

Case Study: “Preventing
Reactor Feed-water 1X
Vibration by the Addition
of Axial Clearance in the
Rotating Assembly”

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CASE STUDY PRESENTATION OUTLINE

- 1. Description of the Siemens Demag Delaval Feed Water Pump**
- 2. Design Fundamentals of This Type of Pump**
- 3. 1X Vibration**
- 4. Conventional Causes of 1X Vibration**
- 5. The Non-Conventional Root Cause of 1X Vibration**
- 6. Elimination of the Root Cause**
- 7. Conclusion**

1. DESCRIPTION OF THE SIEMENS DEMAG DELAVAL FEED WATER PUMP



1. Description of the Siemens Demag Delaval Feed Water Pump

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

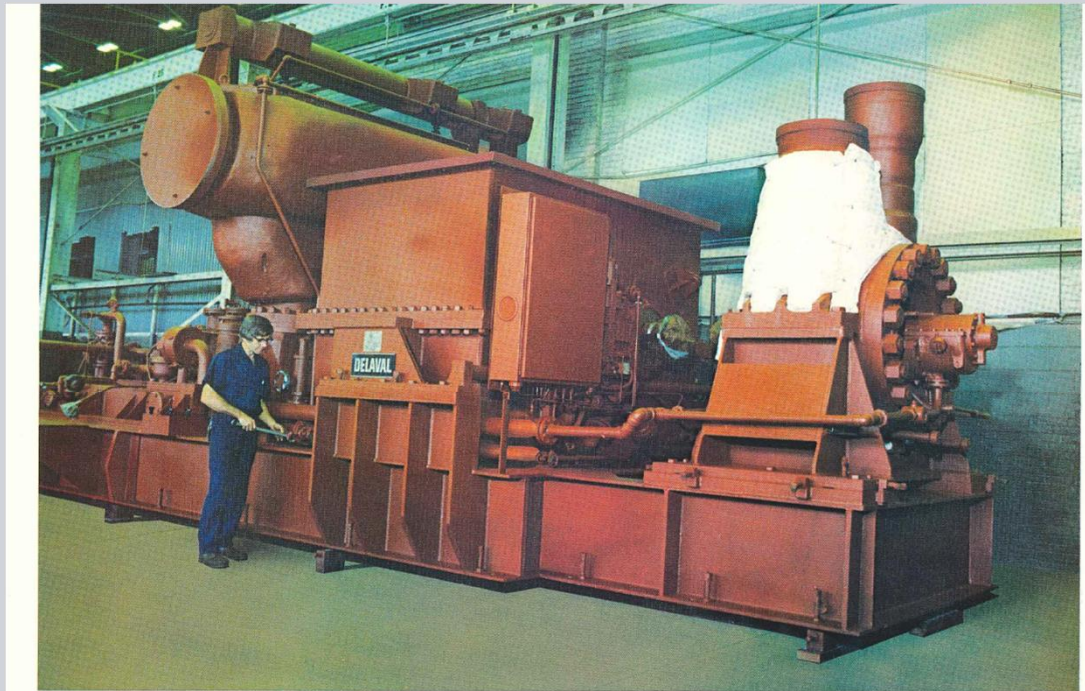
