Overhaul Issues on Vertical Pumps

EPRI/NMAC Pump Users Group

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Kurt Schumann

ProPump Services

Vertical Pumps Come in All Sizes…

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Repair Goals

- Repair Only
  - "Get what you got"
- Solve a Problem
  - Increase MTBR
    - Vs Target 10+ years
  - Increase system capacity
  - Increase efficiency
  - Restore Life to As-New

Mean Time Between Repairs?

- Compare vs. Industry Norms
  - Circulating Water Pumps
    - 5-8 Years Seawater
    - 8-12 Years Freshwater
  - Condensate Pumps
    - 8-12 Years

Weldability

Material	***Weldability***
Cast Iron	Location / Cosmetic
Bronze – Leaded	Location / Cosmetic
Bronze – Nickel/Aluminum	Good
Carbon Steel	Good
316 Stainless Steel	Good
12 Chrome Stainless Steel	Good
5% Chrome Steel	Difficult

Weld Repairs to Cast Iron

- Lower Strength
  - Cosmetic / Profiling
  - Restore fits

Weld Repairs to Cast Iron

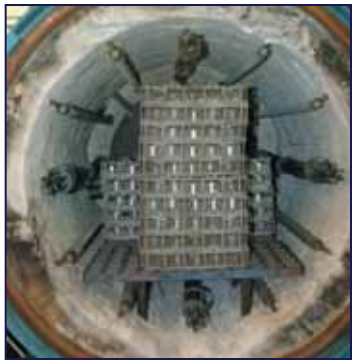
- What are stresses?
- What if it breaks?
  - Is it upstream of impeller?
  - System impact?

Bearing Holder

Suction Bell with Broken Ribs

Post Weld Heat Treatment

- For Corrosion Resistance
  - Must solution anneal CF8M [316 ss]
  - May solution anneal CF3M [316L ss]
- For Stress Relief
  - Especially complex pieces [discharge head]
  - Critical clearance pieces [shroud]
  - After extensive welding



Coatings

- Coal tar epoxy [Bitumastic] used for low/medium velocity, fresh water
- Will not adequately protect carbon steel in seawater

Suction Bell

Shroud Exterior

Epoxy Coatings

Carbon Steel and Cast Iron Pump in Fresh Water - High Grade Epoxy Coating

Coatings - Impellers

Most coatings do not hold up on impellers and shrouds due to high velocities and cavitation/separation

Coatings - Impellers

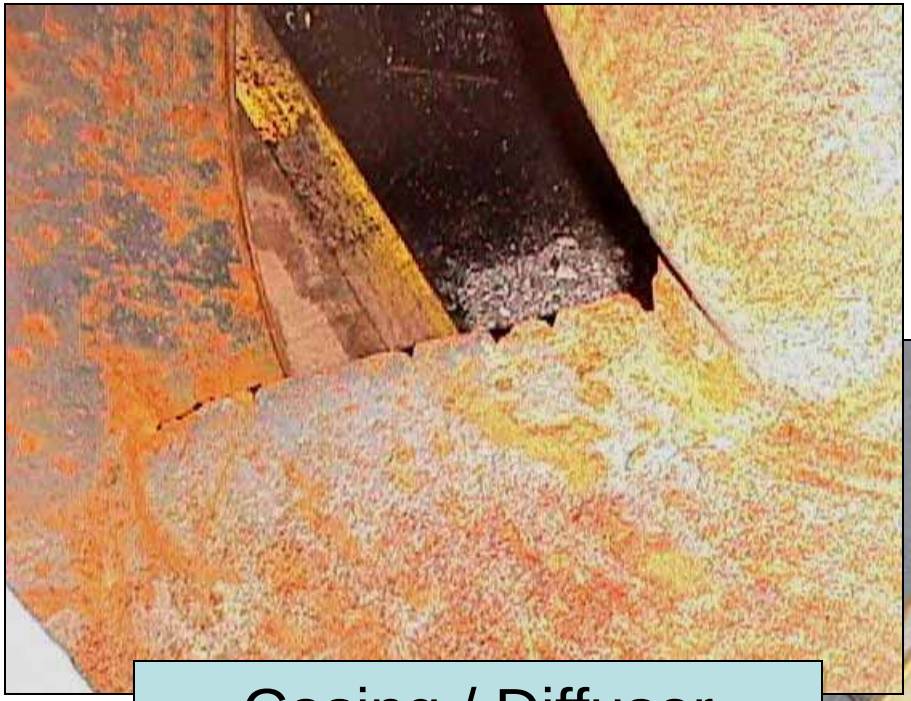
Shafts – Monel in Seawater

Copper Oxide Corrosion Product – Deep Pits

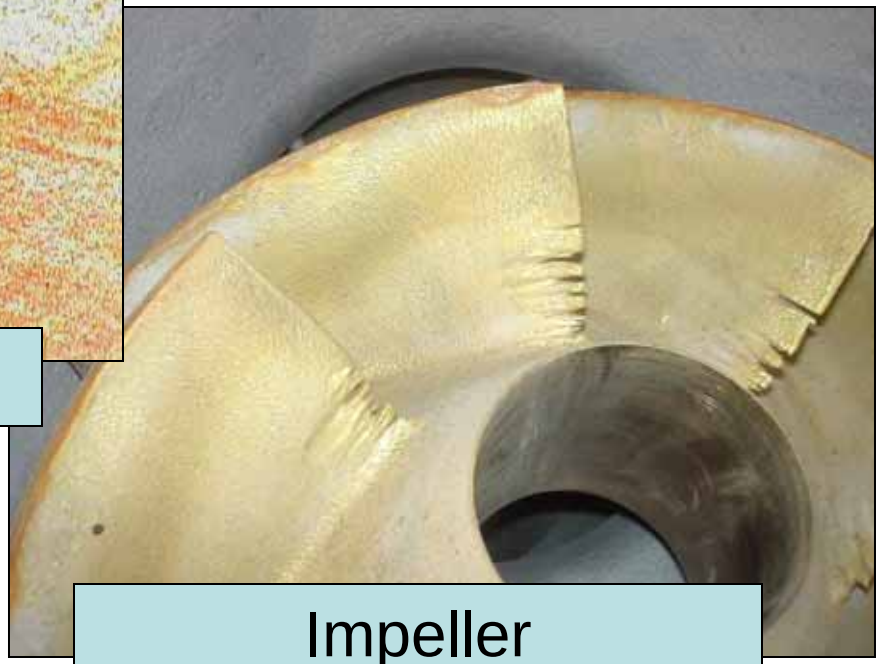
Broken Circulating Water Pump Shaft

- Pump shafts should never fail
- Design for stresses below endurance limit in liquid
- Watch sharp corners
- Some materials problematic

