Case Study: “Improving and Sustaining the Reliability of Reactor Feed Water Pumps”

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PUMP PRESENTATION OUTLINE

1. Description of the Siemens Demag Delaval Feed Water Pump
2. Design Fundamentals of This Type of Pump
3. Mechanical Improvements
4. Instrumentation Improvements For Diagnostic Purposes
5. Operation Modifications To Improve Reliability
6. Conclusions

SIEMENS

1. Description of the Siemens Demag Delaval Feed Water Pump

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SINGLE STAGE NUCLEAR FEED WATER PUMP

Maine Yankee Atomic Power Company

Largest Nuclear Feed Pump Ever Built

24” Nozzles

28,000 GPM

14,763 HP

700 PSI SUCTION

1,800 PSI DISCHARGE

Driven By A Delaval Steam Turbine

NUCLEAR FEED PUMPS IN THE SHOP

Turbine Driven Reactor Feed Pump

DELAVAL REACTOR FEED PUMP 16,000 HP TURBINE WITH ITS REACTOR FEEDWATER PUMP MOUNTED ON A CONTINUOUS BEDPLATE - STEAM CONDITIONS - 90 PSIA/490°F PRIMARY - 883 PSIA/550°F SECONDARY PUMP CONDITIONS - 20,000 GPM @ 2460'TDH @ 5400 RPM.

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2. Design Fundamentals of This Type of Pump

SIEMENS DEMAG DELAVAL NUCLEAR FEED WATER PUMP

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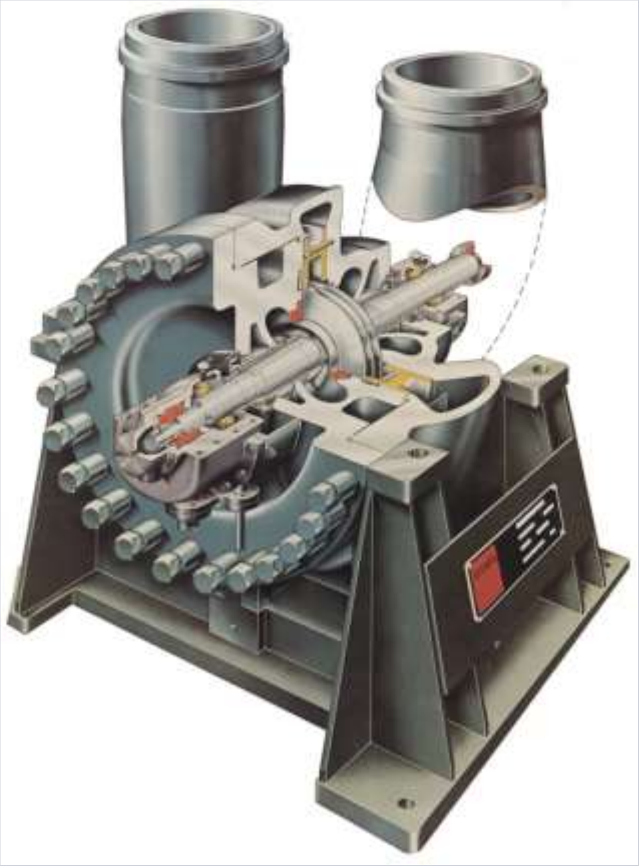

Assembly Drawing of a Reactor Feed-Pump

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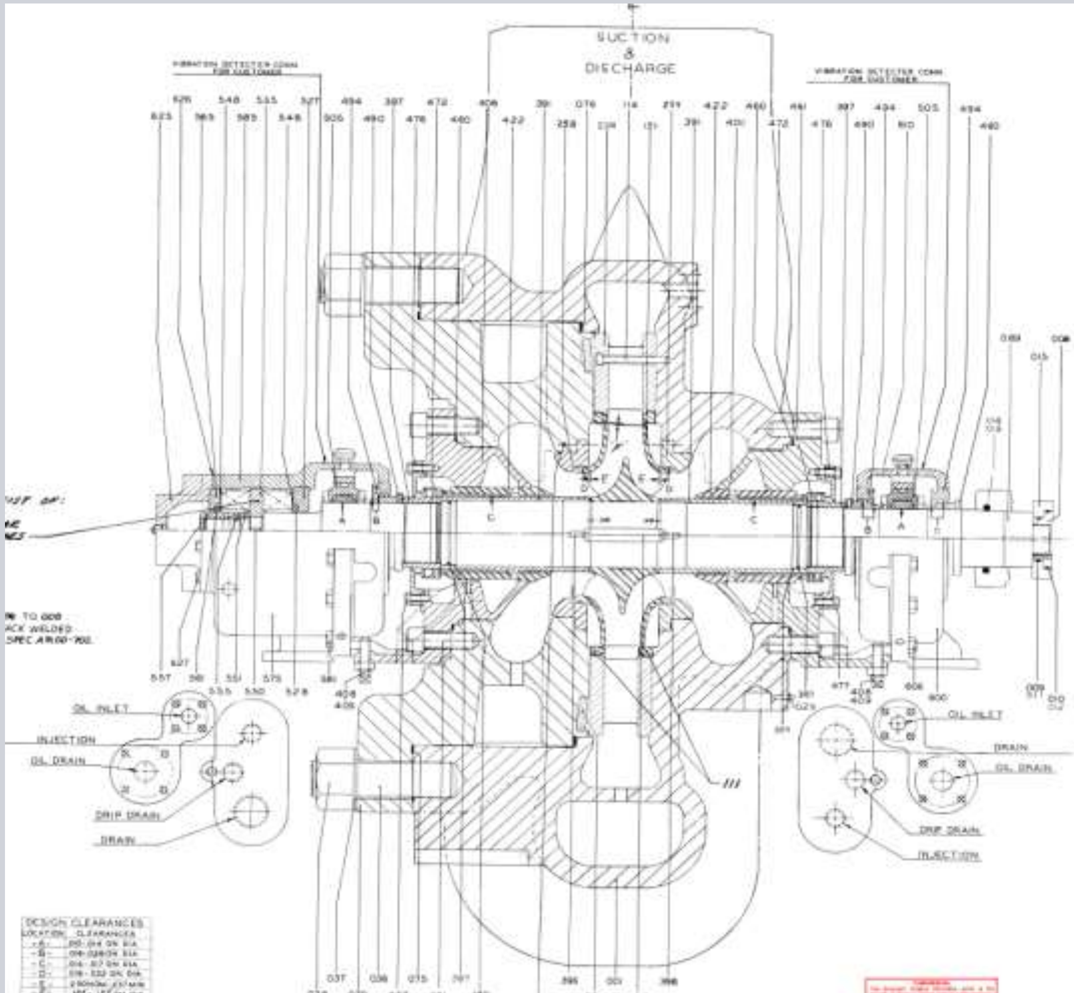


