



# Hydraulic Upgrade of Hot Water Circulation Pumps in a District Heating System

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# Introduction - Particulars

## District heating circulation pumps (2 blocks):

- Single stage
- Double suction
- Between bearing
- Radial split casing  
(API 610 BB2)
- Side-side nozzles
- Variable speed  
(1000 – 1500 r/min)



# Introduction - Particulars

## Conditions of service:

- Pre-upgrade: 500 – 1500 m<sup>3</sup>/h @ 60 m
- Requested for upgrade: 720 – 2400 m<sup>3</sup>/h @ 80 m

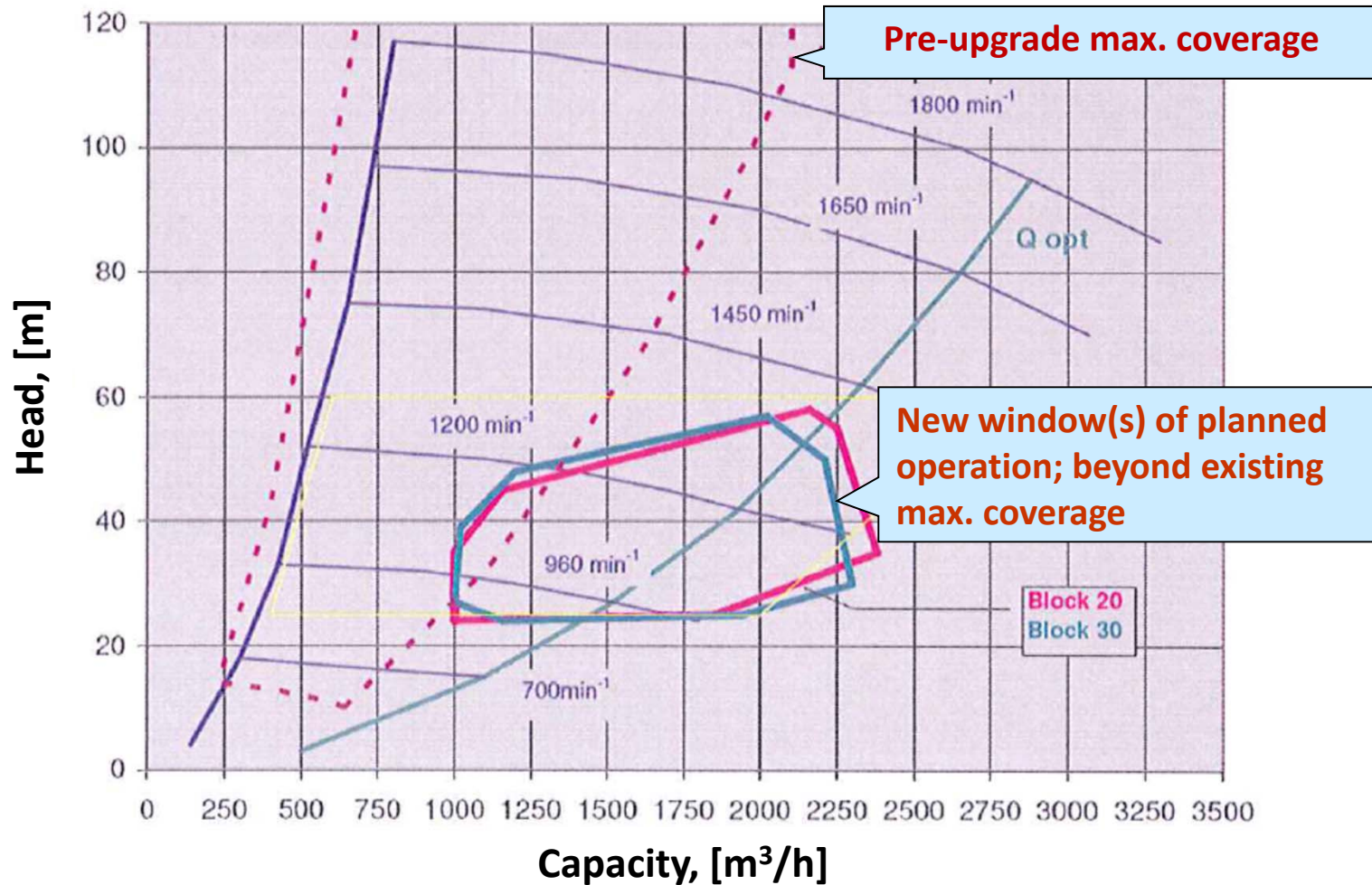


Normal duty: 1750 m<sup>3</sup>/h @ 35 m (1000 r/min)

