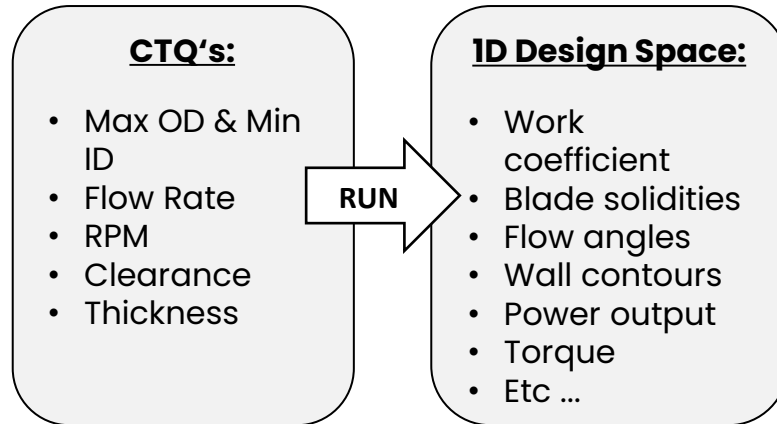


3500rpm • 3.5"

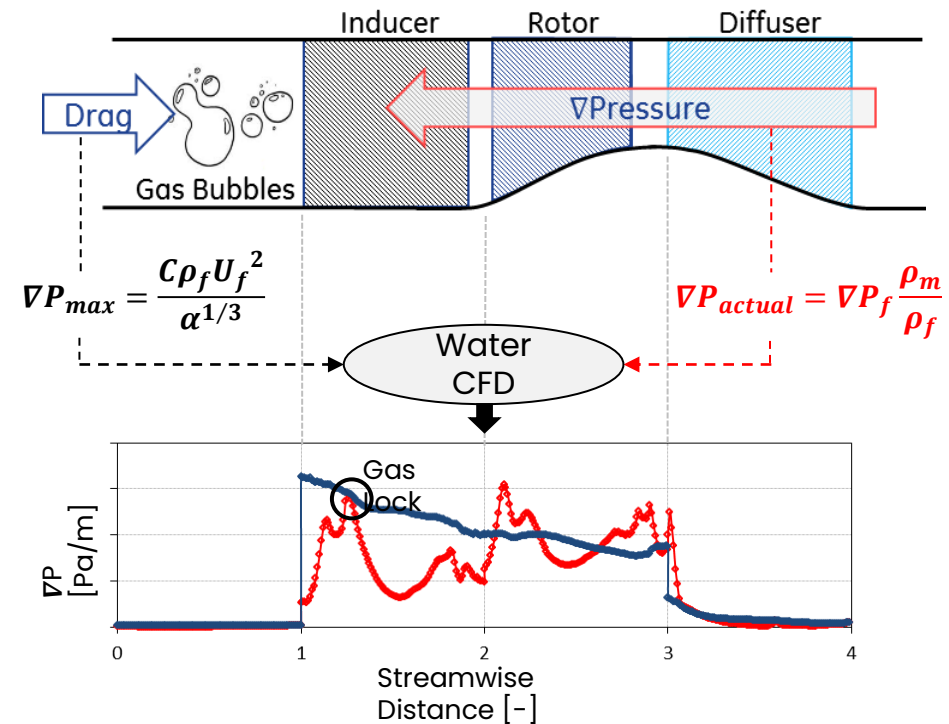
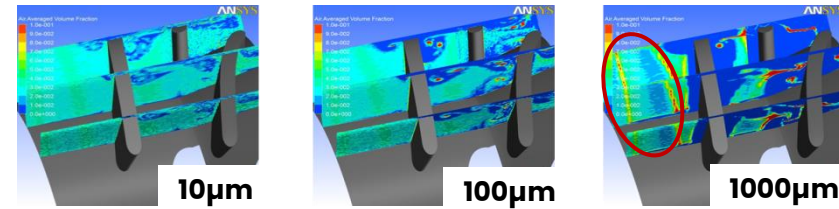
Design optimization and CFD best practice through rigorous verification and validation to guide new stages development