Driven By A Delaval Steam

Turbine

NUCLEAR FEED PUMPS IN THE SHOP



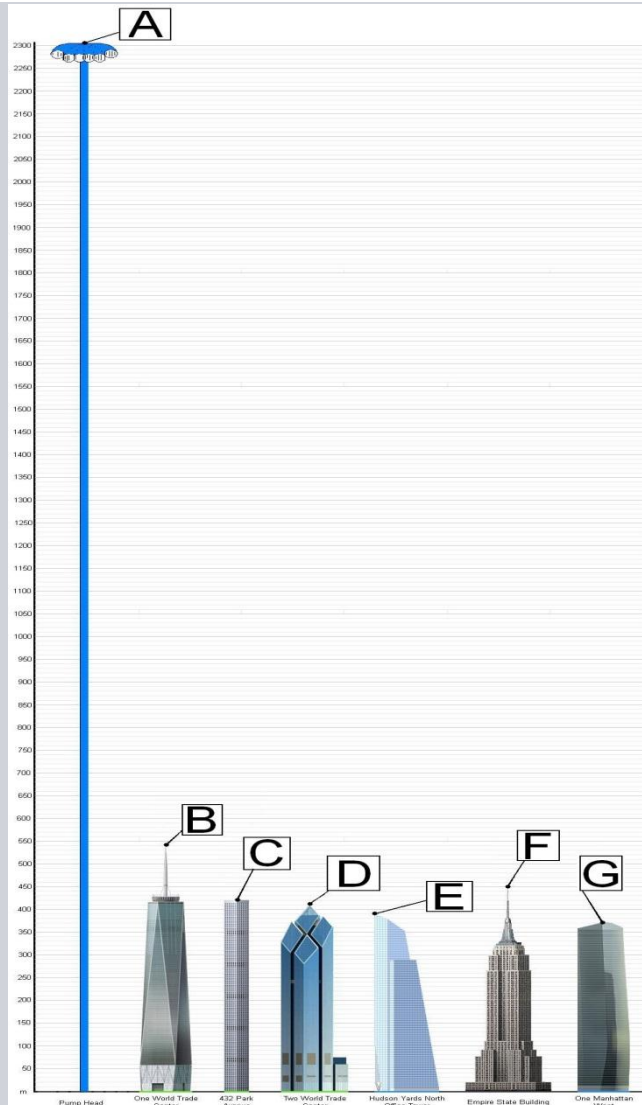
TURBINE DRIVEN REACTOR FEED PUMP



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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VISUALIZATION OF PUMP HEAD PRESSURE VS. NYC SKYLINE



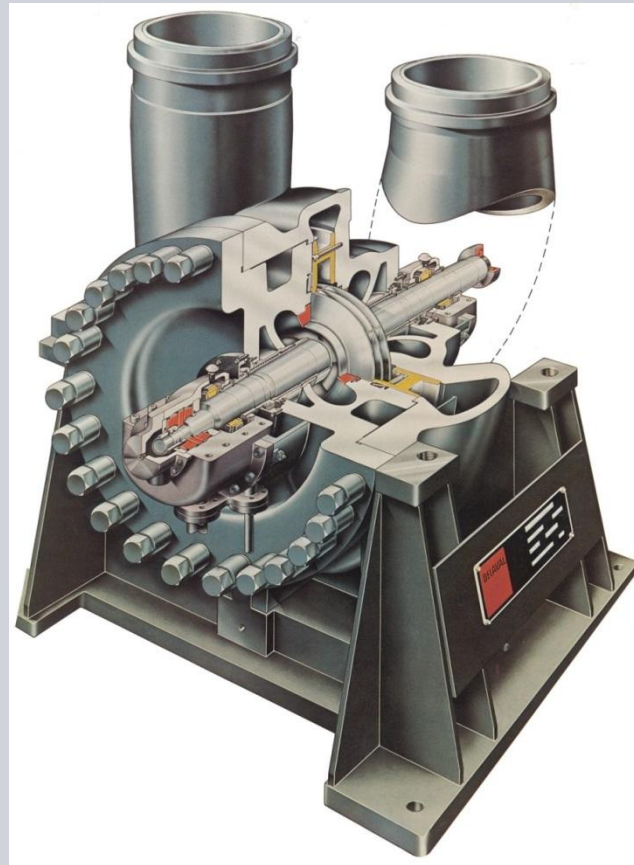
- A. *Pump Head Pressure*
~7570 ft (2307.3 m)
- B. *One World Trade Center*
~1775.9 ft (541.3 m)
- C. *432 Park Avenue*
~1378.9 ft (420.3 m)
- D. *Two World Trade Center*
~1350.4 ft (411.6 m)
- E. *Hudson Yards North Office Tower*
~1292 ft (393.8 m)
- F. *Empire State Building*
~1454.1 ft (443.2 m)
- G. *One Manhattan West*
~1215.9 ft (370.6 m)