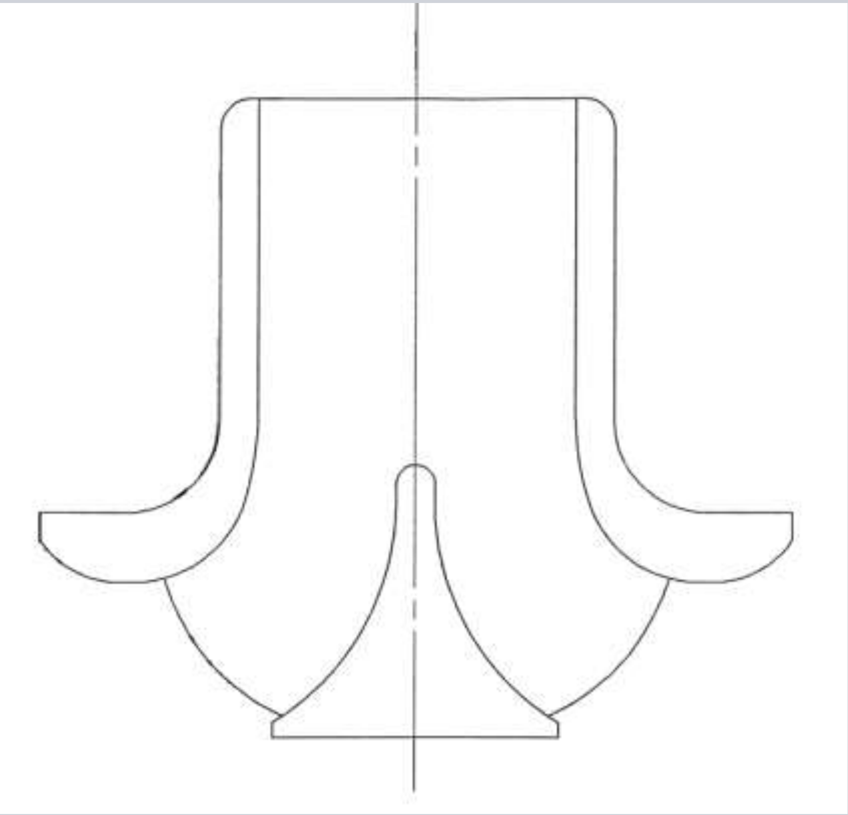
DOUBLE SUCTION

NORMALLY REFERS TO THE DESIGN OF IMPELLER INLET

THE IMPELLER HAS TWO (DOUBLE) INLET EYE AREAS

½ OF THE TOTAL PUMP INLET FLOW ENTERS EACH SIDE OF THE IMPELLER

PRIMARILY USED ON SINGLE STAGE PUMPS



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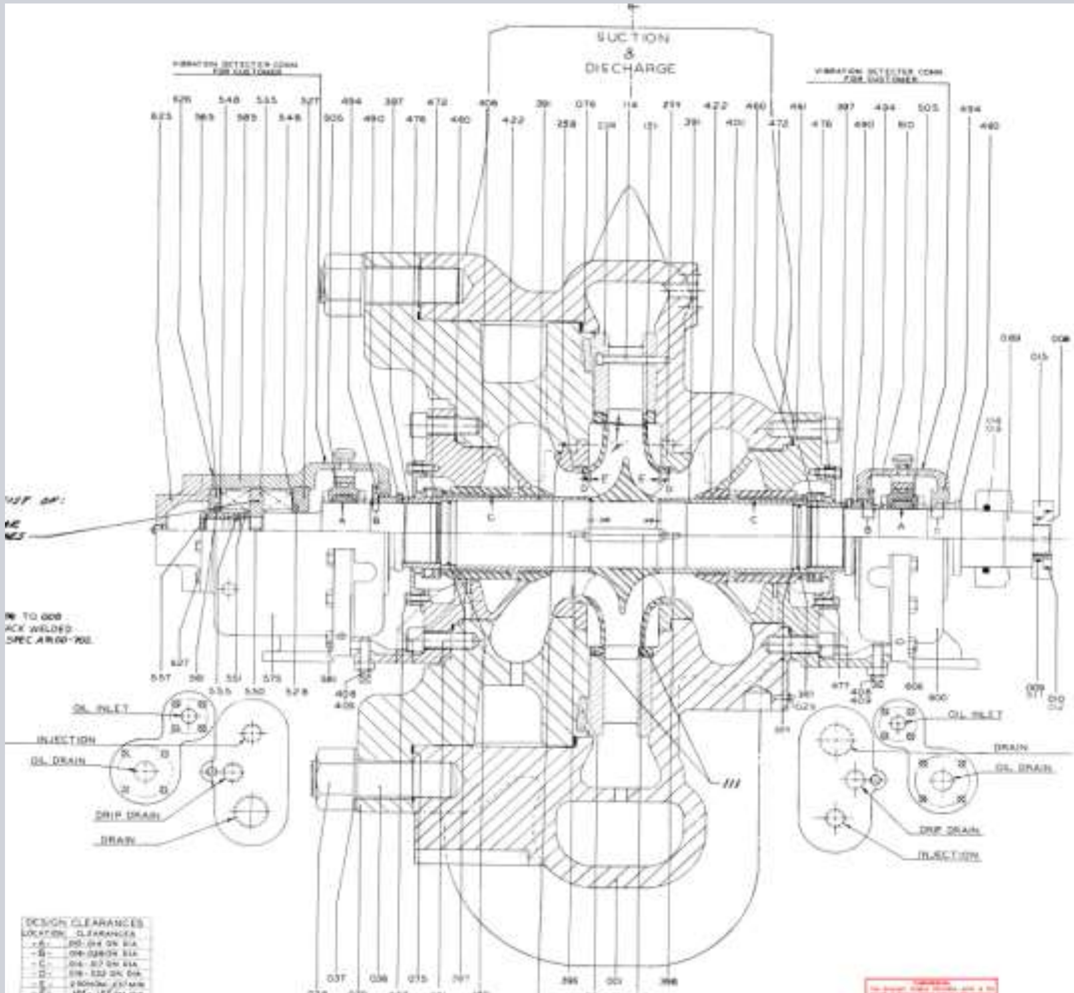
A Nuclear Feed Pump Rotor Assembly