Gas Handler Design Tool

Gives a preliminary map of what is feasible within CTQ's

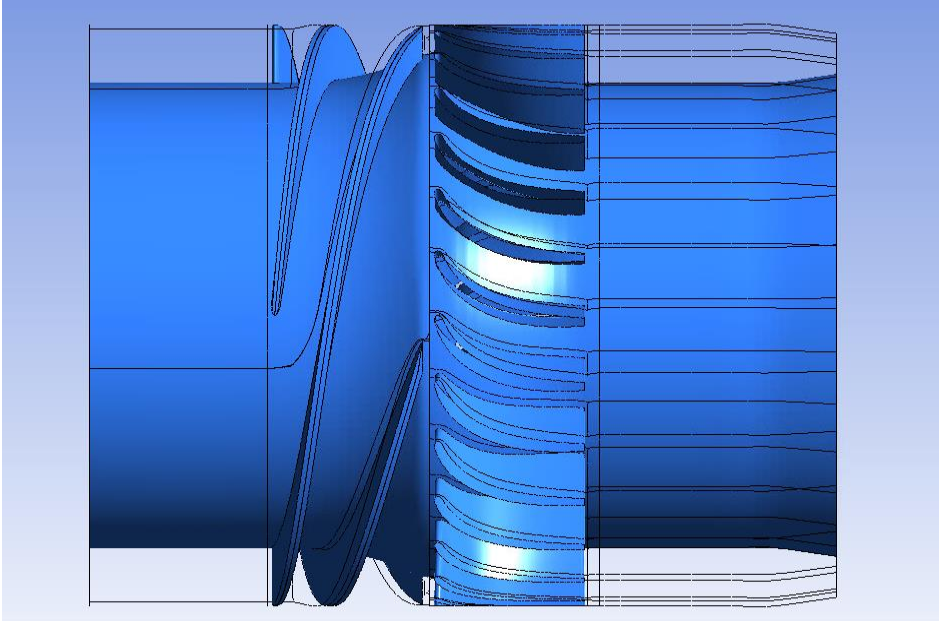


Semi-empirical model to predict occurrence of gas-lock

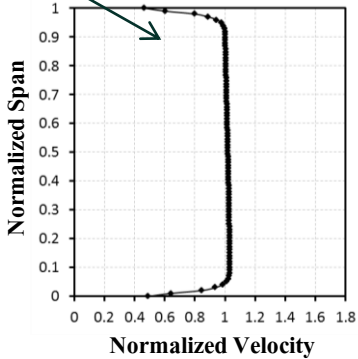


HelicoAxial-Type 2500BPD

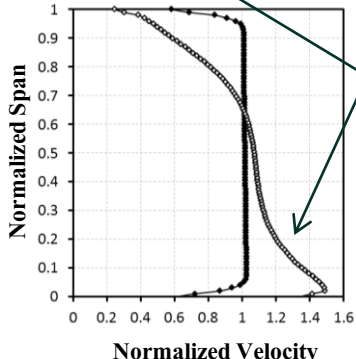
SUCTION ————— flow —————> DISCHARGE



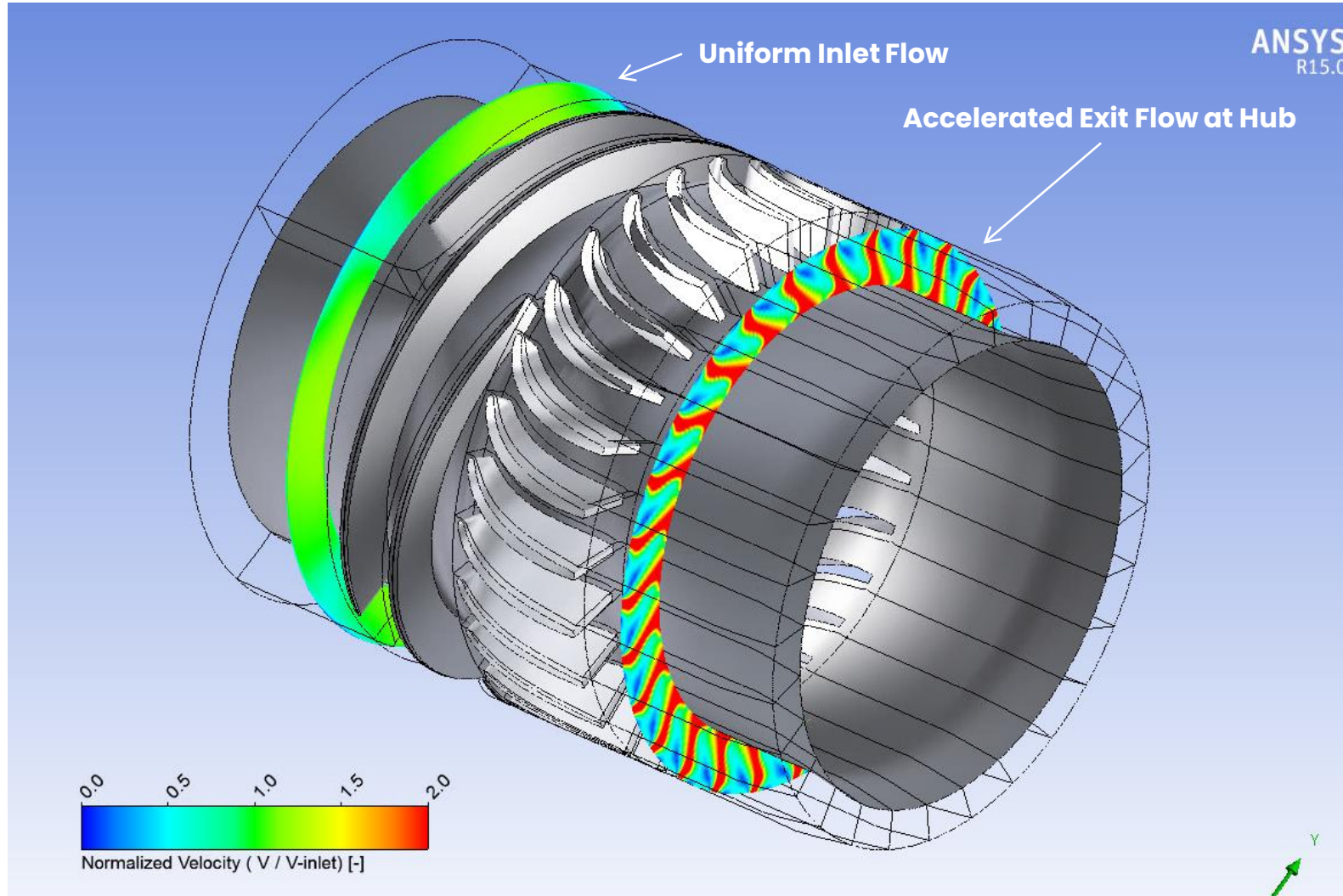
Uniform Inlet Flow



Accelerated Exit Flow at Hub



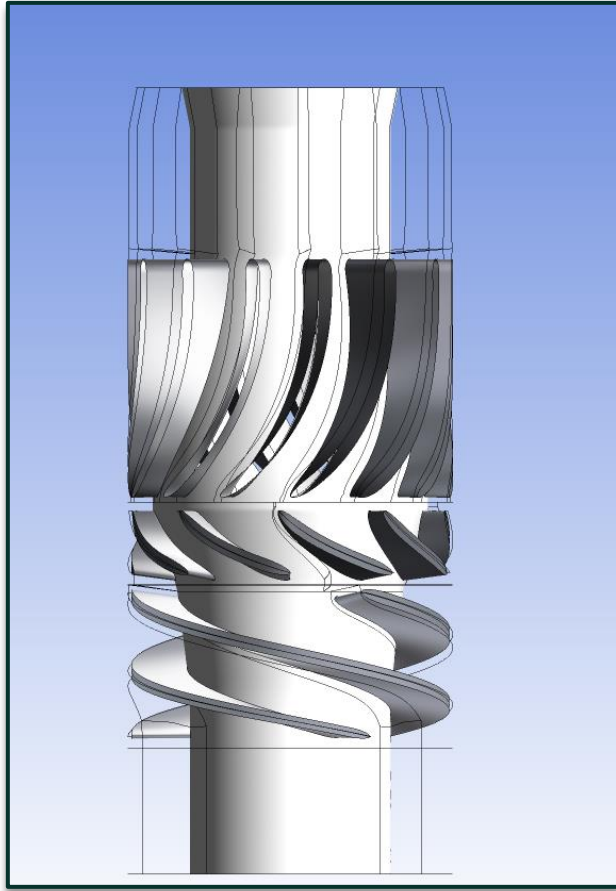
HelicoAxial-Type 2500BPD



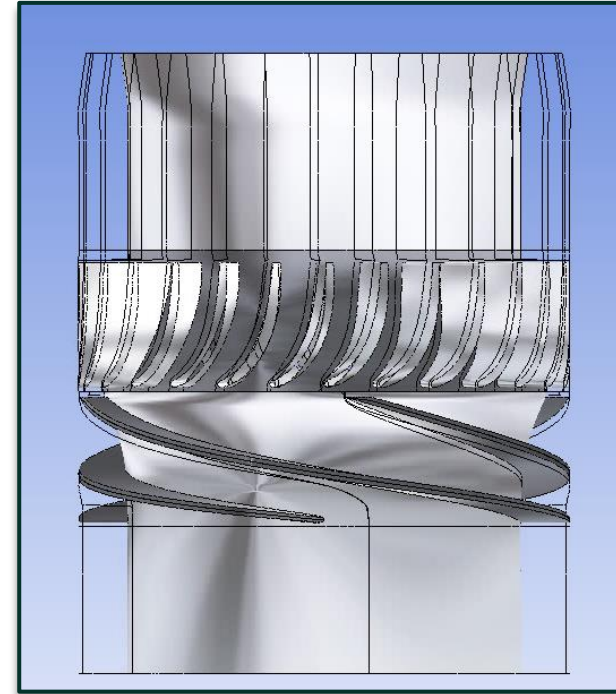
GH2500 vs. Typical Gas Handler

3.5" Diameter - 2500bpd BEP - 3500RPM

400 Series GH2500

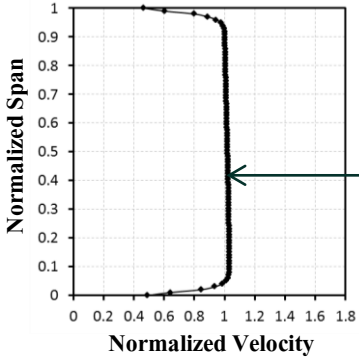
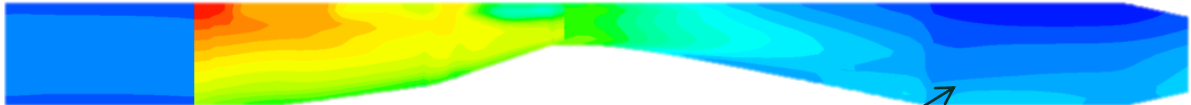
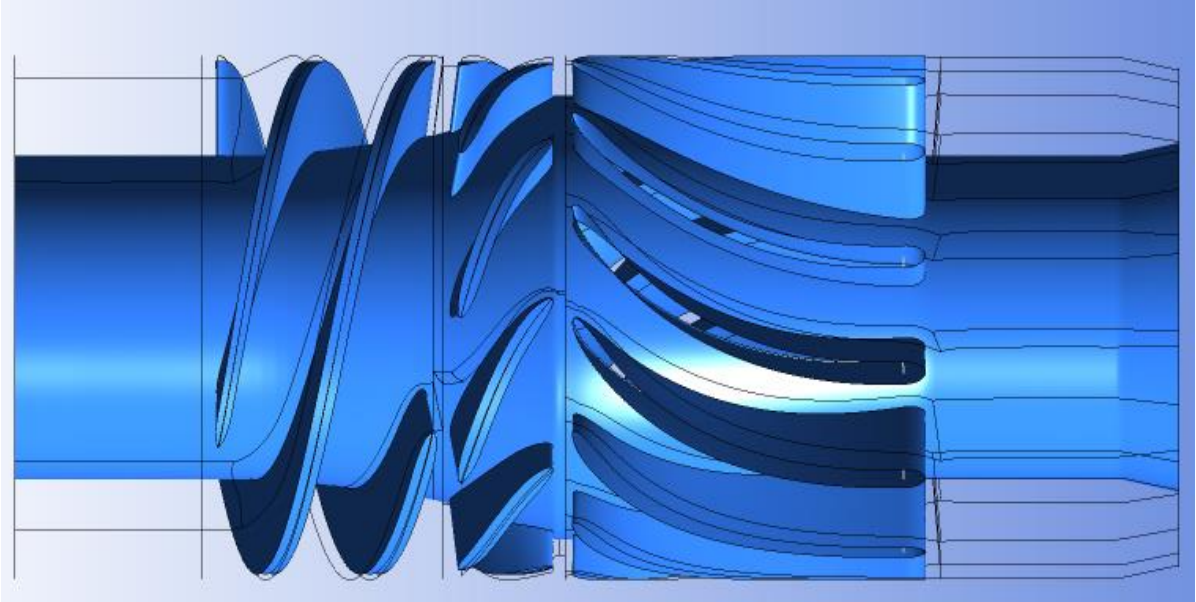