Max. (design) duty: 2400 m<sup>3</sup>/h @ 80 m (1490 r/min)

- Fluid: Hot pressurized water (70 – 140 °C)
- Suction pressure: 6.9 – 11 bar

# Introduction - Particulars



# Introduction - Objective

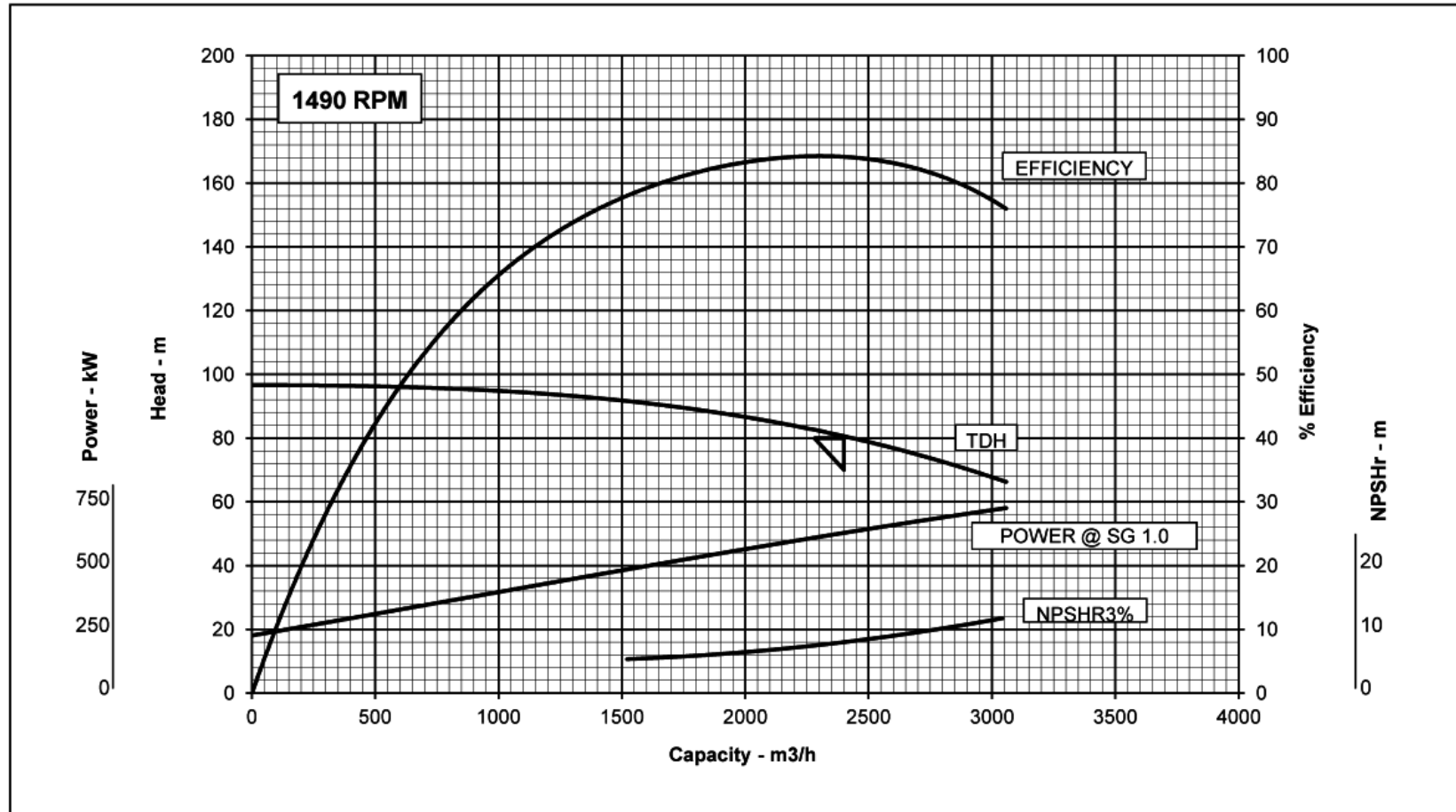
## Objective / Scope of supply:

1. Re-rate existing pumps with new hydraulic end, keeping existing shaft.
2. Replace existing DC speed controlled motors with VFD driven asynchronous motors
3. Replace existing conventional packing with mechanical seal

## Hydraulic Options:

- New impeller and new diffuser (→ First design iteration)
- vs.**
- New impeller and volute insert (→ Second design iteration)

# Introduction - Objective



**Proposal curve for the hydraulic upgrade (max. duty;  $N_{s,design} = 2350$ )**



# First Design

Existing pump

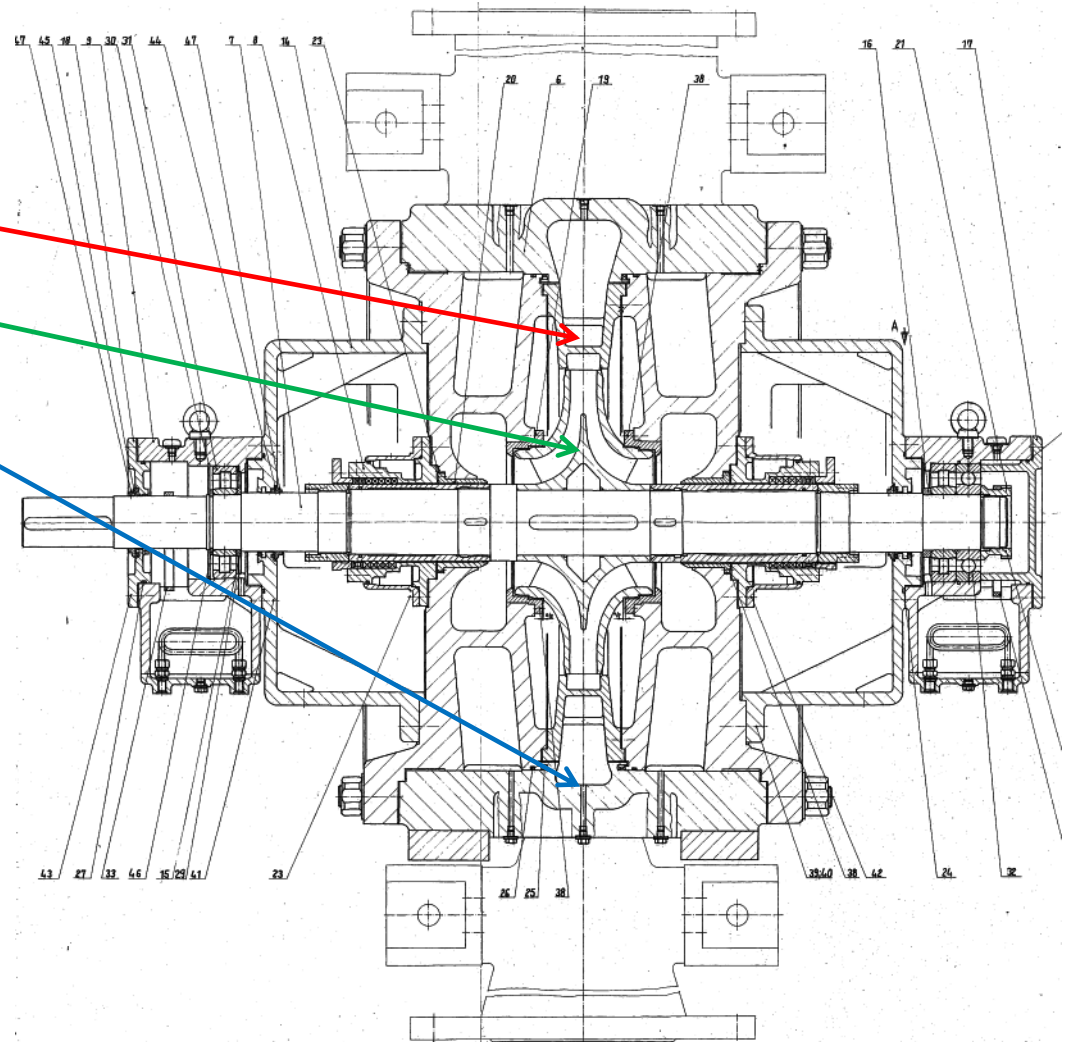
Impeller/diffuser

in

single volute casing



Existing diffuser (4 vanes)