3. Mechanical Improvements

3. Mechanical Improvements

Assembly Drawing of a Reactor Feed-Pump



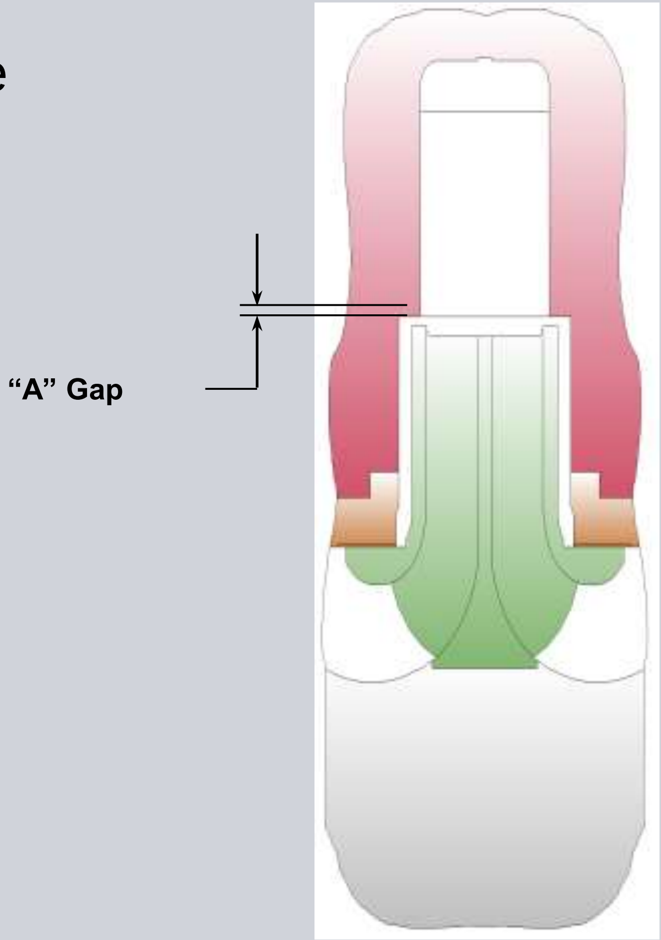
HISTORY OF “A” GAPS

“A” Gap

First used in nuclear feed water pumps.
Single stage, double suction impeller design.

HISTORY OF “A” GAPS

- Seals main flow from open space between impeller sideplates and stationary walls.
- Filters unstable hydraulic pressure pulsation.
- Reduces onset of axial shaft shuttling to lower flows on single stage, double suction impeller type pumps.
- Delaval received an patent for the "A" Gap.



SUPERBOLTS ARE BEING USED MORE FREQUENTLY TO BOLT THE END HEAD TO THE PUMP CASE

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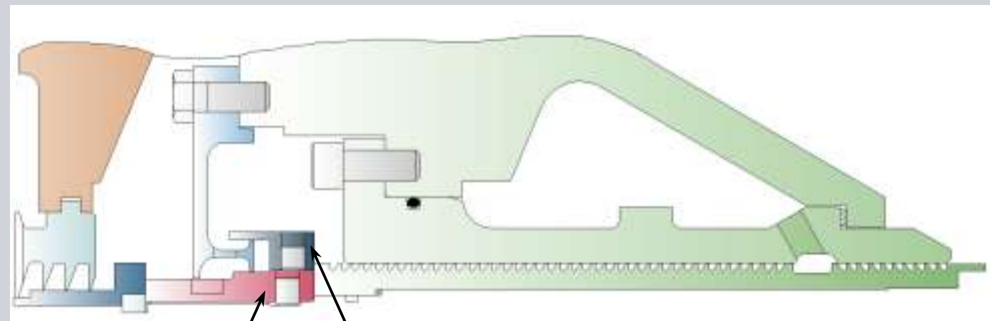
Monolithic Checknut

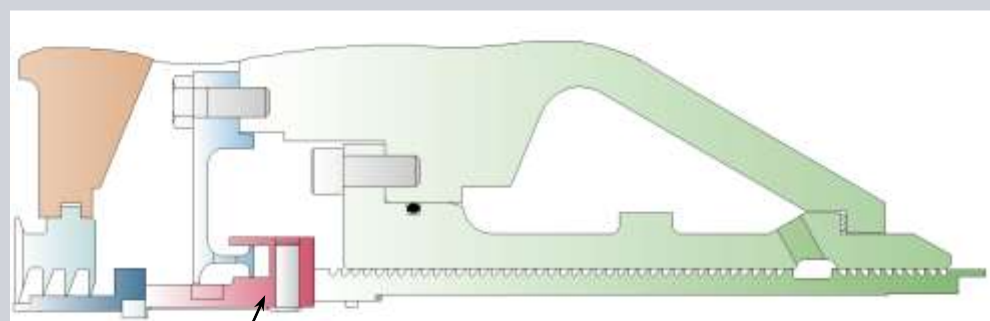
DEVELOPED AS A RESULT OF VIBRATION PROBLEMS