Erosion Damage



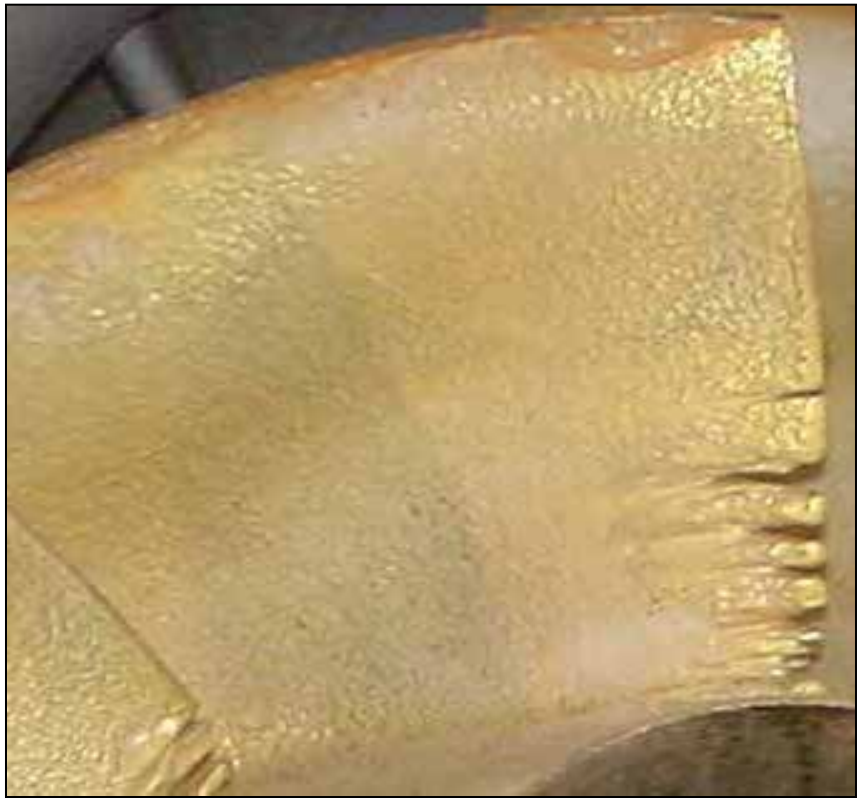
Casing / Diffusor



Impeller

Erosion Damage

- Symptoms
  - Vane Thinning
  - Saw Cuts at Leading Edge
  - Shallow pock marks
  - Scalloped leading edge



Mechanical Upgrades

- Alignment
  - Internal
  - To Driver
- Coupling Design
- Bearing Span

Restore Critical Alignment Fits

Reduce Bearing Span

Shaft Couplings

Function:

- Transmit torque from shaft to shaft
- Act as a stiff shaft for lateral loads
- Provide for ease of disassembly

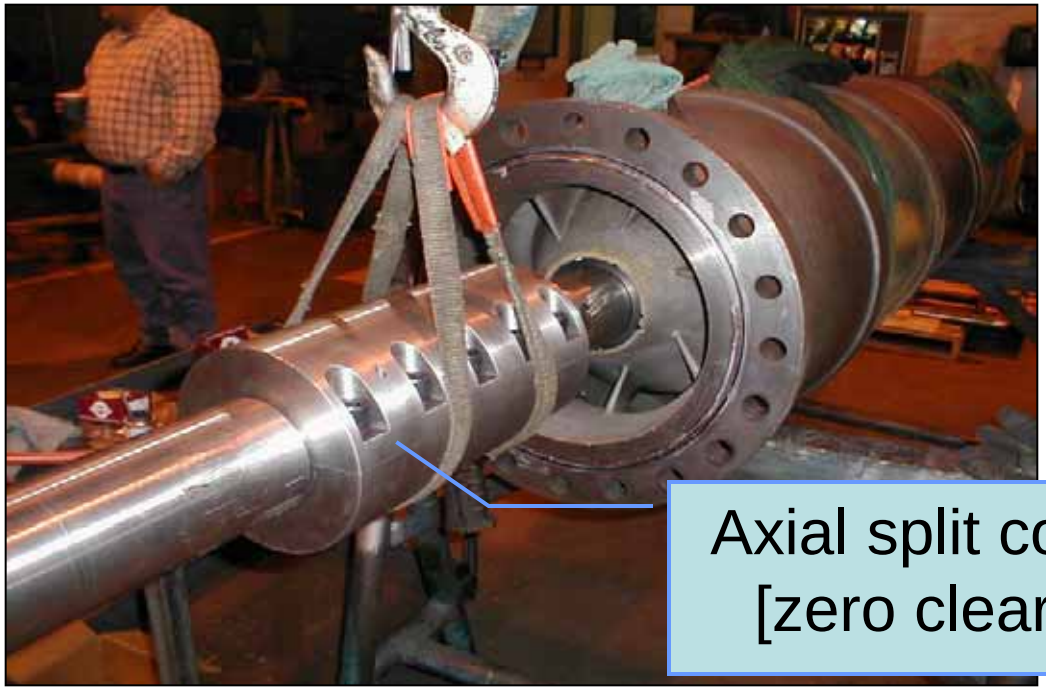
Problem Areas:

- Threaded Couplings
  - Hard to maintain alignment
  - Difficult to disassemble

Solutions:

- Replace with non-threaded design

Shaft Couplings



Axial split coupling
[zero clearance]

Discharge Head

Problem Areas:

- Maintain alignment between motor and pump
- Cracking in high stress areas
- Erosion/corrosion of fits