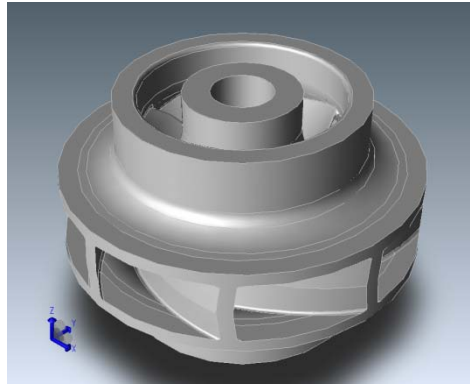


# First Design

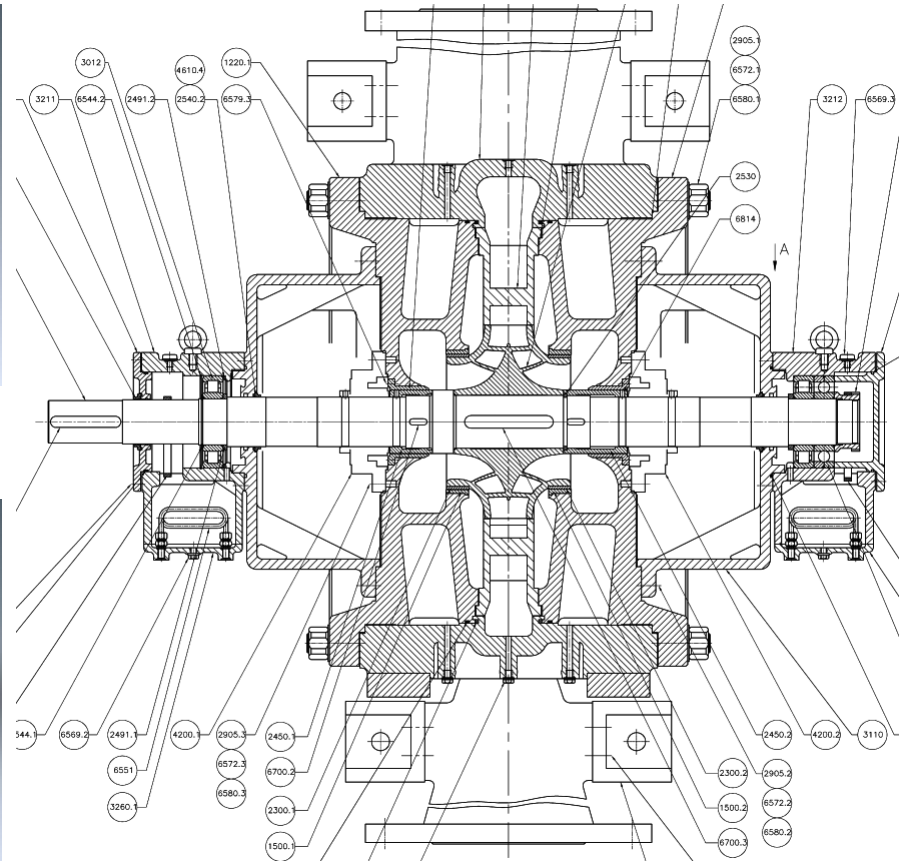
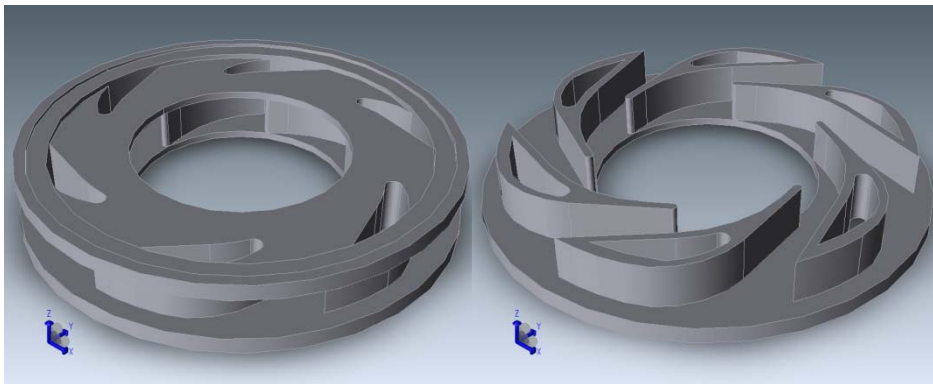
- New high capacity impeller