GUARD (270) MIGHT BECOME LOOSE ON THE SLEEVE NUT (402) IF SET SCREWS ARE INSUFFICIENTLY TIGHTENED AND CAUSE VIBRATION PROBLEMS

NEW DESIGN COMBINES THE GUARD AND CHECKNUT INTO ONE PIECE

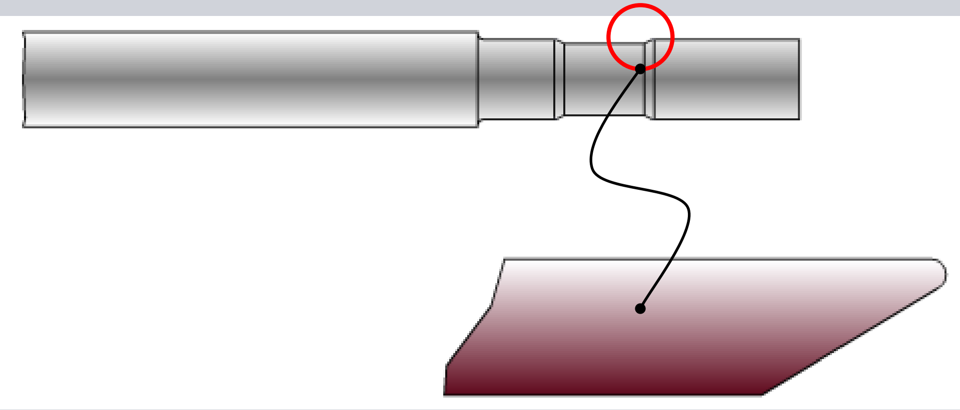
INSTALLS WITHOUT MACHINING OF THE MATING PARTS





Carbon Steel Overlays at Journal Bearing Areas

416 & 410 STAINLESS STEEL SHAFT MATERIAL
OVERLAY IS A CABON MOLY FILLER
WHY?
TO PREVENT “WIRE WOOLING”



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SHAFT PRE-MACHINED FOR WELD OVER-LAY

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What is Wire Wooling?

ABRASIVE-WEAR FAILURE
SHAFT MATERIAL REMOVAL BY MACHINING
WIRE SHAVINGS RESEMBLE STEEL WOOL
OCCURS ON 410 AND 416 STAINLESS STEELS IN THE PRESENCE OF CERTAIN CHLORIDE CONTAINING OILS
HARD PARTICLES FORM & DEPOSIT IN BEARING BABBIT
THESE PARTICLES CUT & SPIN SLIVERS OF SHAFT MATERIAL

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4. Instrumentation Improvements For Diagnostic Purposes

RADIAL VIBRATION MONITORING

Radial proximity probes

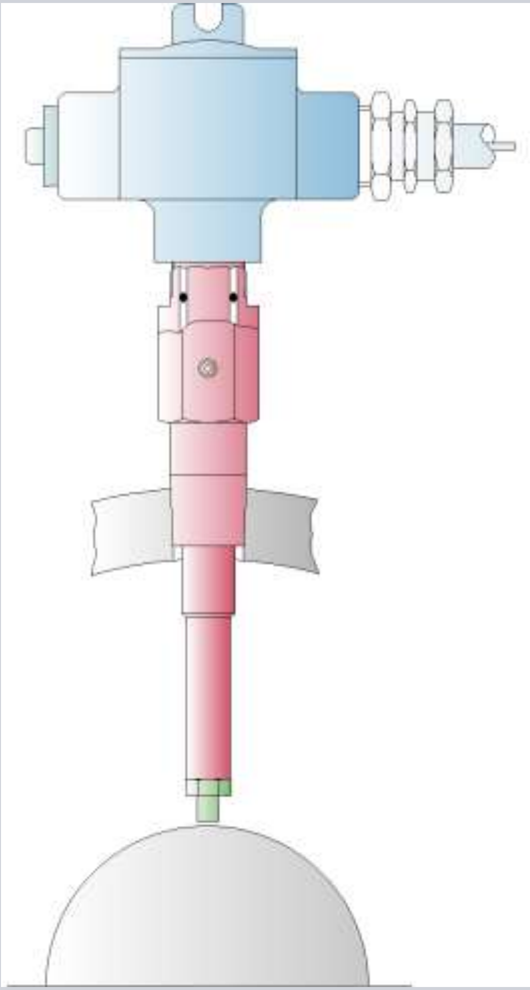
Two probes (90 degrees apart) near each radial bearing