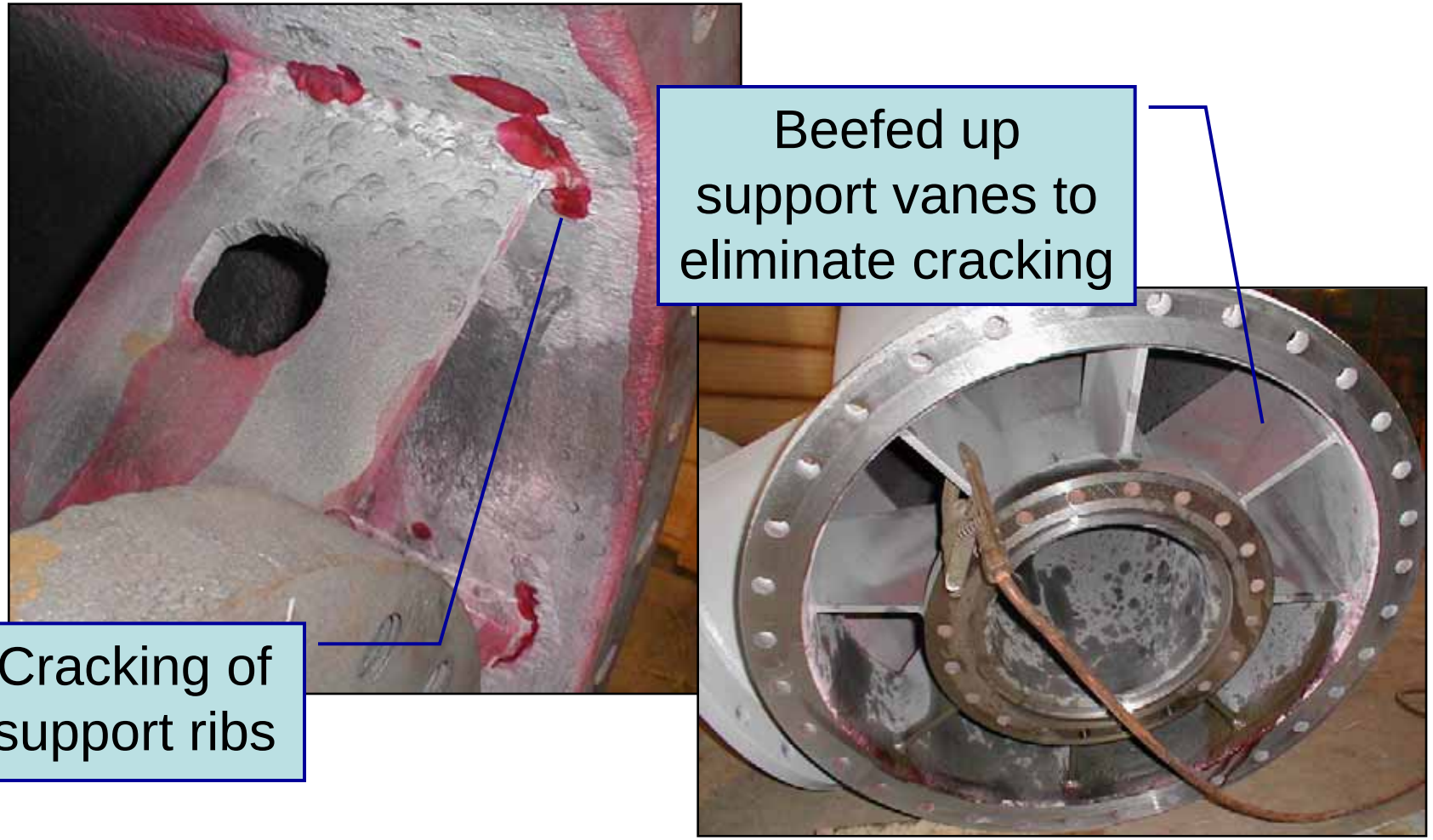
Solutions:

- Ruggedize discharge head
- Remachine for concentricity and parallelism

Discharge Head

Machining to restore concentricity and parallelism

Discharge Head



Hydraulic Upgrades

- Increase H-Q
  - Meet System Needs
  - Shut Down an Extra Pump
- Increase Efficiency

Impeller Redesign

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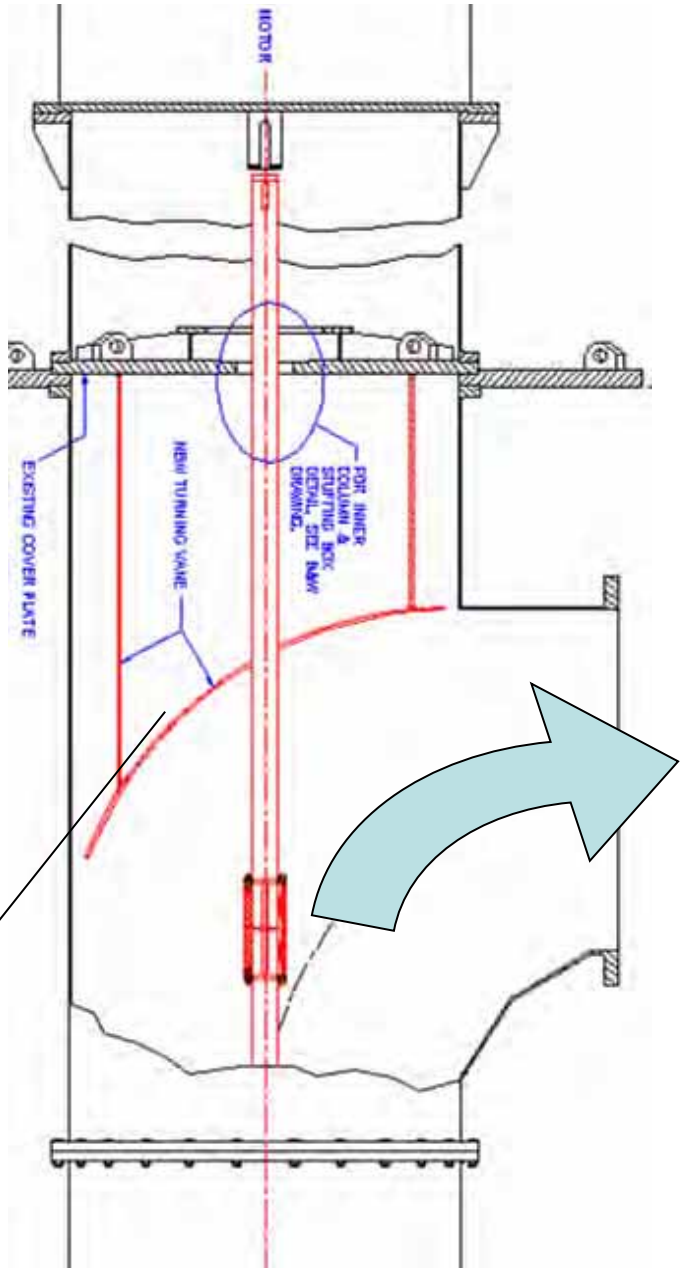
Underfile Impellers

- Add 2-5% Capacity
- Add 1-2% Efficiency

Add Turning Vane

- Many old pumps use simple tee for turn
- Can add turning vane design to improve efficiency

Add turning vane



Materials Upgrades

- Velocity Sensitive
  - Impeller
  - Shroud
  - Diffusor
- Wearing Components
  - Bearings
  - Wear Rings
- General Corrosion
  - Shafting
  - Stationary Components