2. DESIGN FUNDAMENTALS OF THIS TYPE of PUMP

2. Design Fundamentals of This Type of Pump

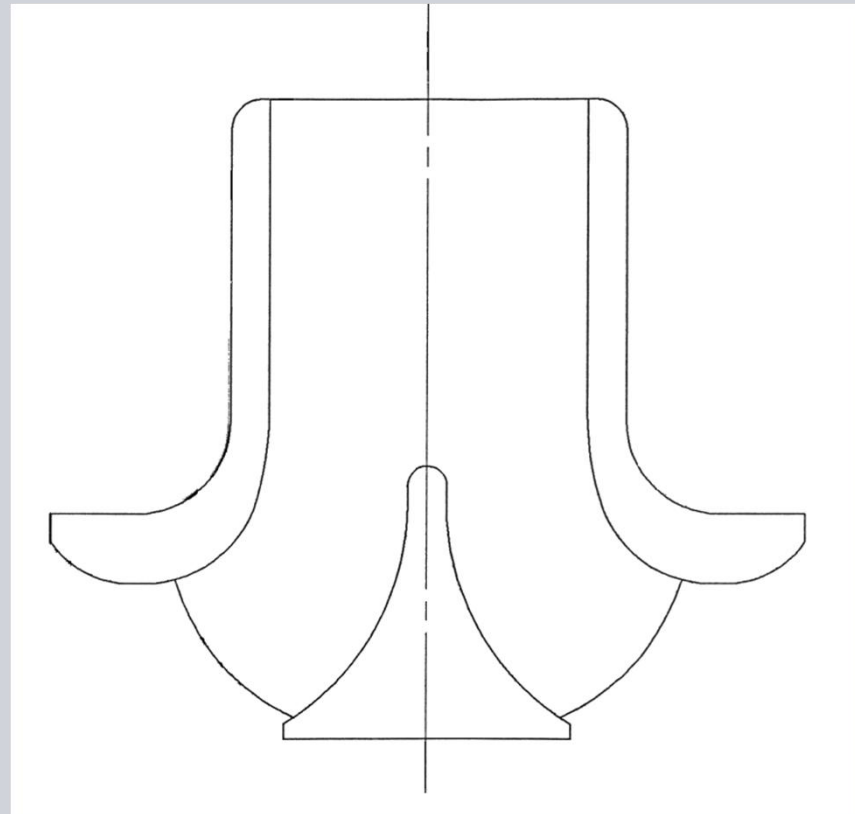
SIEMENS DEMAG DELAVAL NUCLEAR FEED WATER PUMP