Probes used in conjunction with a key phaser

Configuration provides

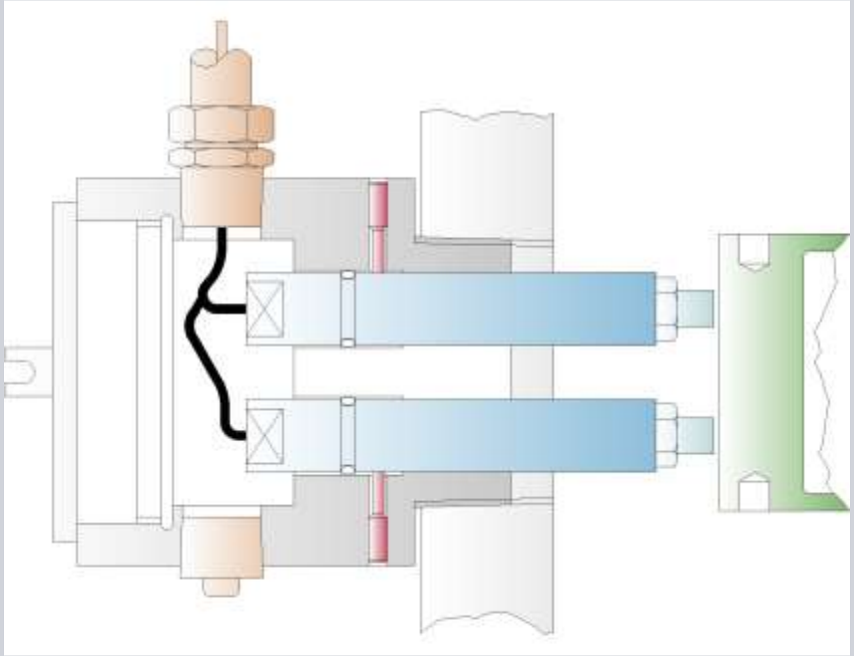
- Magnitude of shaft radial displacement
- Information to determine shaft orbit shapes

Magnitude and frequency of vibration are both important



AXIAL POSITION MONITORING

Used to determine stable operating
Particularly important for pumps with a hydraulic balance device having a radial variable orifice
"On-line" monitoring of axial position



- Monitor if axial wear occurs
- Determine and prevent
  - "Operating events" that affect wear

5. Operation Modifications To Improve Reliability

AN EXAMPLE of a REACTOR FEED WATER PUMP PERFORMNCE CURVE

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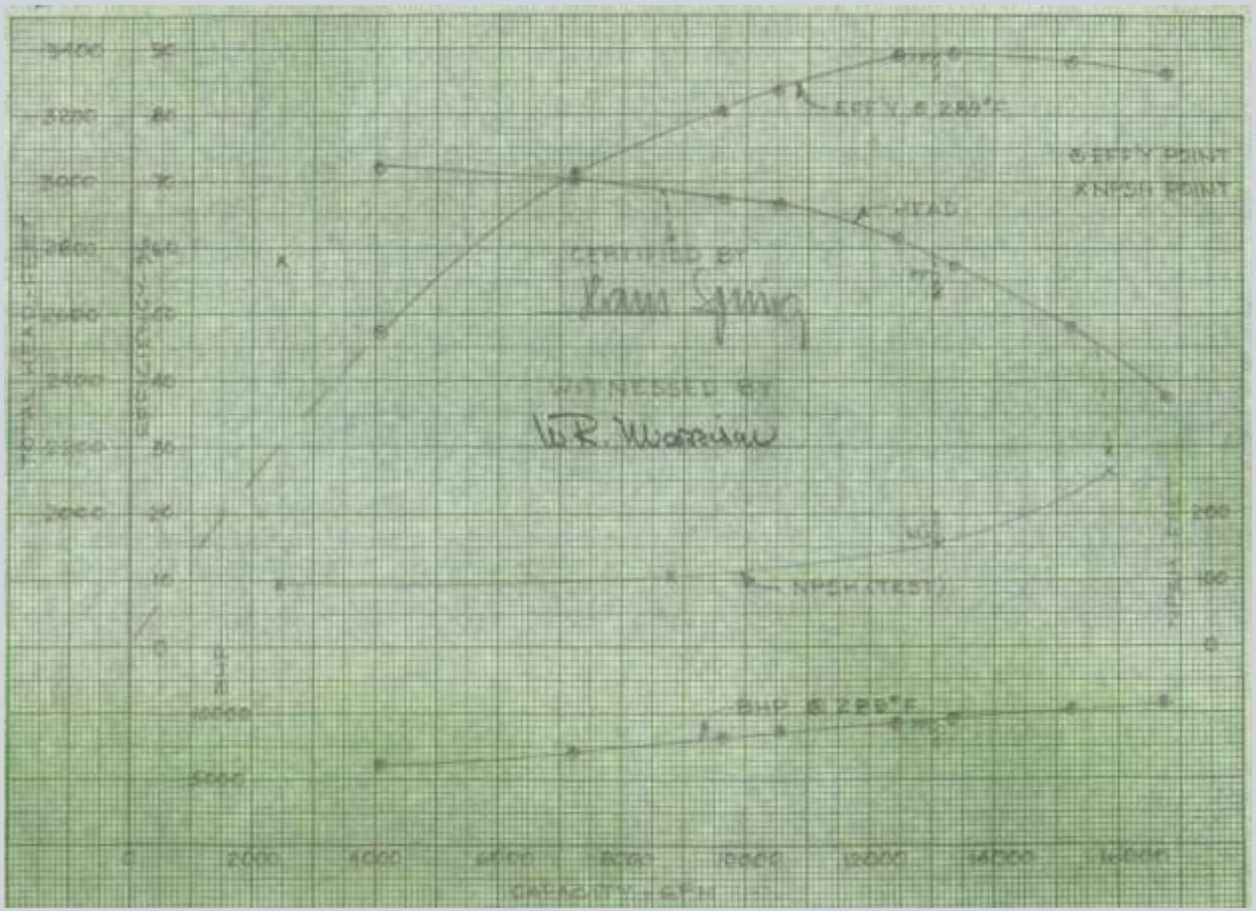
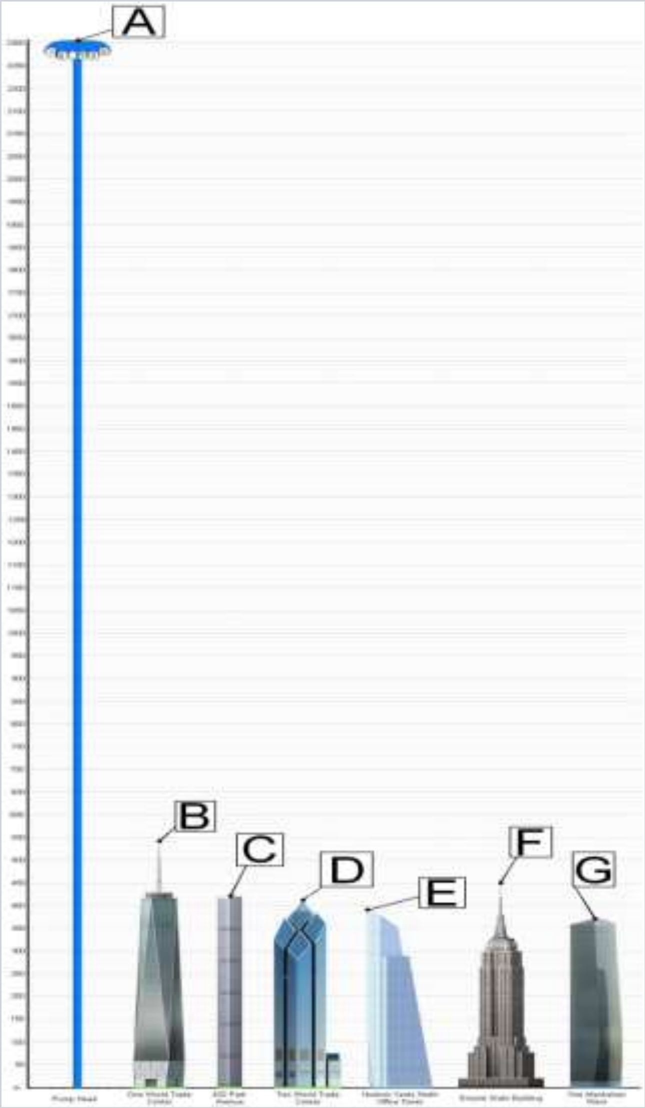