Velocity Corrosion

- Impeller
- Shroud
- Diffusor

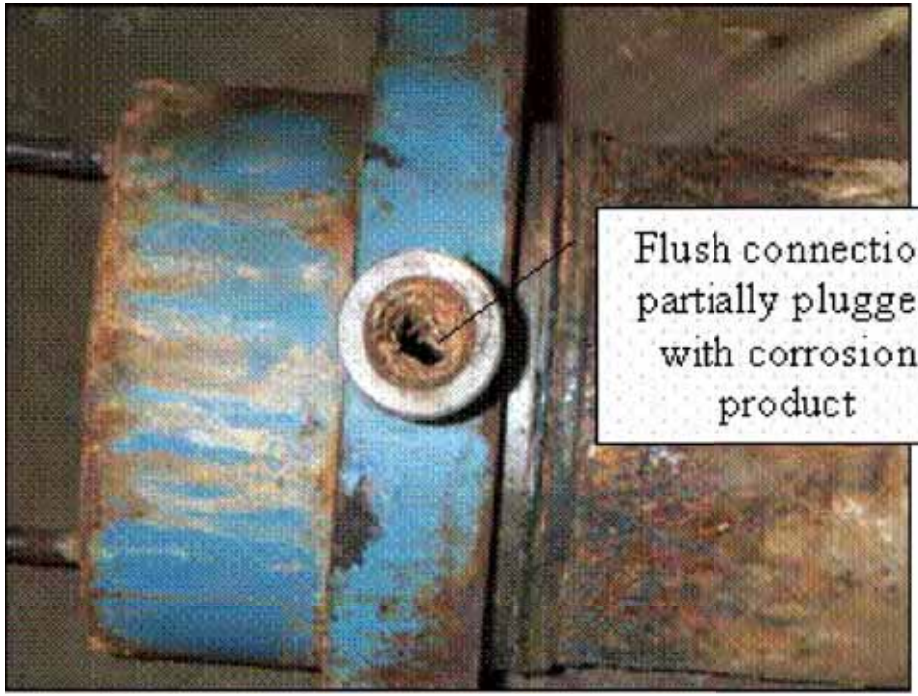
Eroded Cast Iron Shroud

New Stainless Steel Shroud

Bearings After Loss of Water Injection

Bearing Flush Piping

Carbon Steel Flush Piping Corroded Due to Aggressive Water



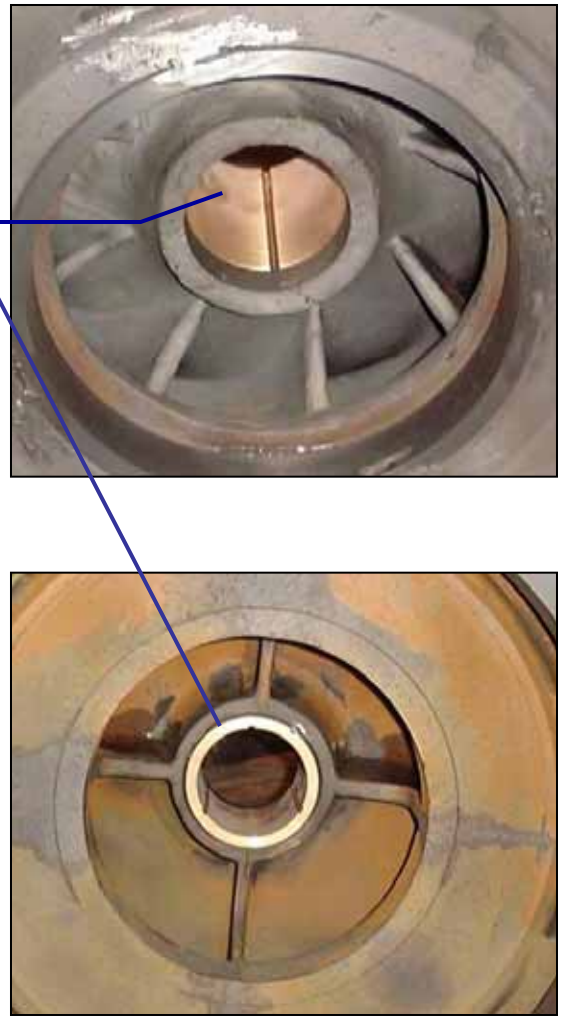
Bearings

Problem Areas:

- Premature wear
- Half frequency whirl
- Cavitation of first stage

Solutions:

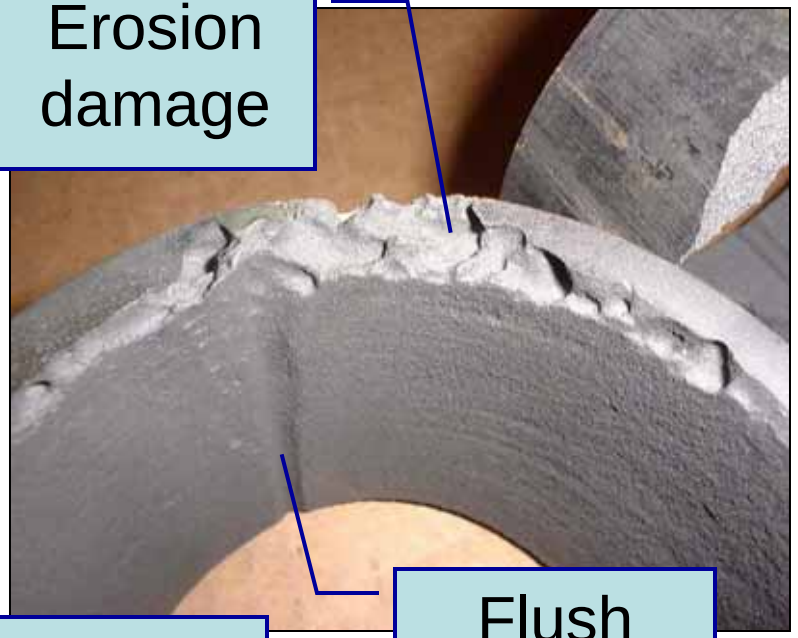
- Upgrade bearing materials
- Redesign flush grooves