HelicoAxial



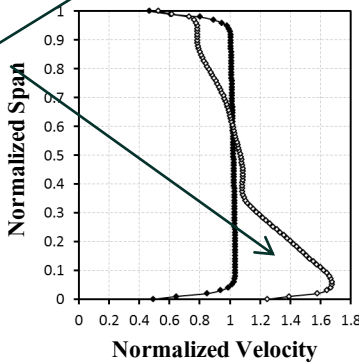
400 Series GH2500

SUCTION $\xrightarrow{\text{flow}}$ DISCHARGE

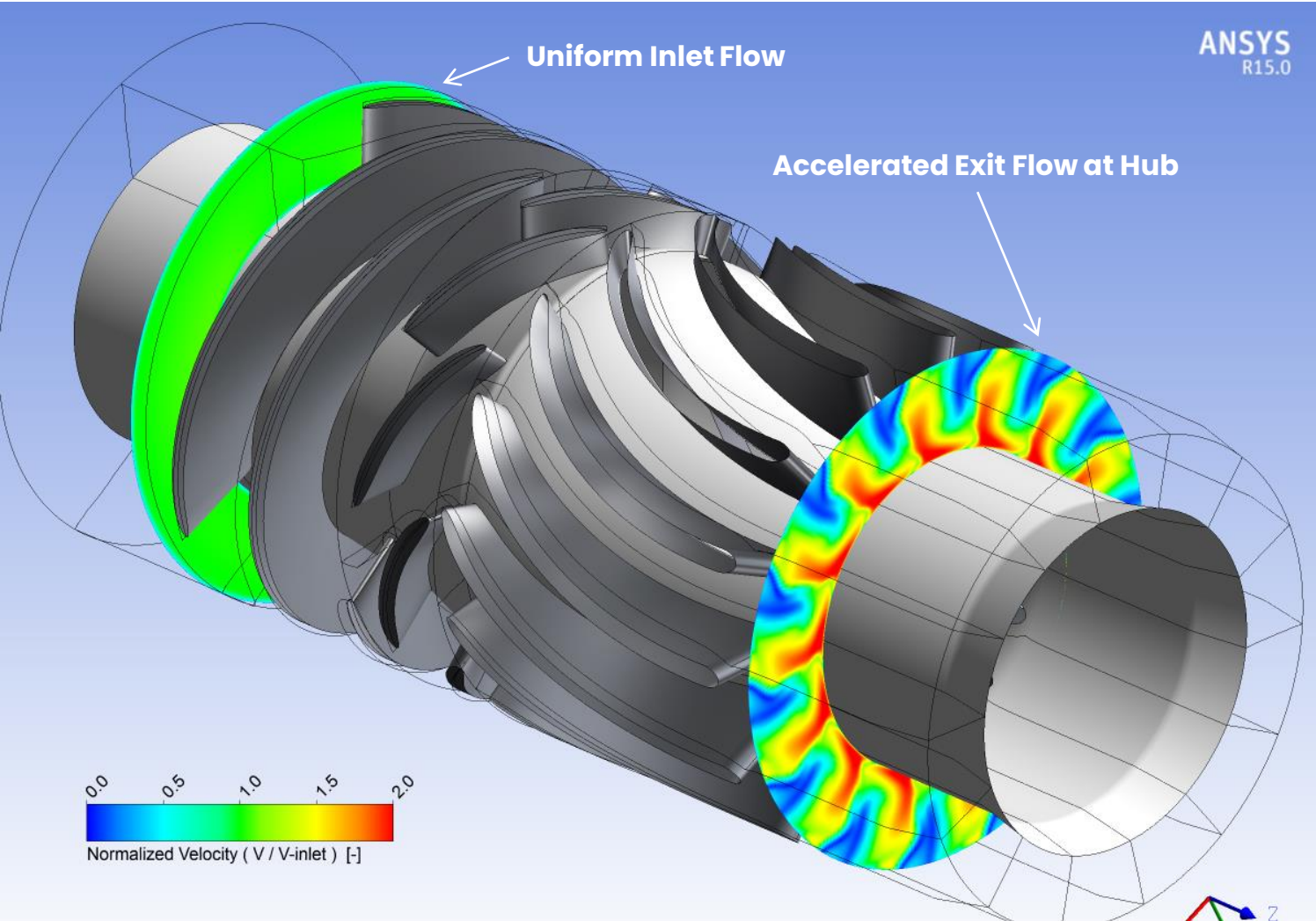


Accelerated Exit Flow at Hub

Uniform Inlet Flow

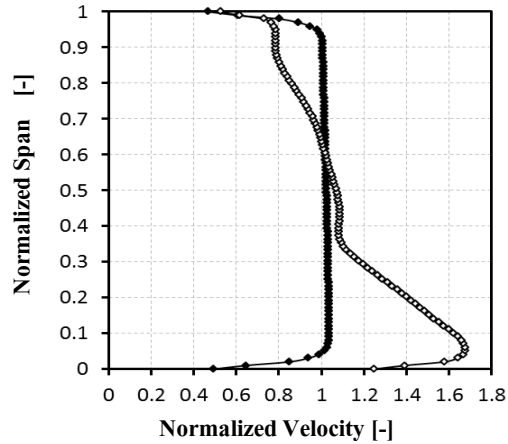


400 Series GH2500

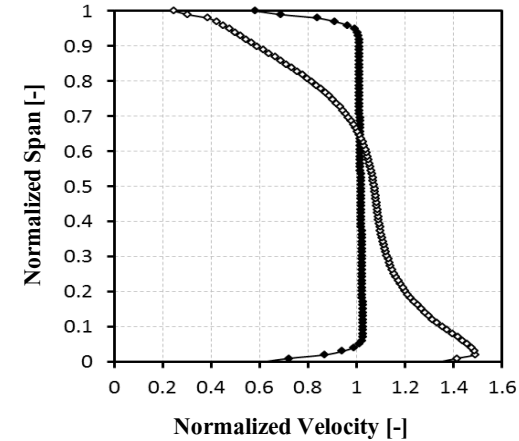


GH2500 vs. Typical Gas Handler

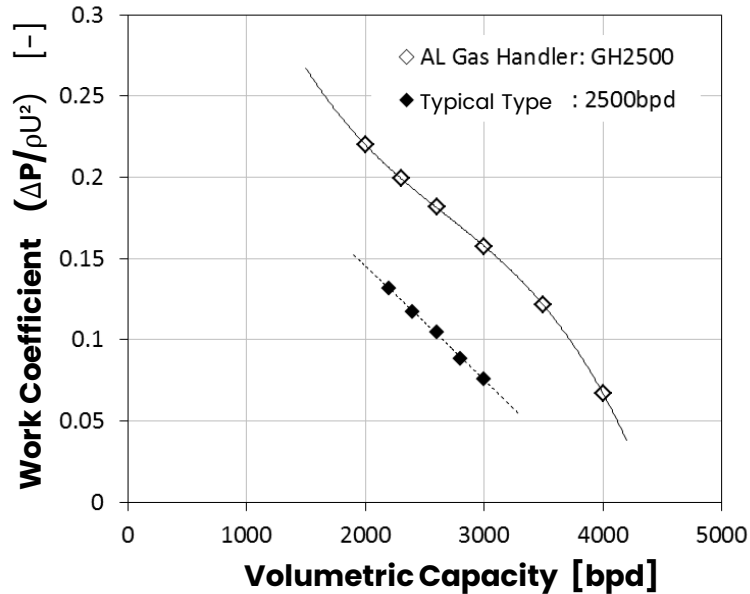
AL Gas Handler GH2500