PUMP HEAD PRESSURE VS. NYC SKYLINE



A. *Pump Head Pressure*
~7570 ft (2307.3 m)

B. *One World Trade Center*
~1775.9 ft (541.3 m)

C. *432 Park Avenue*
~1378.9 ft (420.3 m)

D. *Two World Trade Center*
~1350.4 ft (411.6 m)

E. *Hudson Yards North Office Tower*
~1292 ft (393.8 m)

F. *Empire State Building*
~1454.1 ft (443.2 m)

G. *One Manhattan West*
~1215.9 ft (370.6 m)

SUCTION AND DISCHARGE RECIRCULATION AFFECTS THE HEAD CAPACITY CURVE

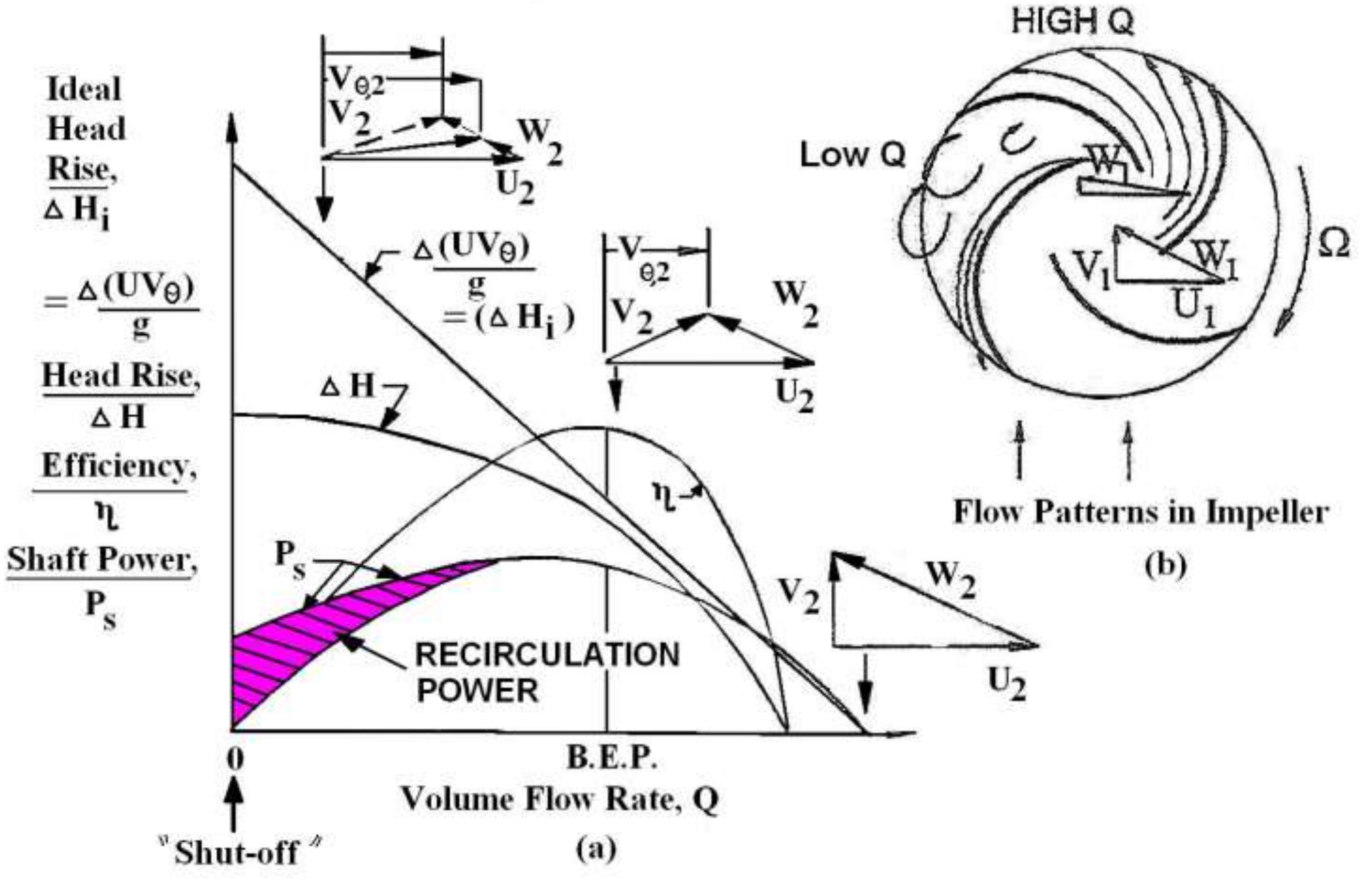


Figure 6A and B Characteristic performance curves of a pump stage, related to velocity diagrams

Pump Handbook 4th Ed.