Bearings

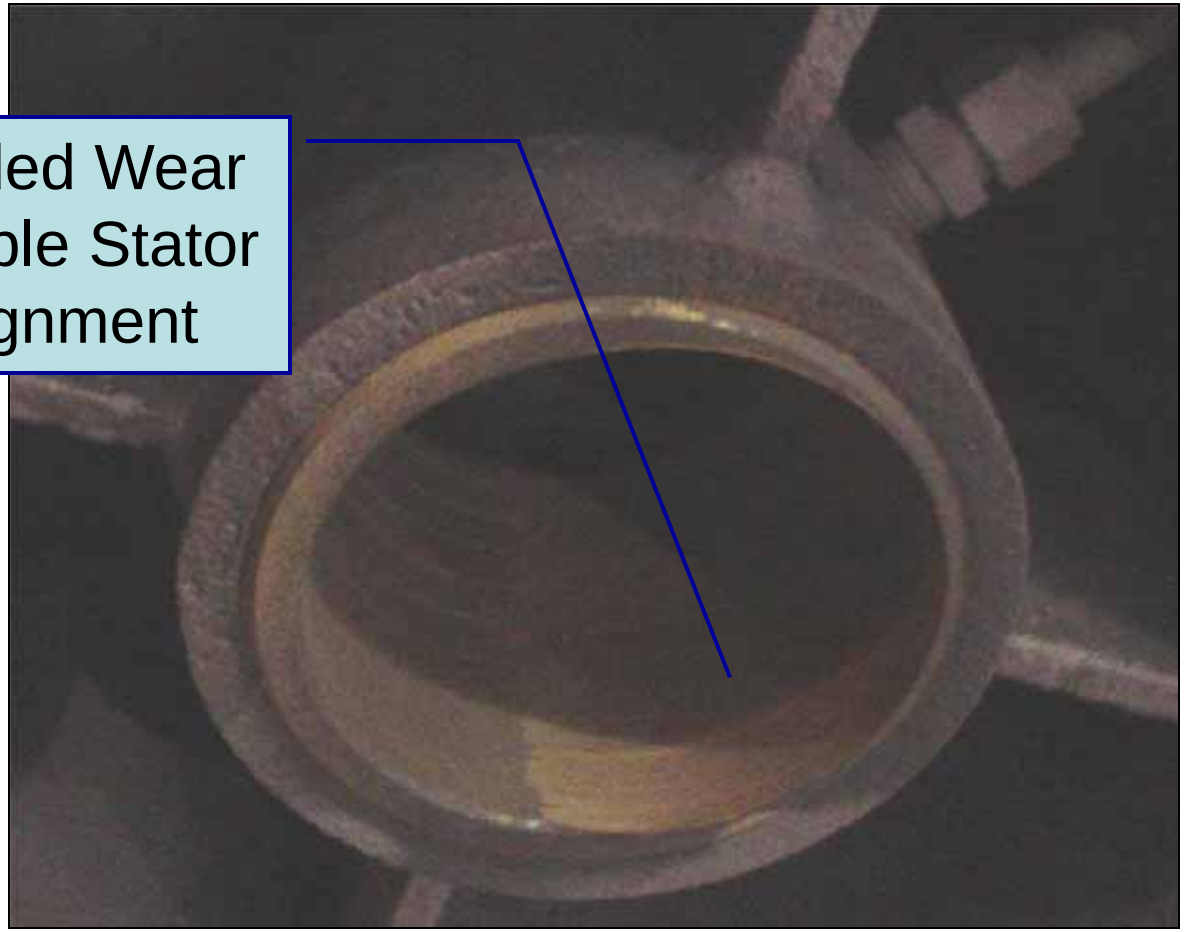
Cavitation damage to suction head bearing in Graphalloy material

Erosion damage



Flush grooves

Bearings

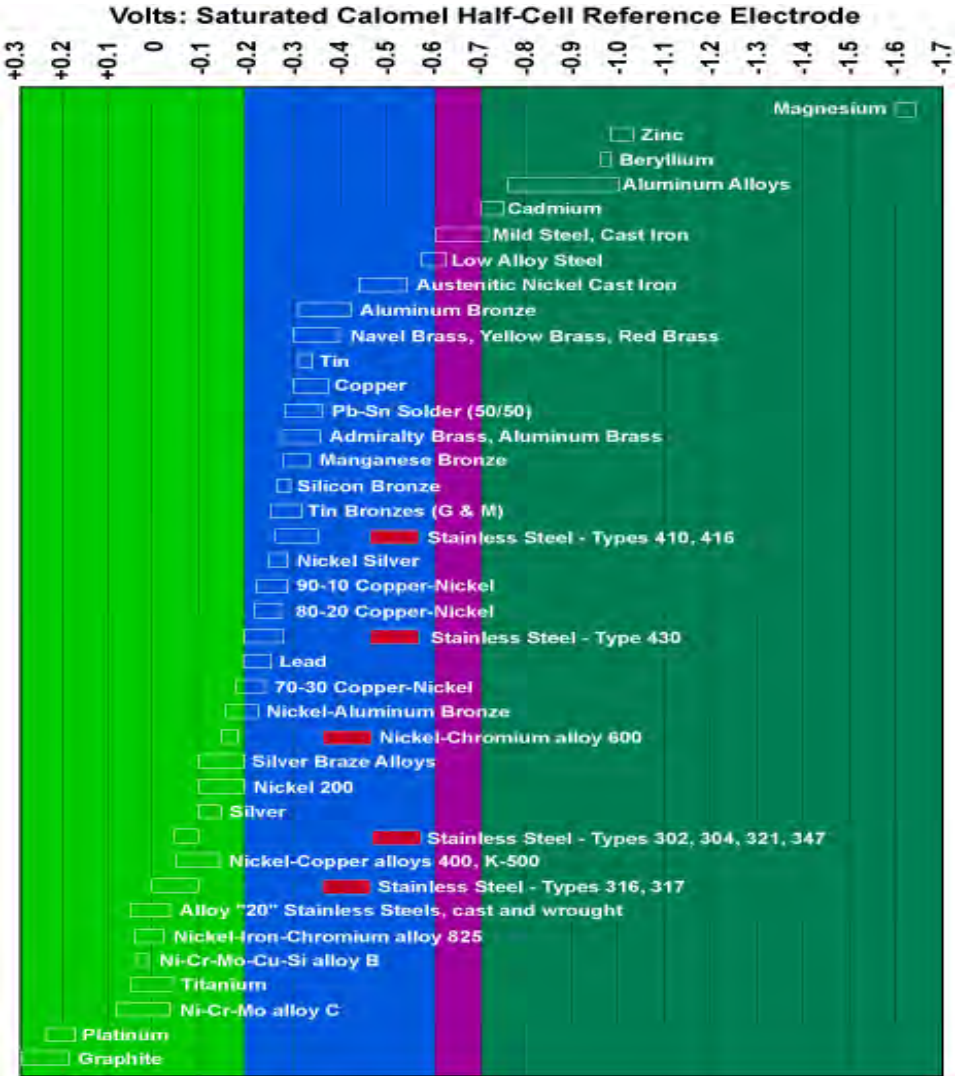


One Sided Wear – Probable Stator Misalignment

Galvanic Corrosion

- Electrochemical Reaction
- Area Ratios
- Dissimilar Materials
- Cathodic protection

Corrosion Potentials in Flowing Seawater



Alloys are listed in the order of the potential they exhibit in flowing sea water. Certain alloys indicated by the symbol: ▬ in low-velocity or poorly aerated water, and at shielded areas, may become active and exhibit a potential near -0.5 volts.