Helico-Axial type: 2500bpd



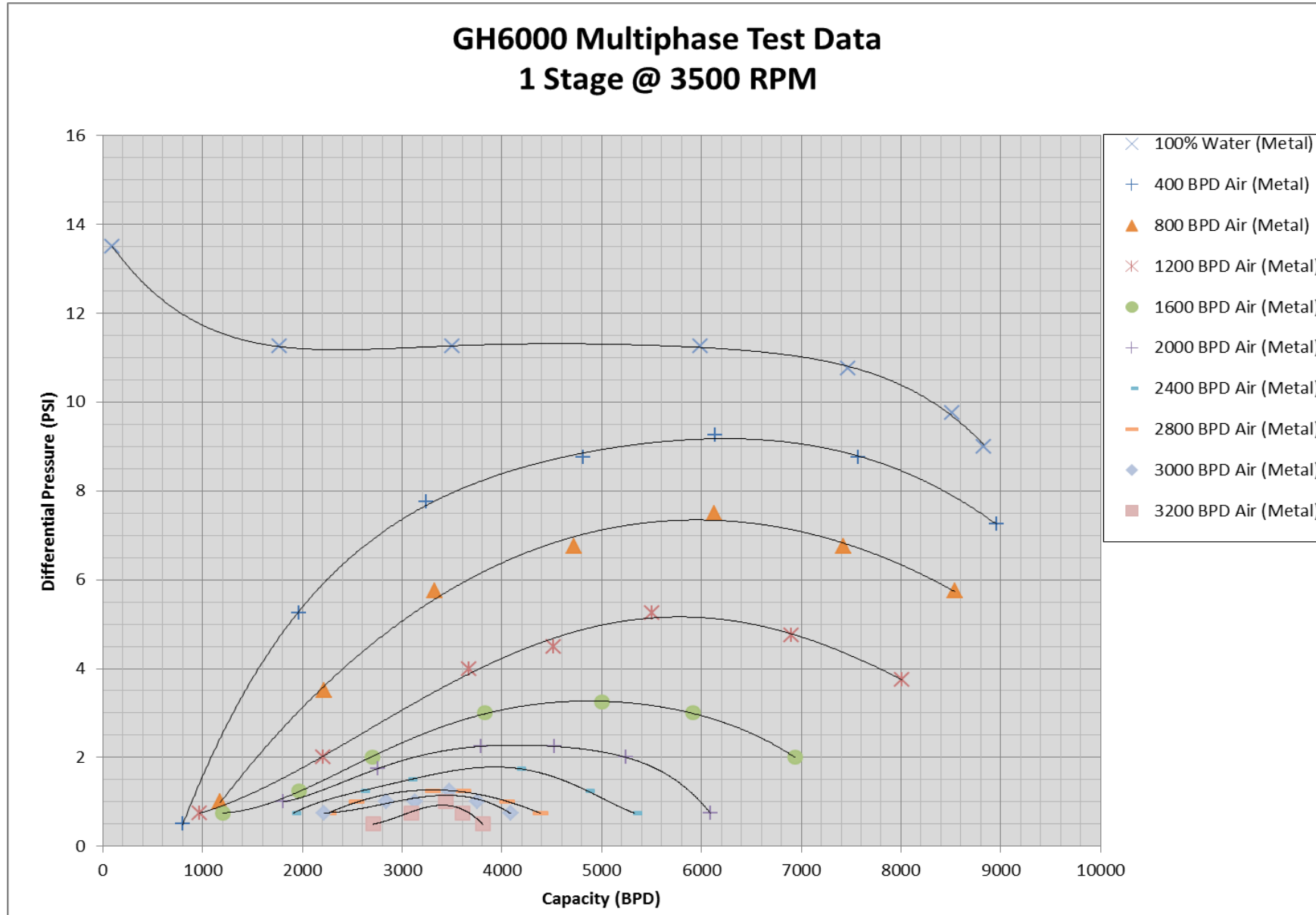
Comparable
Exit Velocity
Profiles



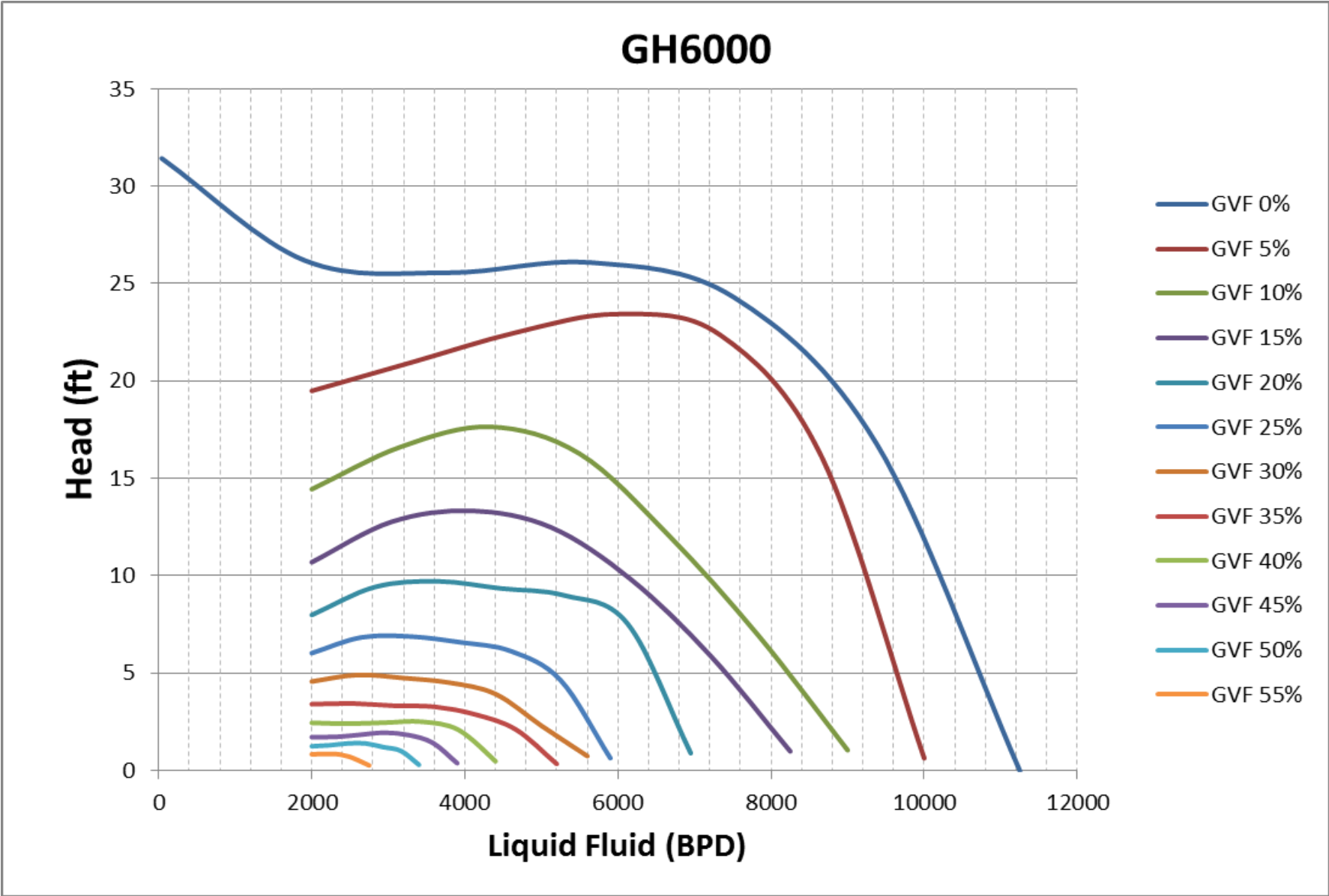
AL Gas Handler delivers higher head:

- Increase in exit velocity
- Higher pressure generated
- Lower exit GVF
- Improved performance of 1st ESP stage
- Less ESP stages required

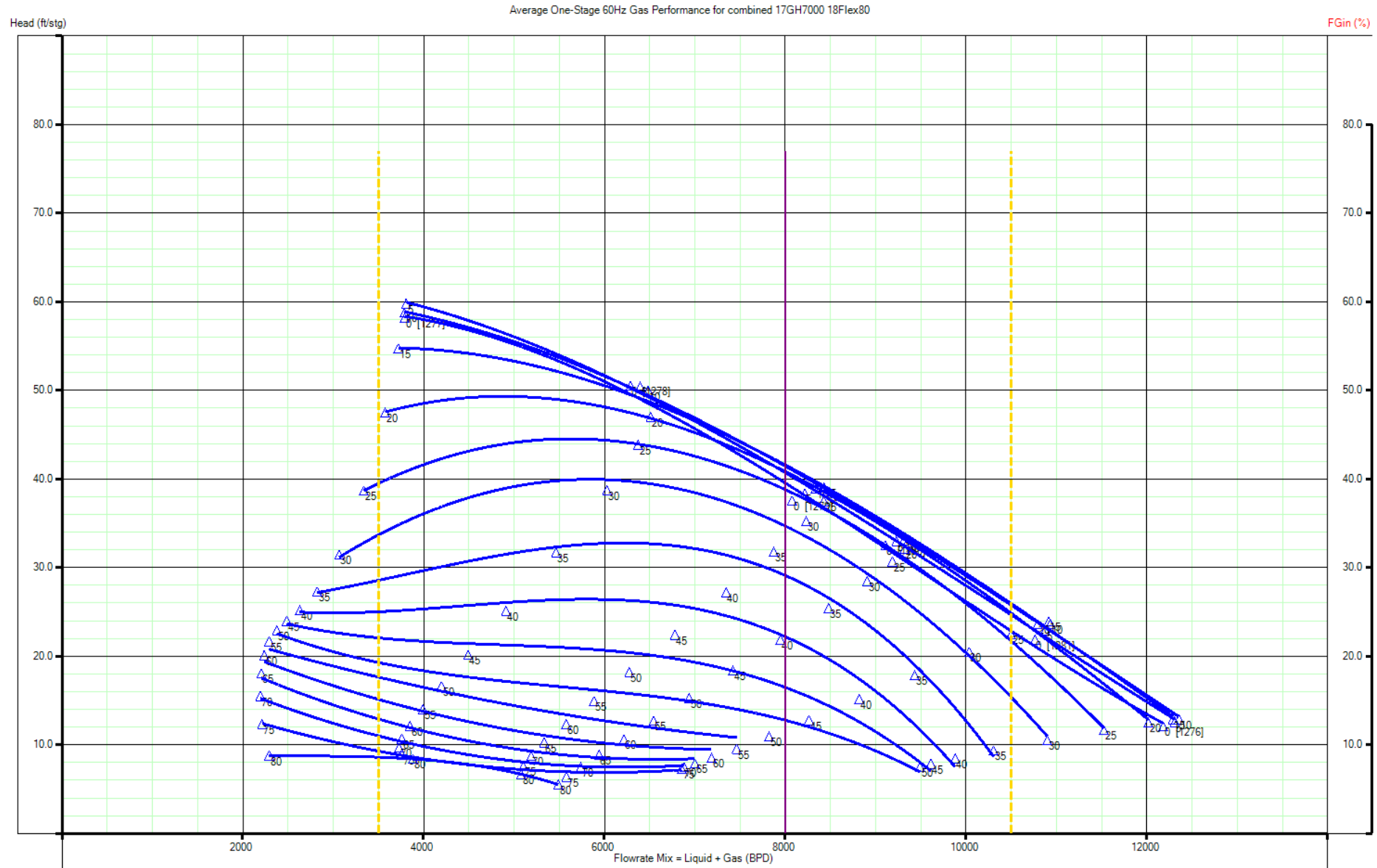
Performance Test



Performance Test (Gas Map - GVF Graph)