ARTIST REPRESENTATION OF SUCTION AND DISCHARGE RECIRCULATION.

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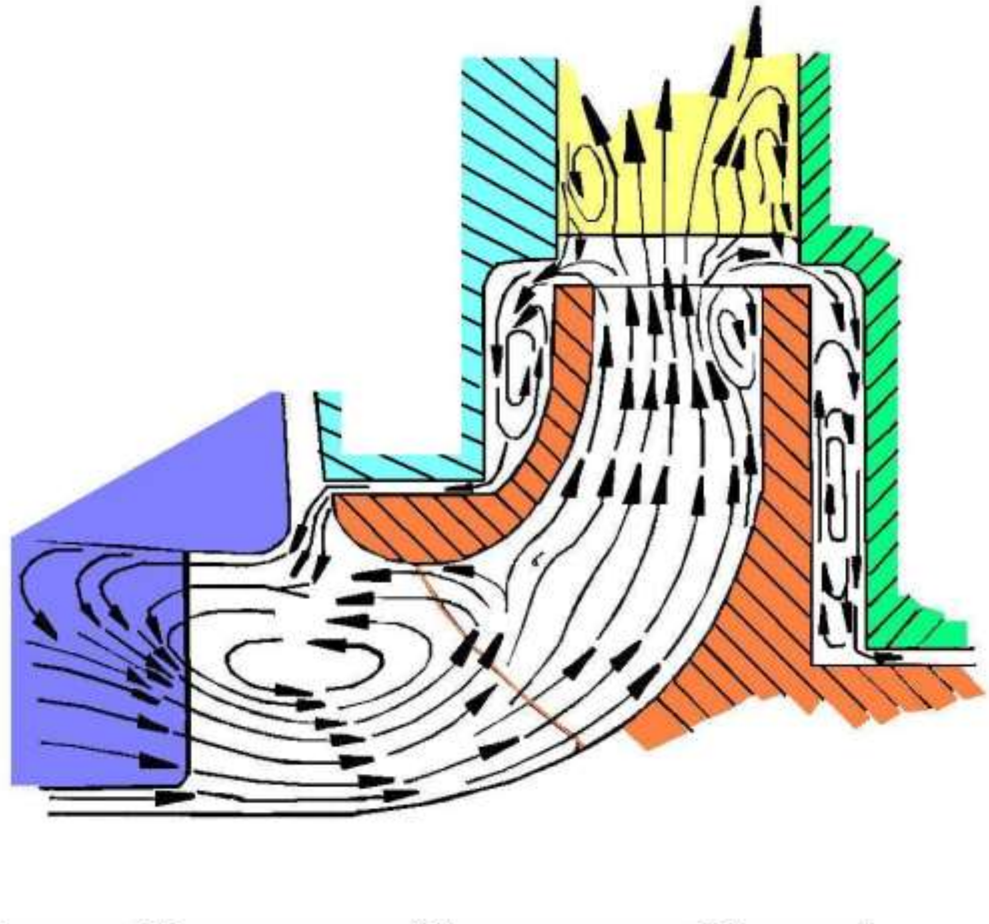
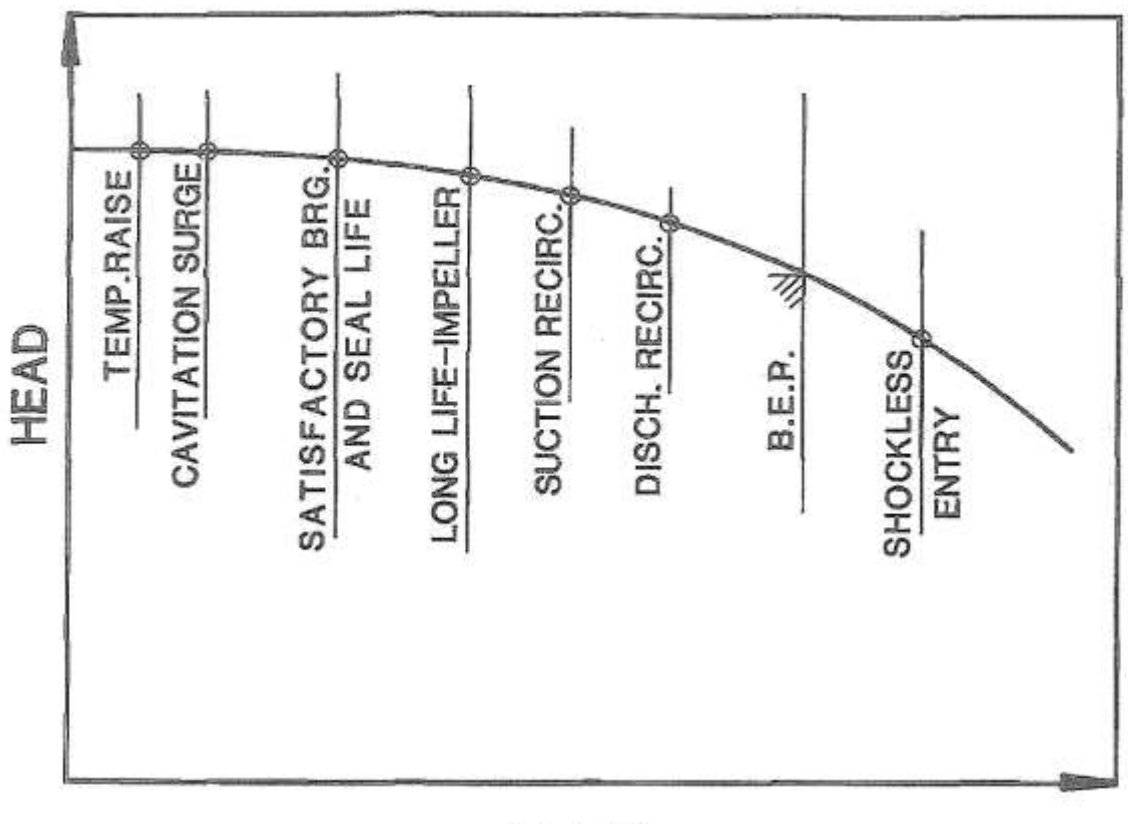