SIEMENS

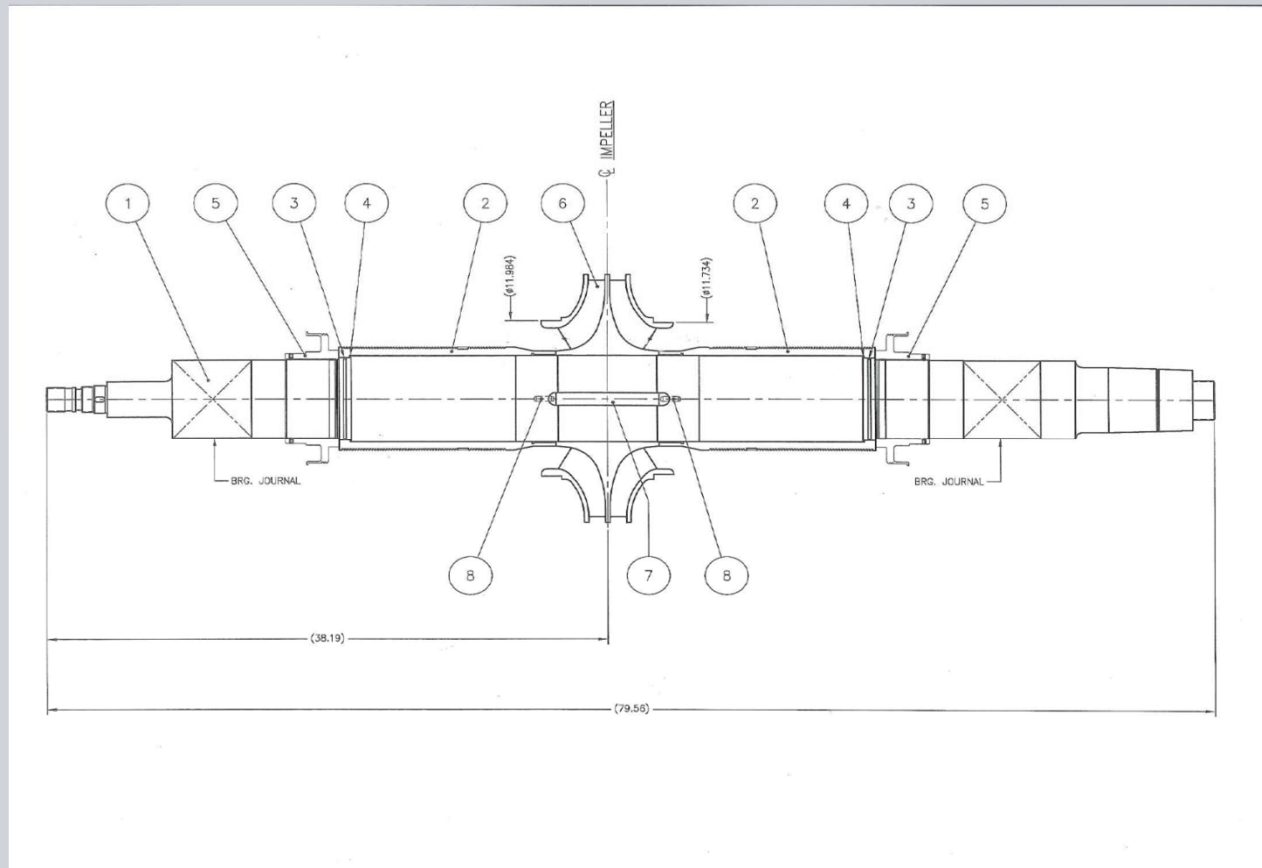


DOUBLE SUCTION

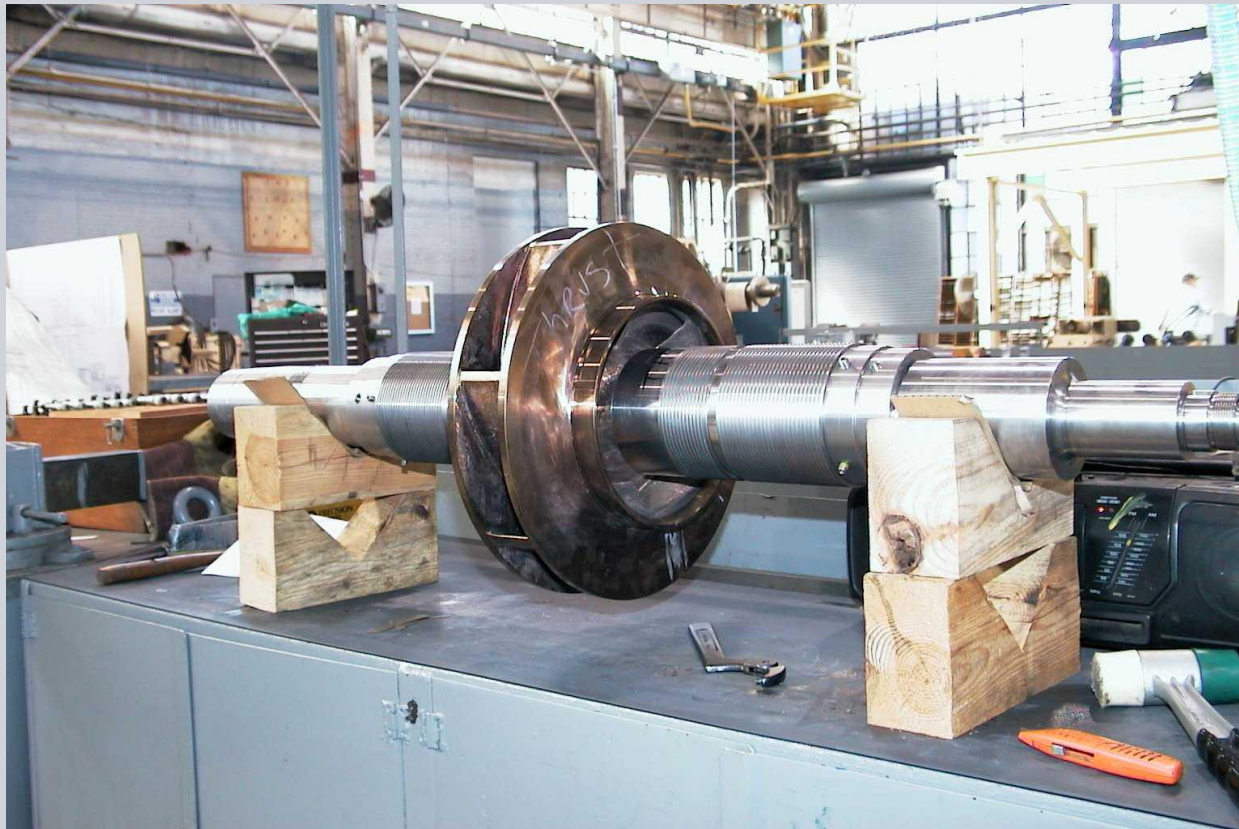
- NORMALLY REFERS TO THE DESIGN OF IMPELLER INLET
- THE IMPELLER HAS TWO (DOUBLE) INLET EYE AREAS
- $\frac{1}{2}$ OF THE TOTAL PUMP INLET FLOW ENTERS EACH SIDE OF THE IMPELLER
- PRIMARILY USED ON SINGLE STAGE PUMPS



ORIGINAL ROTOR ASSEMBLY



A NUCLEAR FEED PUMP ROTOR ASSEMBLY



3. 1X VIBRATION

1X vibration is a vibration that has the frequency of running speed.

This type of vibration was observed on the running reactor feed water pump when run at operating temperature and design conditions.