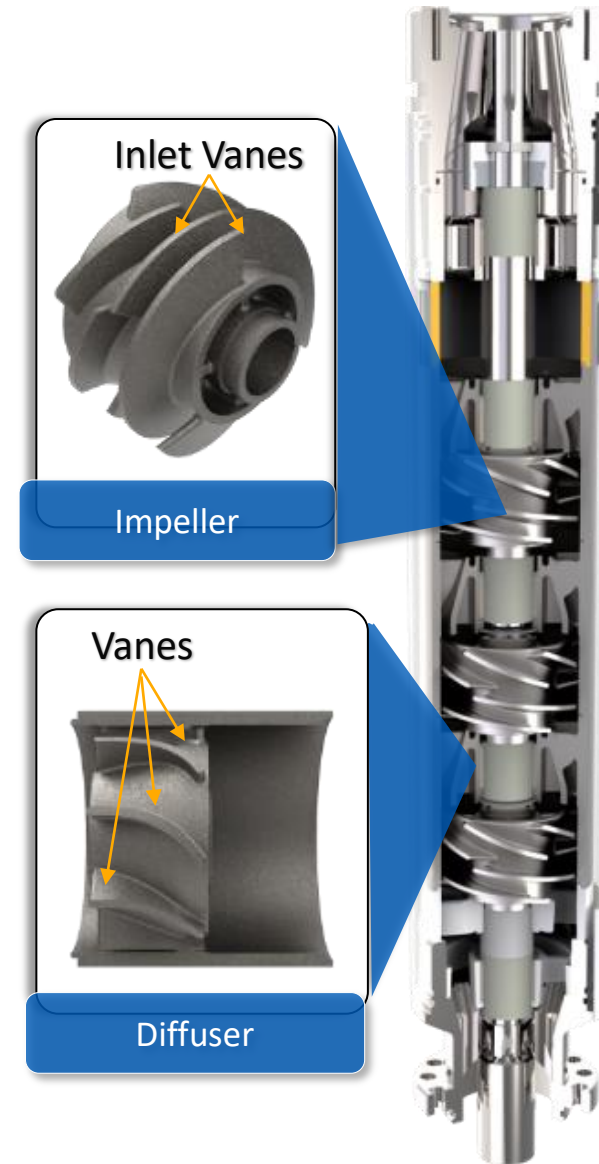
GH7000 on Flex80 Gas Map (Liquid+Gas)



Ace PLUS™ Gas Handling Pump

- Patented technology
- 400 and 538 Series Stages
- Handles 75% of free gas without gas locking at low intake pressures
- Compression design

Ace PLUS™ Gas Handling Pump Product Line				
Ace PLUS™ Model	Series	Outside Diameter	BEP (BPD)	Application Range (BPD)
GH 650	400	4"	650	300-1200
GH 1400	400	4"	1500	800-1800
GH 2500	400	4"	2650	1000-3200
GH 6000	400	4"	6300	3400-7600
GH 4000	538	5.38"	4500	1400-5400
GH 7000	538	5.38"	8000	3000-9600



An aerial photograph of a forest. The left side of the image is dominated by a dense stand of dark green evergreen trees. The right side shows a mix of deciduous trees, some with bright yellow autumn foliage and others that are bare and greyish. A sharp, diagonal boundary separates the two types of forest. The text 'Stage Coating' is overlaid in white on the evergreen side.

Stage Coating

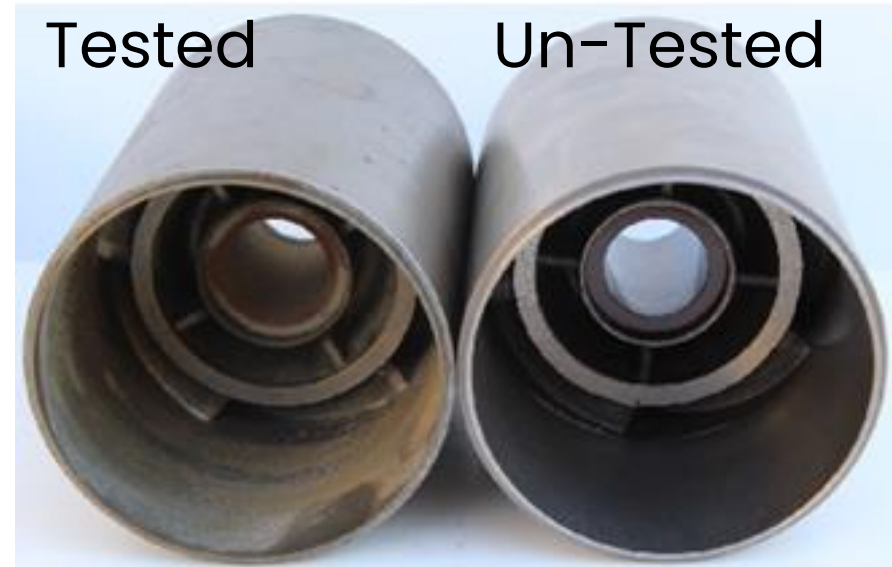
Abrasion Flow Loop Test Setup



Abrasion Test Review



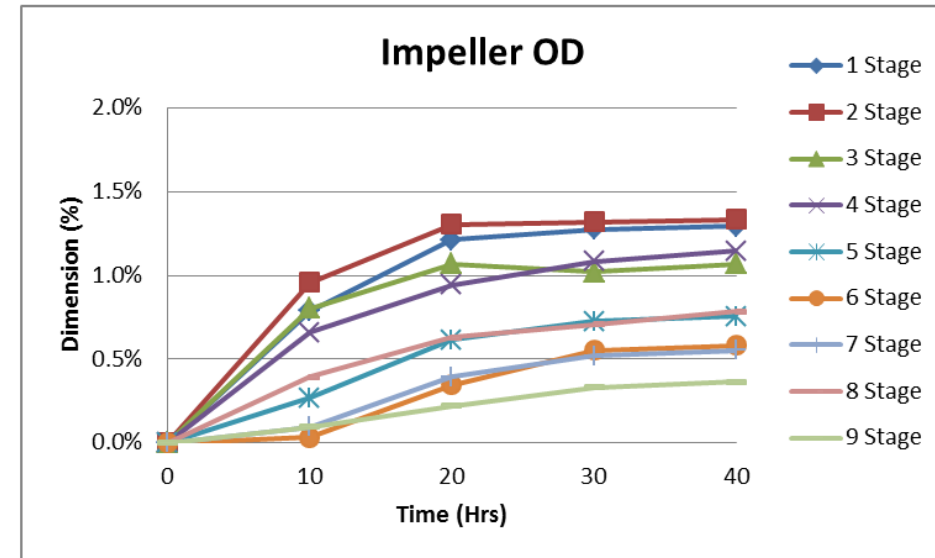
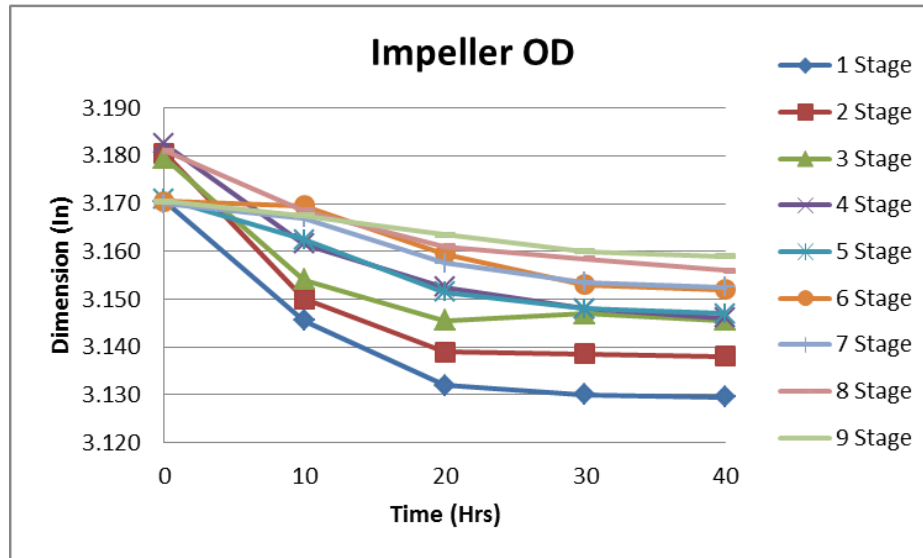
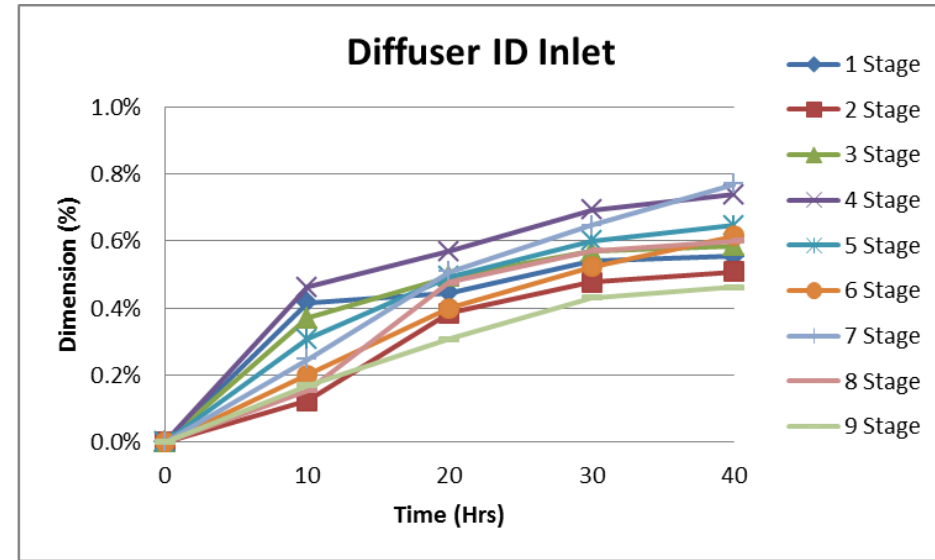
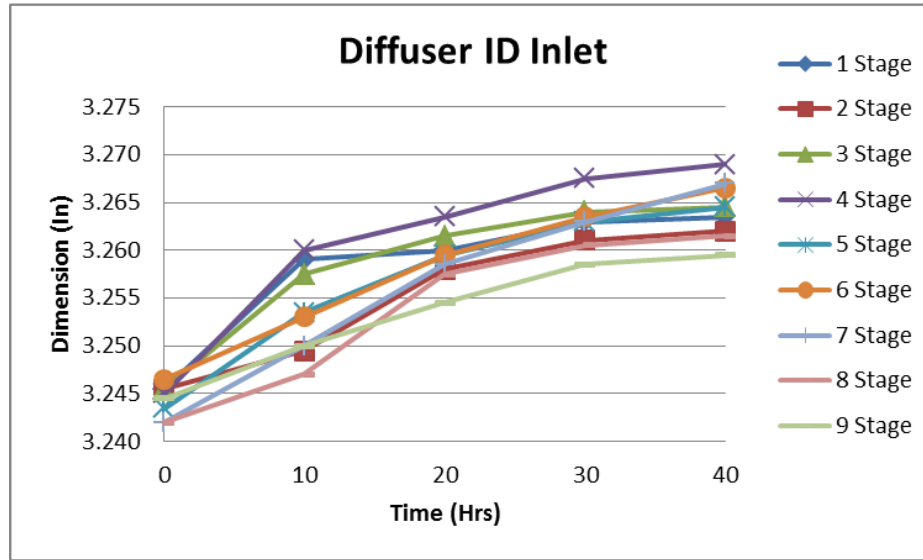
Gas Separator Compression tube
@ 25 hrs. Abrasive Loop Testing