Galvanic – Insulated Design

- One solution is to insulate the anodic material from the cathodic material
- Difficult to maintain electrical insulation

Lifting Stresses

Often the Highest Design Stresses a Vertical Pump is Exposed to is During Lifting and Transportation

Shipping Fixtures

- Block Rotor to Prevent Movement

Dropped Circulating Water Pump

Circulating Water Pump With Broken Column

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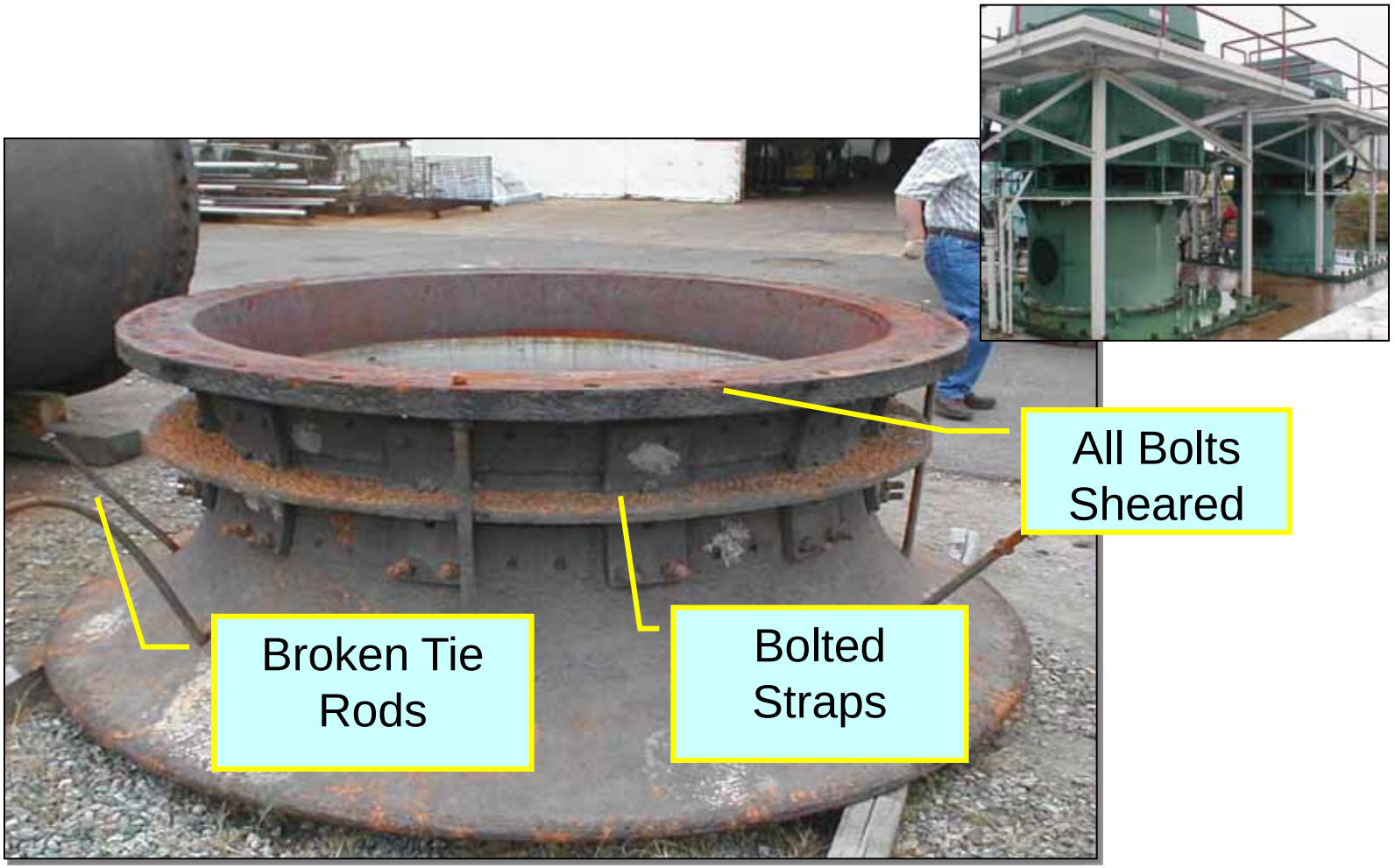
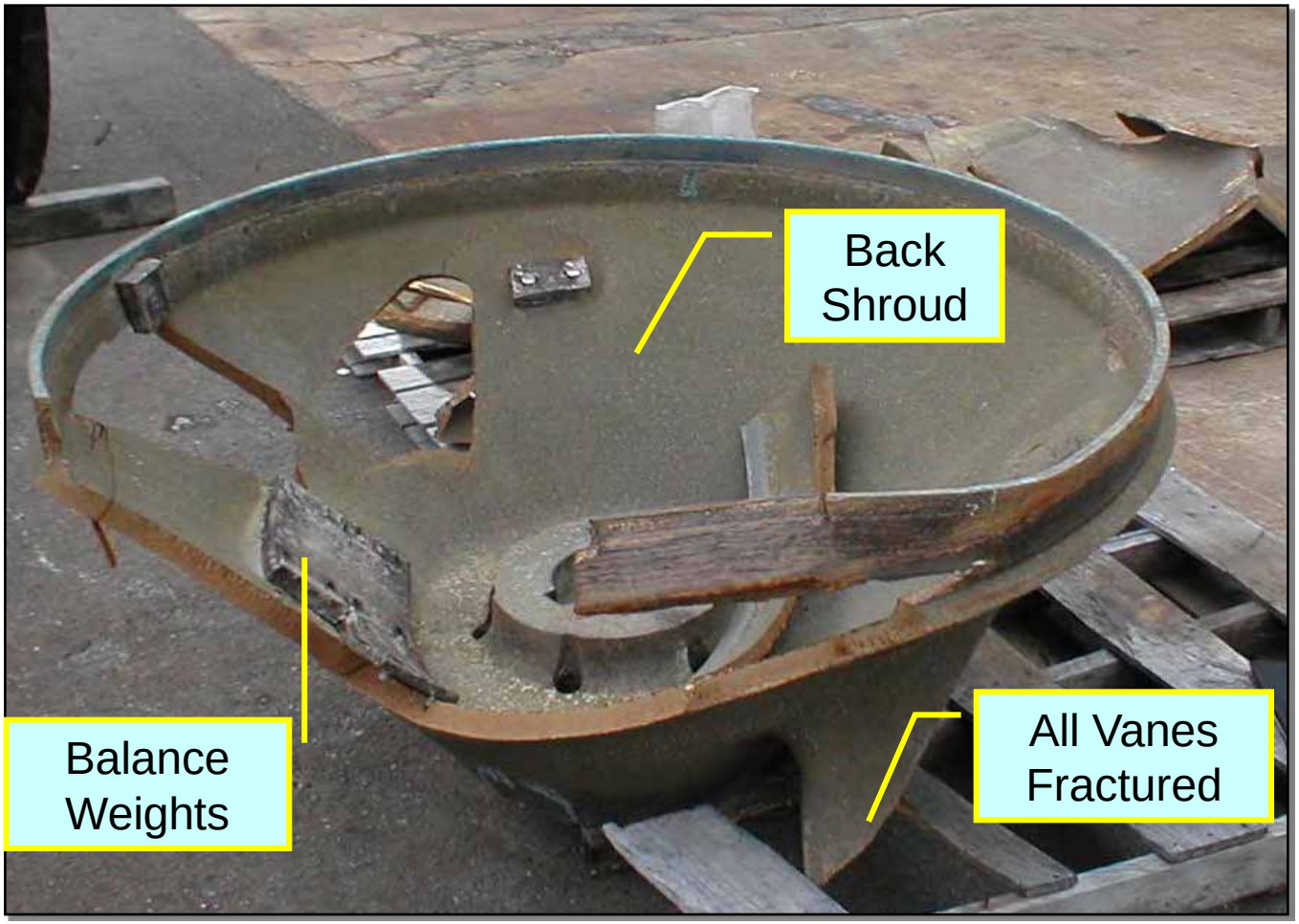
Impeller Inspection