4. CONVENTIONAL CAUSES OF 1X VIBRATION

- A. Imbalance in the rotating assembly.
- B. Coupling Unbalance.
- C. Driver rotor unbalance.
- D. Structural Resonance or Looseness.

5. THE NON-CONVENTIONAL ROOT CAUSE OF 1X VIBRATION

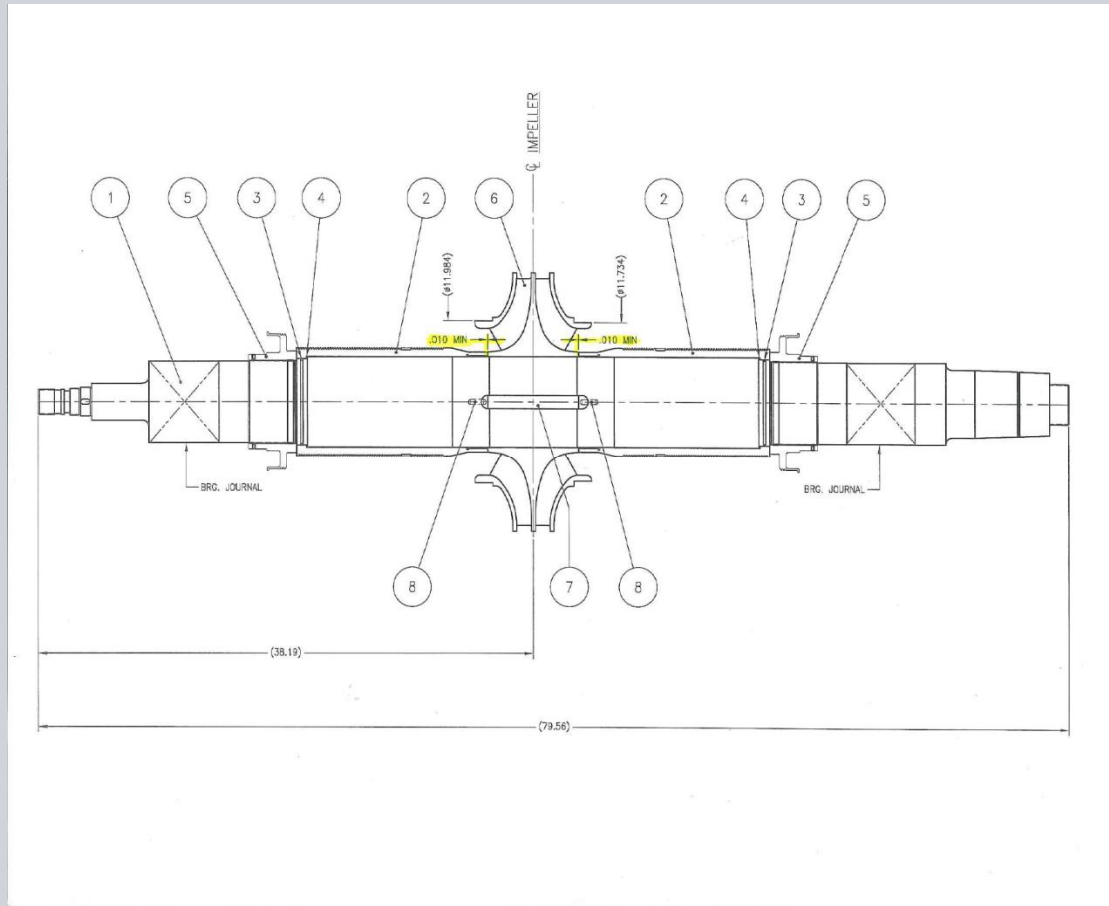


- a. Initiated a program to determine the “root cause”.
- b. First attempts were to investigate the conventional causes. All did not seem to be the cause initially.
- c. The major pump characteristic was determined to be the elevated temperature of the running pump.
- d. A hypothesis was developed that the differential thermal expansion between the sleeves and shaft could cause the rotor to bend (kink) to cause a 1X vibration.

6. ELIMINATION OF THE ROOT CAUSE

- e. An axial clearance was added between both shaft sleeves and the impeller to prove or disprove the hypothesis described in d. to eliminate the 1X vibration.
- f. After implementing the axial clearances as described in e., the 1X vibration was eliminated.

6. ELIMINATION OF THE ROOT CAUSE



7. CONCLUSION

The lack of the axial clearance between the shaft sleeves and impeller was determined to be the “root cause” of the 1X vibration. To eliminate this cause of 1X vibration, all reactor feed-water pumps were supplied with this axial clearance.