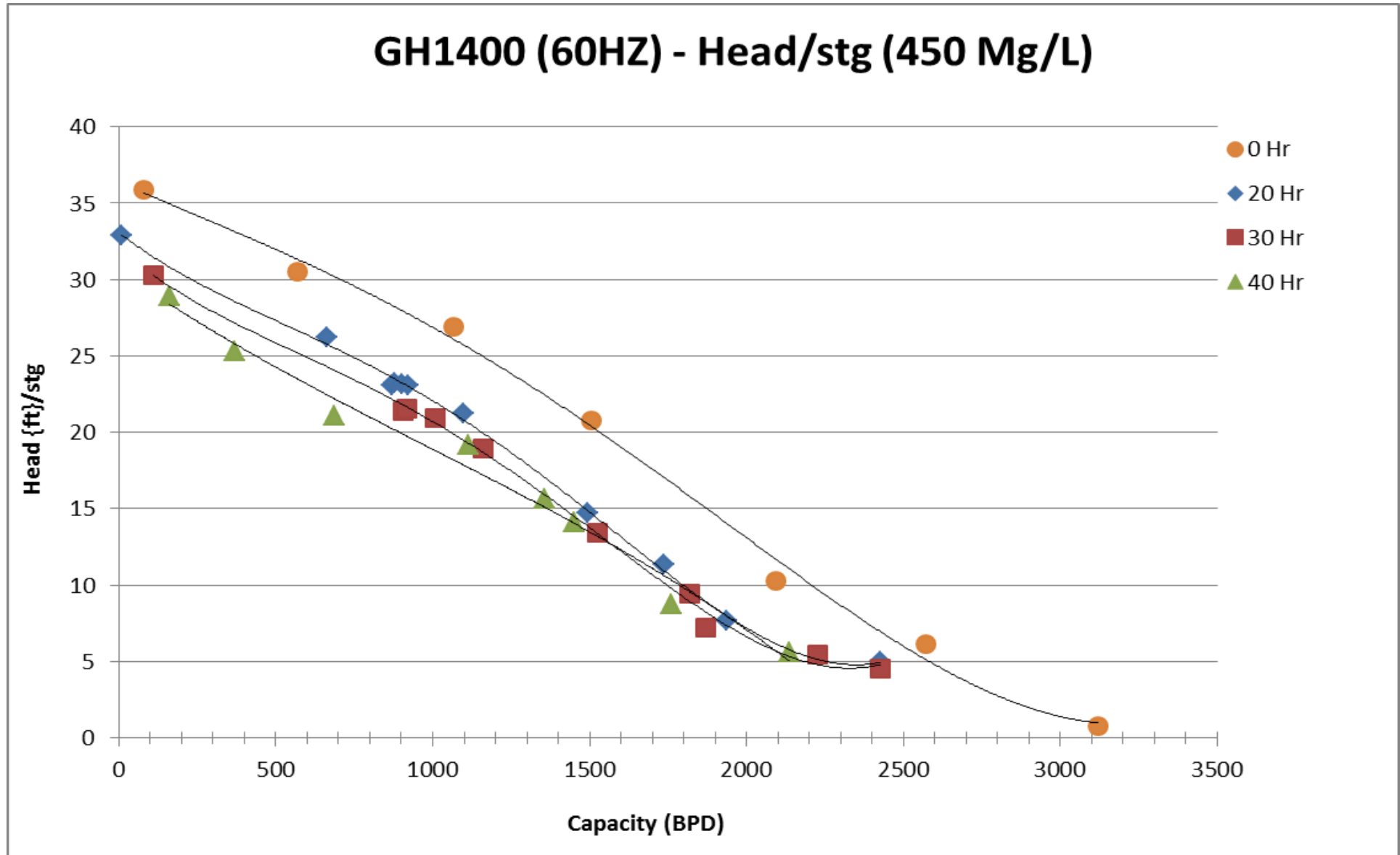
Gas Handler Diffuser ID
@ 30 hrs. Abrasive Loop
Testing

- Concern about using a shroud-less impeller arose after severe abrasive wear damage was found in the field in our Gas Separators
- Wear observed in the Gas Handler Diffuser was minimal when compared against an untested diffuser approximately 0.020" (0.6%) of wear diametrically after 40 hours
- When compared to the wear seen in the Gas Separators, the wear in the Gas Handlers is insignificant

GH1400 Abrasion Test (Dimensional Changes)



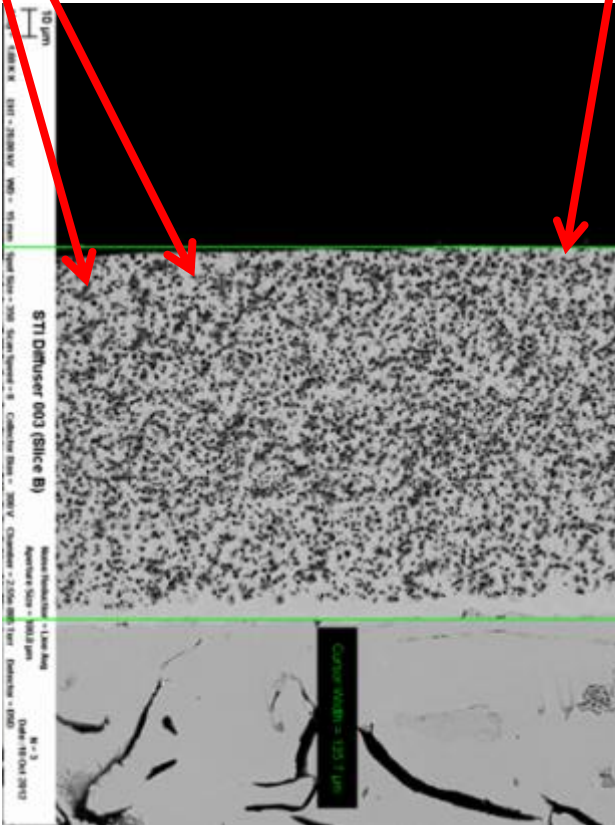
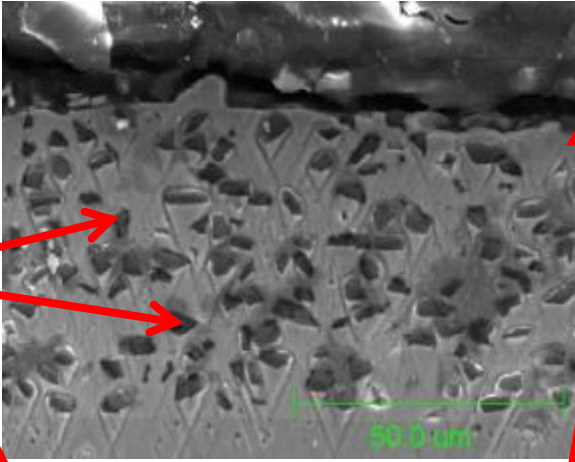
GH1400 Abrasion Test (Performance Drop)