Recirculating Flow Pattern in the Meridional Plane of a Centrifugal Impeller.

Gopalakrishnan, S., "A New Method for Computing Minimum Flow", presented at 5th International Pump Users Symposium, (1988)

WHERE IS MINIMUM FLOW?



Typical Head-Flow Characteristic of a Centrifugal Pump Indicating Several Important Flow Rates.

Gopalakrishnan, S., "A New Method for Computing Minimum Flow", presented at 5th International Pump Users Symposium, (1988)

PERFORMANCE CURVE AREAS TO AVOID

Minimum flow that may cause potential issues.
Suction and discharge recirculation.
Resulting pump operation effects from recirculation flows, (pressure pulsations and vibration).

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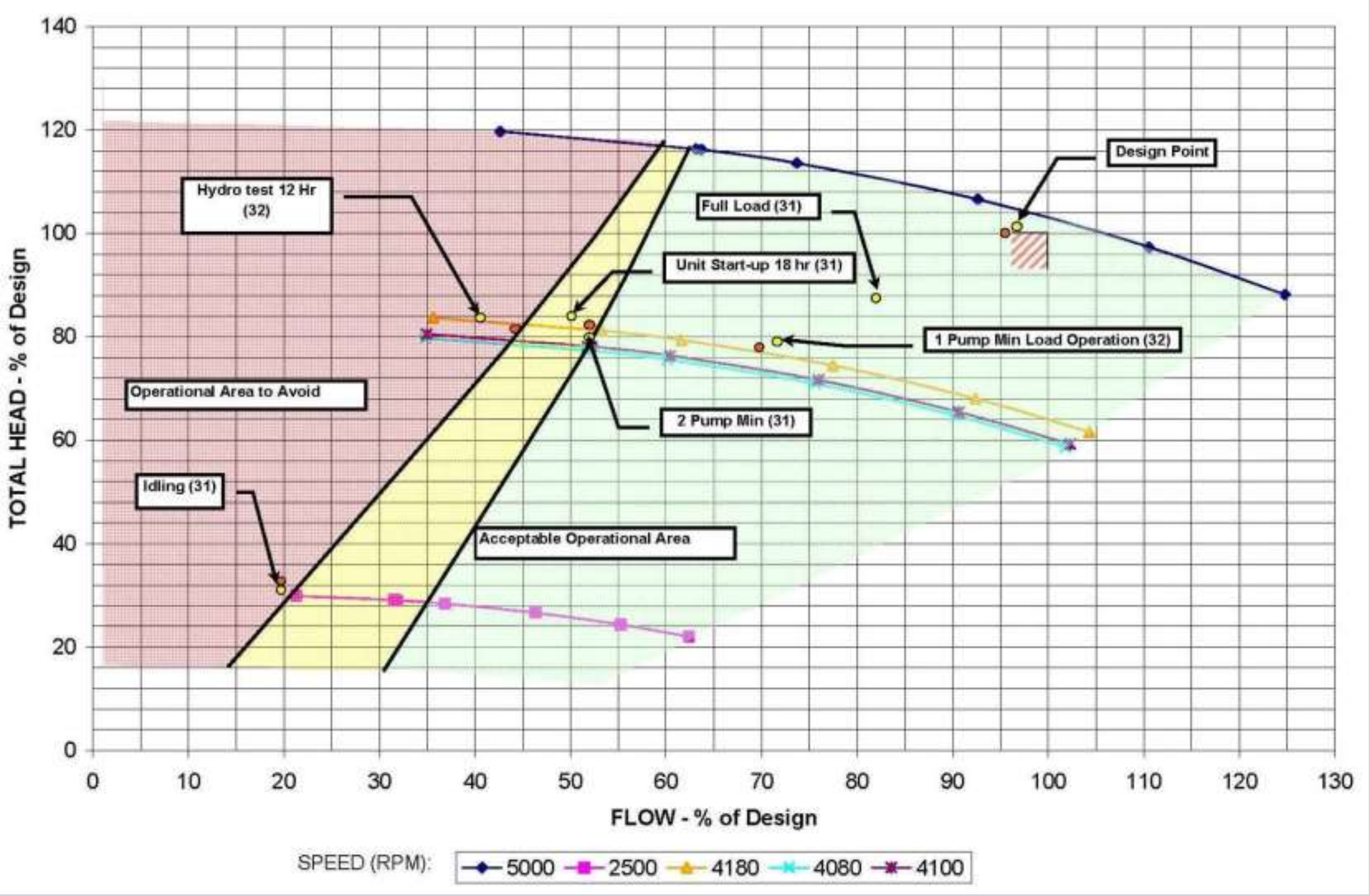
DEVELOPING THE “SWEET” ZONE



6. Conclusions

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6. CONCLUSIONS:

IMPROVING AND SUSTAINING RELIABILITY BY:

Applying Mechanical Improvements

Utilizing Instrumentation Improvements For Diagnostic Purposes

Applying Operation Modifications To Operate In a “Sweet Zone”.