- Proper blade shape to meet performance
- All blades equal to minimize hydraulic imbalance
- Proper profiling at inlets and exits

Case Example – Large Circulating Water Pump



Case Example – Large Circulating Water Pump



Reverse Engineering Large Impeller

Use the Faro Arm to obtain impeller vane geometry

Faro Arm

Portable Coordinate Measuring Machine

Measuring curved shroud profile

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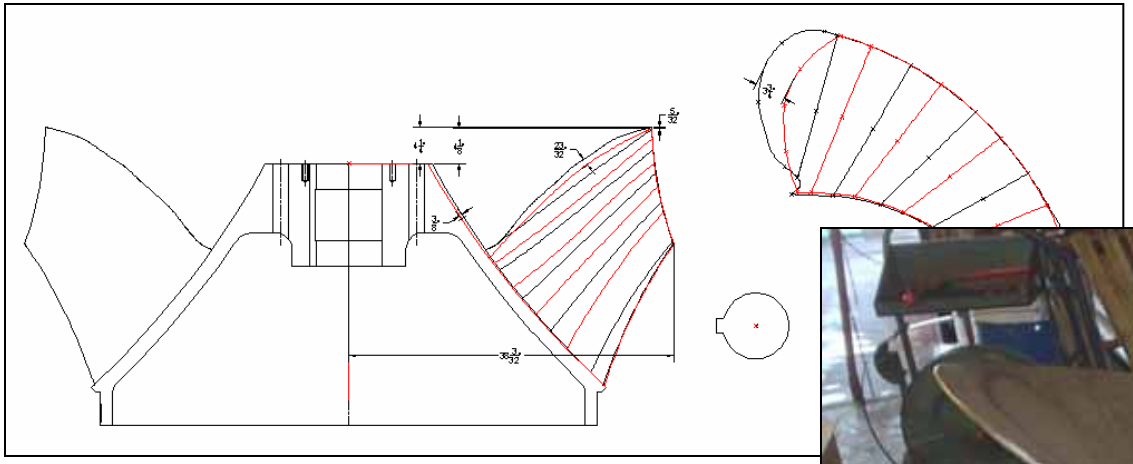
New Impeller in CF3M [316L] Stainless Steel