Microstructure of Coating

Diamond particles

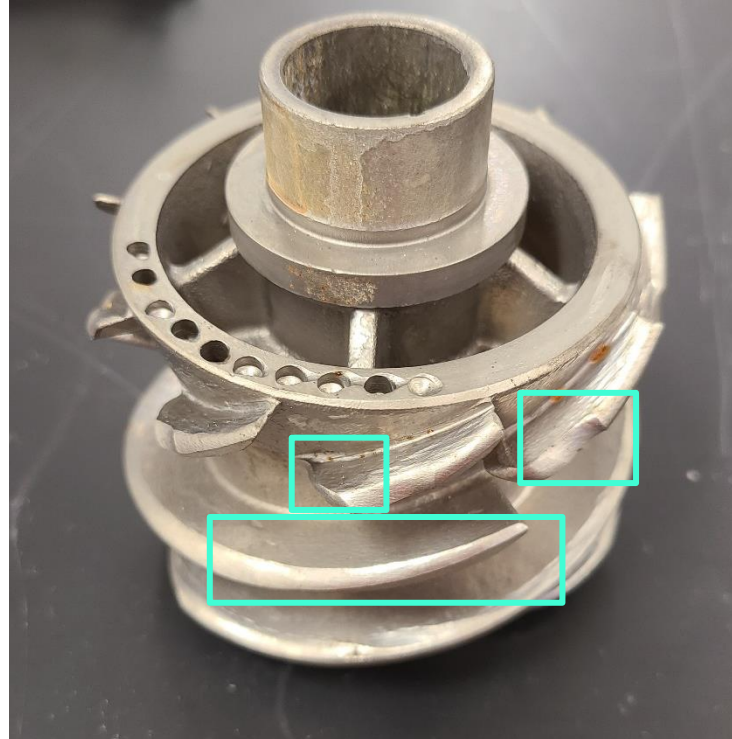
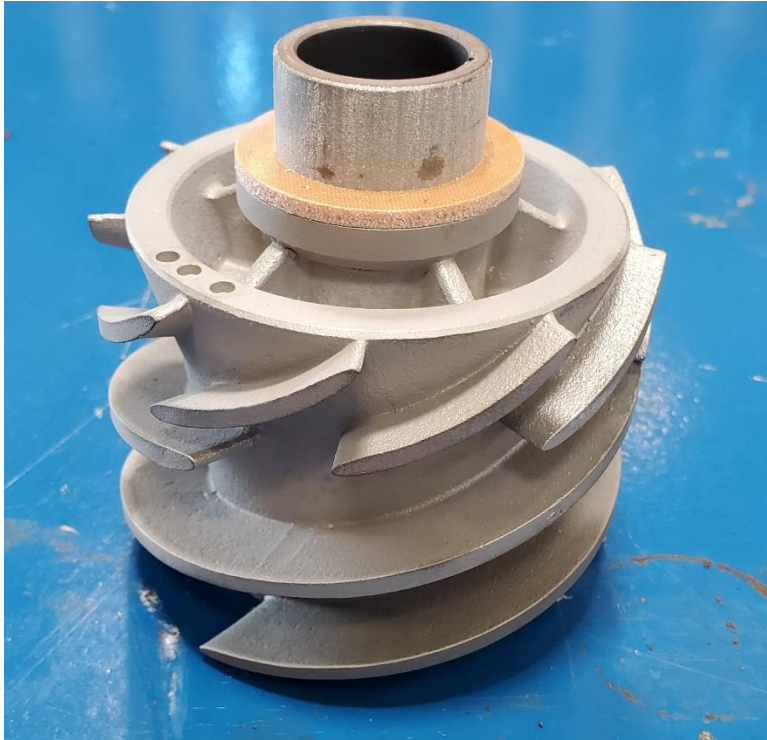
- Much smaller diamond particles
- Many more particles
- Diamond particles 2 microns
- No clumping of diamond particles
- Between 35v/o and 38v/o diamond particles



Nickel/Phosphorous

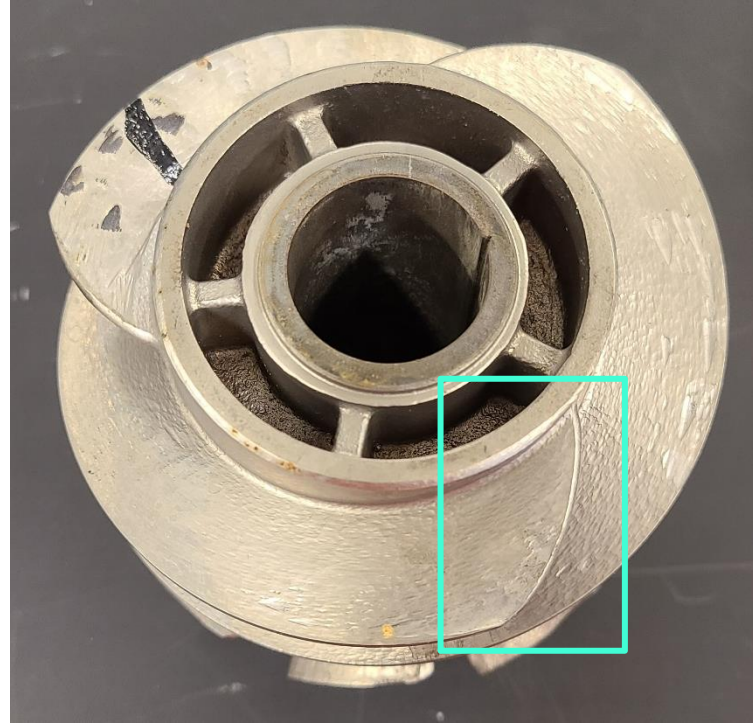
- Excellent Chemistry for Oil & Gas downhole environment (Abrasive & Corrosive)
- Extends pump life 5 times longer
- Application Temperature: Max 250°C
- Coating Hardness: Average 1400 - 1500 Hv
- Uniform thickness control (+/- 0.0005 inches) with dense and consistent microstructure
- Excellent adhesion strength to substrate
- Smooth surface finish
- Entire stage coated

GH2500 Slurry Test



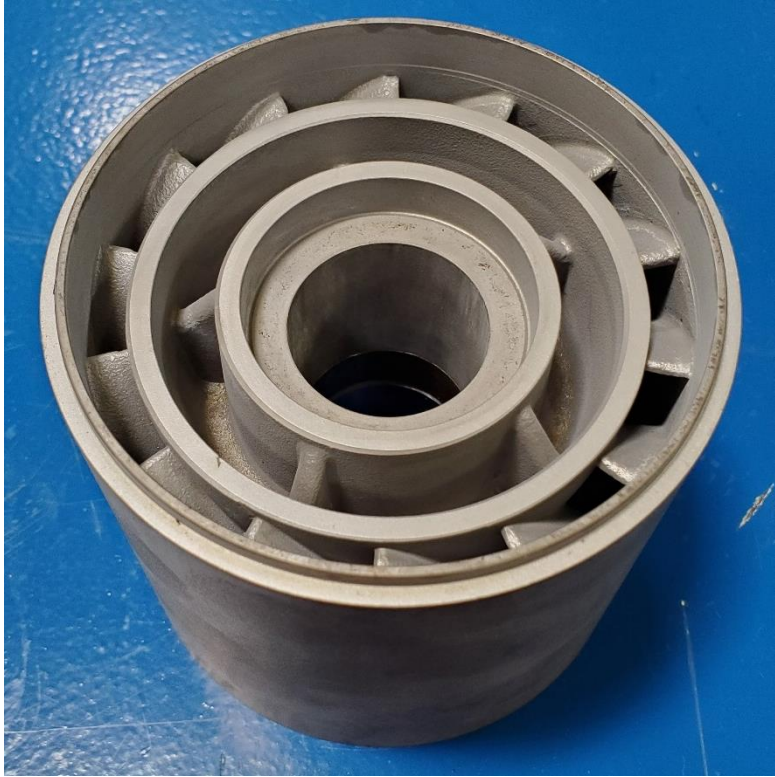
The wear shown blocked here was present on all impellers and comparing the pre-run coated image on the left you can also see a good amount of the upper vane had eroded away on leading edge and the lower helical vane's edge has been rounded over. You can also see the coating appears to be lost on the impeller.

GH2500 Slurry Test



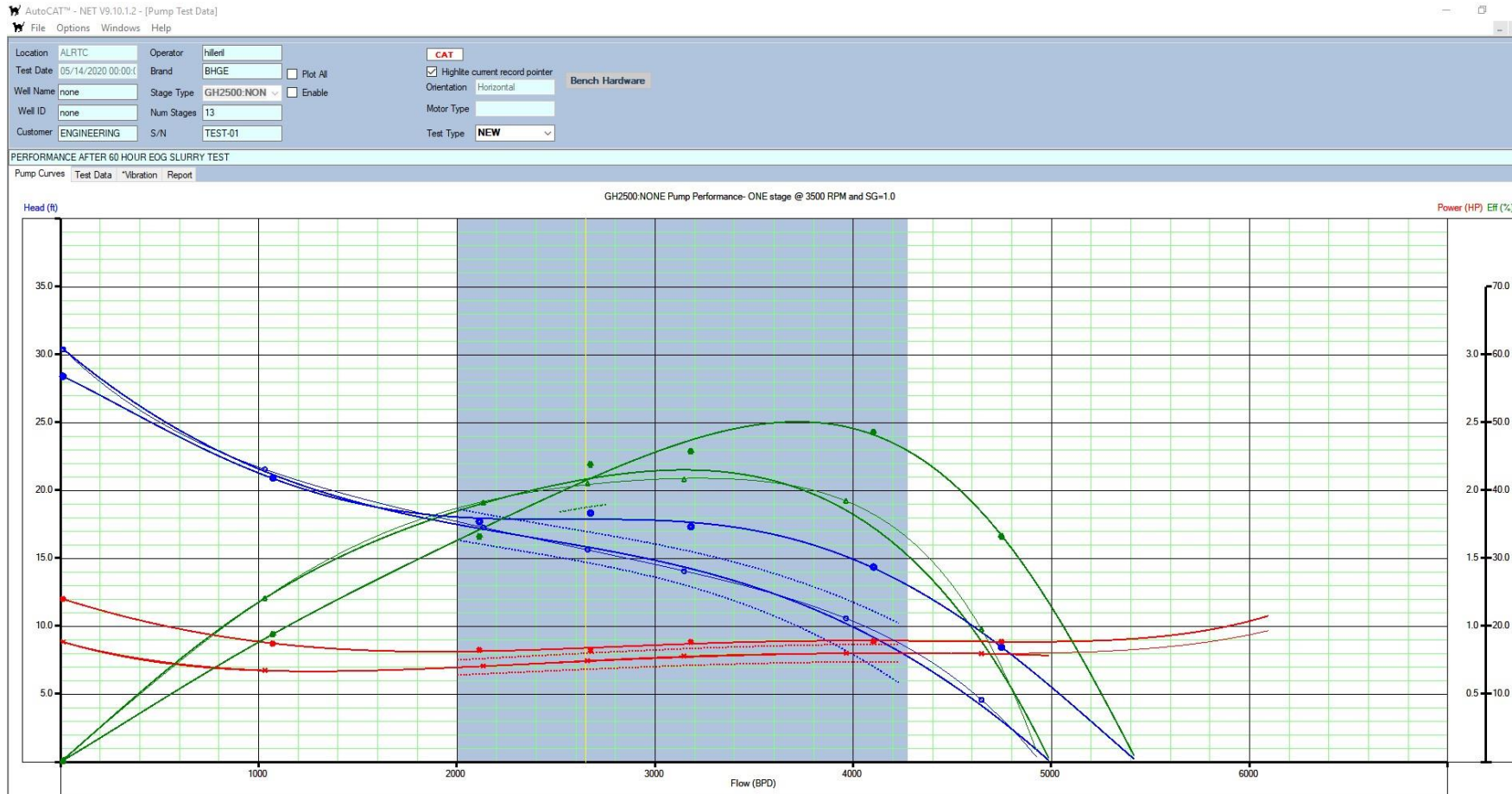
Bottom view of impeller showing impact to leading edge of the 3 helical vanes. This wear was also present on all impellers.

GH2500 Slurry Test



Diffuser vane entry side,
tip wear.

GH2500 Slurry Performance Test



GH2500 post slurry performance test overlaid with test from first article.

There was no performance drop even after the slurry test.

An aerial photograph of a forest. The left side of the image is dominated by a dense stand of dark green evergreen trees. The right side shows a more diverse forest with many deciduous trees in various shades of yellow, orange, and light green, indicating autumn. The text 'Case Studies' is overlaid in white on the left side.

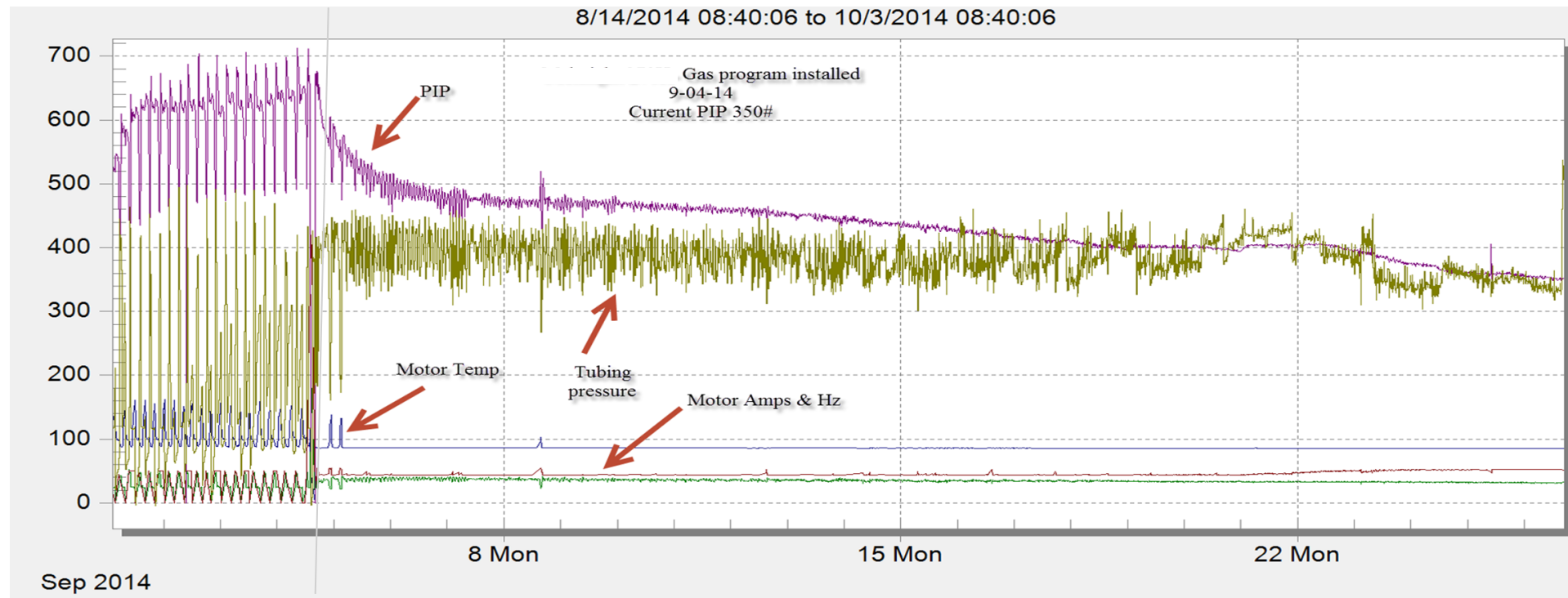
Case Studies

Case Study

Gassy Well Shutdown Avoidance

Example:

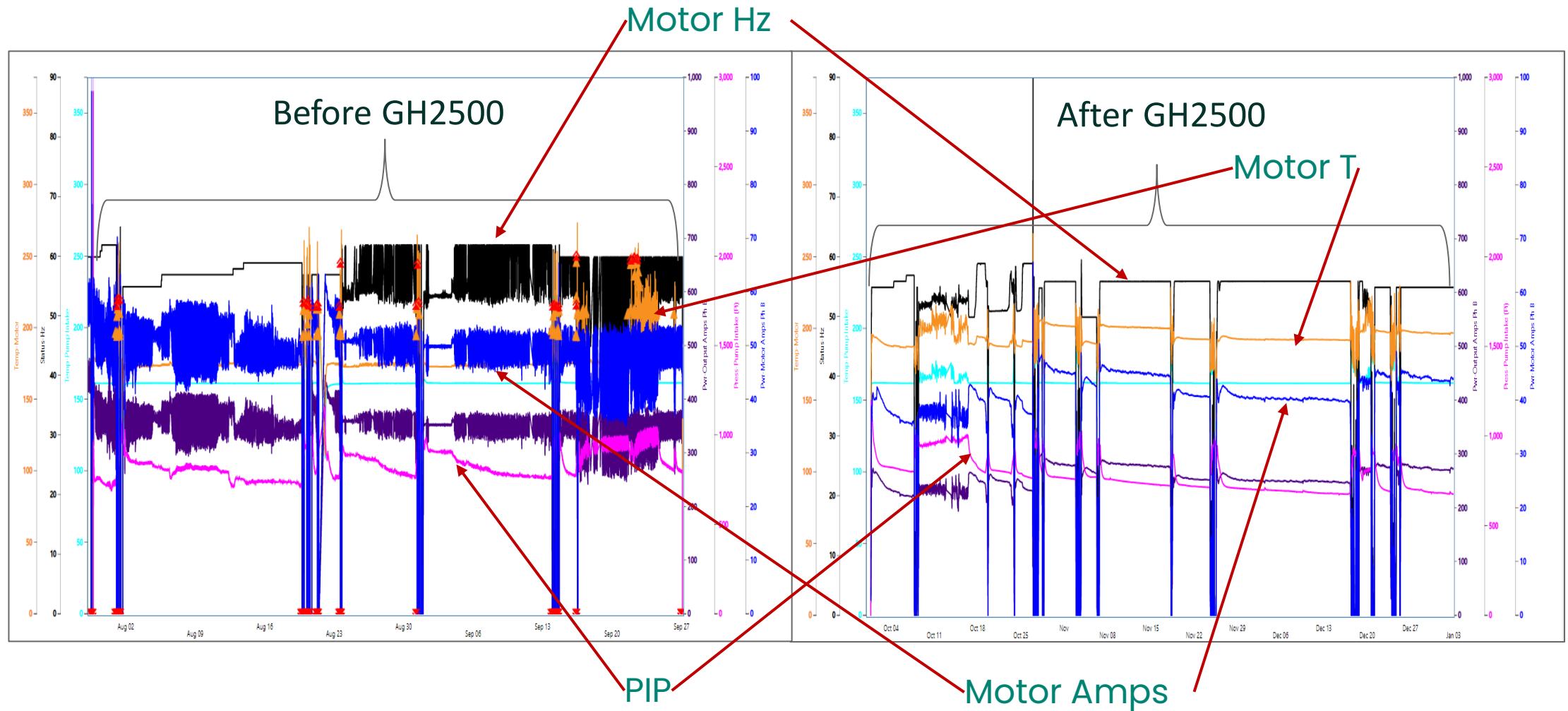
Continuously Cycling Well \longrightarrow Continuous Production



Program Installed

Case Study

ESP Operational Trends before and after GH2500 Installation



Baker Hughes 