CAD Drawing Made from Faro Arm Data

One of Three Impellers Supplied

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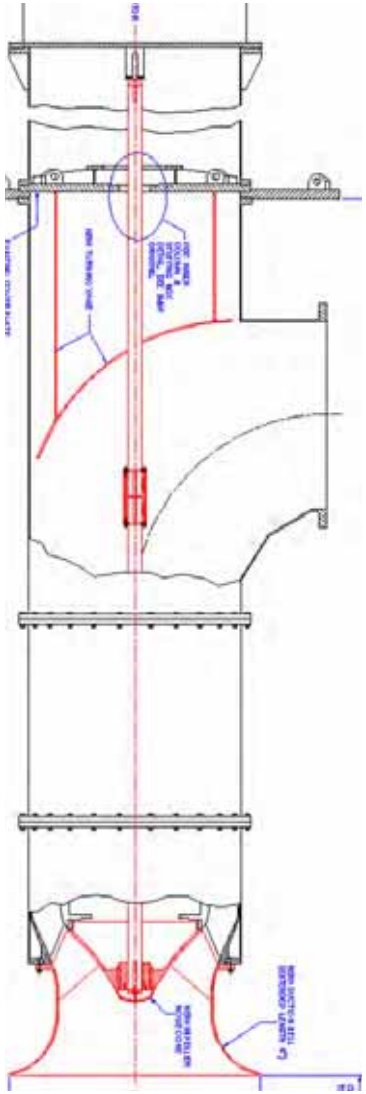
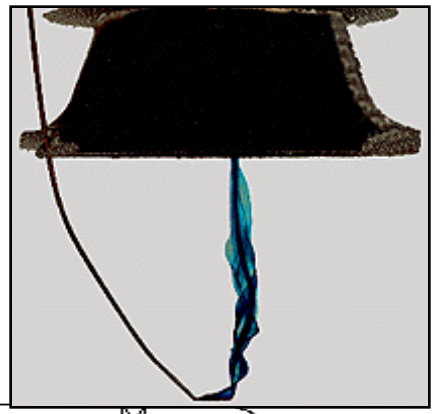
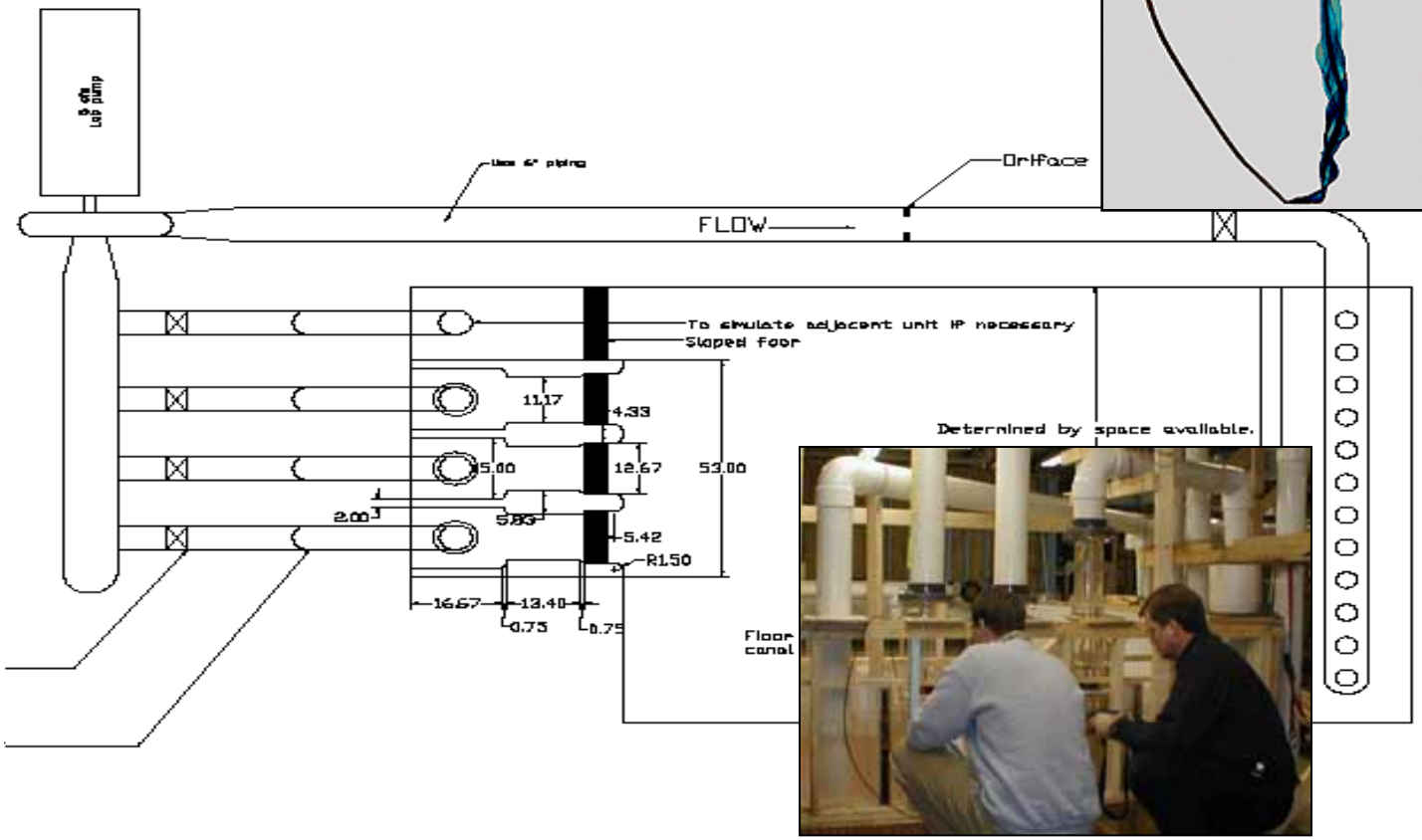
Case Example – Large Circulating Water Pump

- Increased Head – Capacity
- Upgraded shroud to stainless steel
- Unitized bell/shroud design
- Eliminated nose cone struts
- Added discharge head turning vane
- Restored concentricity and parallelism to components



Intake Model Test





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Vertical Pump Parts

- Provide *fabrications to replace most castings*
  - Lead time faster than castings – no pattern needed
  - Can upgrade materials [cast iron to stainless steel]
  - Cost less/equal than cast
- Can make *design improvements*
  - rerate hydraulic performance
  - solve design and metallurgy problems

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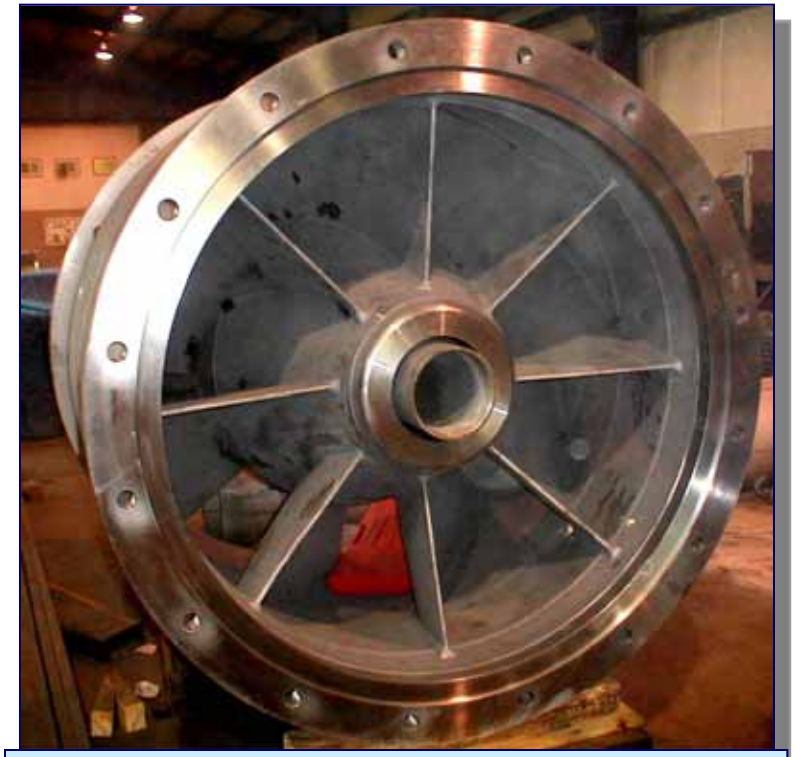
Fabrications to Replace Castings

Original Suction Bell in Cast Iron Showing Corrosion Damage in Seawater

New Suction Bell in Stainless Steel Being Fabricated

Fabrications to Replace Castings

Original Casing in Cast Iron was Severely Corroded



New Casing in Stainless Steel

Case Example – Large Circulating Water Pump

Cast Iron Diffusor with Erosion and Corrosion Damage

New 316L SS Fabricated Diffusor Being Machined

Fabrication Steps – 83” Diffusor in 316L SS

Inner Hubs

Outer Wrapper

Finished Diffusor

Case Example – Medium Circulating Water Pump

Casing Damage Repaired

New Stainless Steel Impeller