- 8 vanes

- $D_{2,max}$  21½”  
(546.1 mm)



- New diffuser (6 vanes)



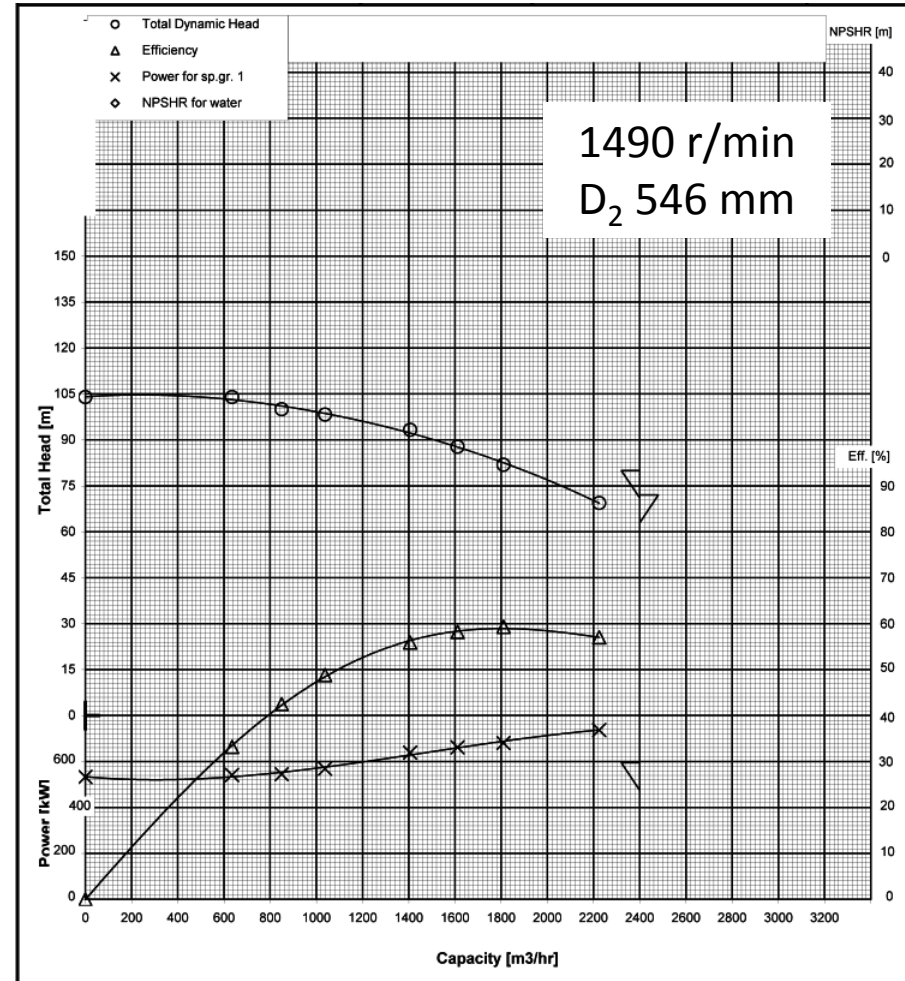
# First Design

## First Test Result:

- ❖ Failed to make the head
- ❖ Efficiency too low
- ❖ Power too high
- ❖ BEP at too low capacity

## Suspected Cause:

- Choking casing discharge (narrow throat passage)



# First Design

## Second Test Result:

(After opening up casing discharge throat area)

- Head picked-up
- Efficiency improved
- BEP shifted to higher capacity

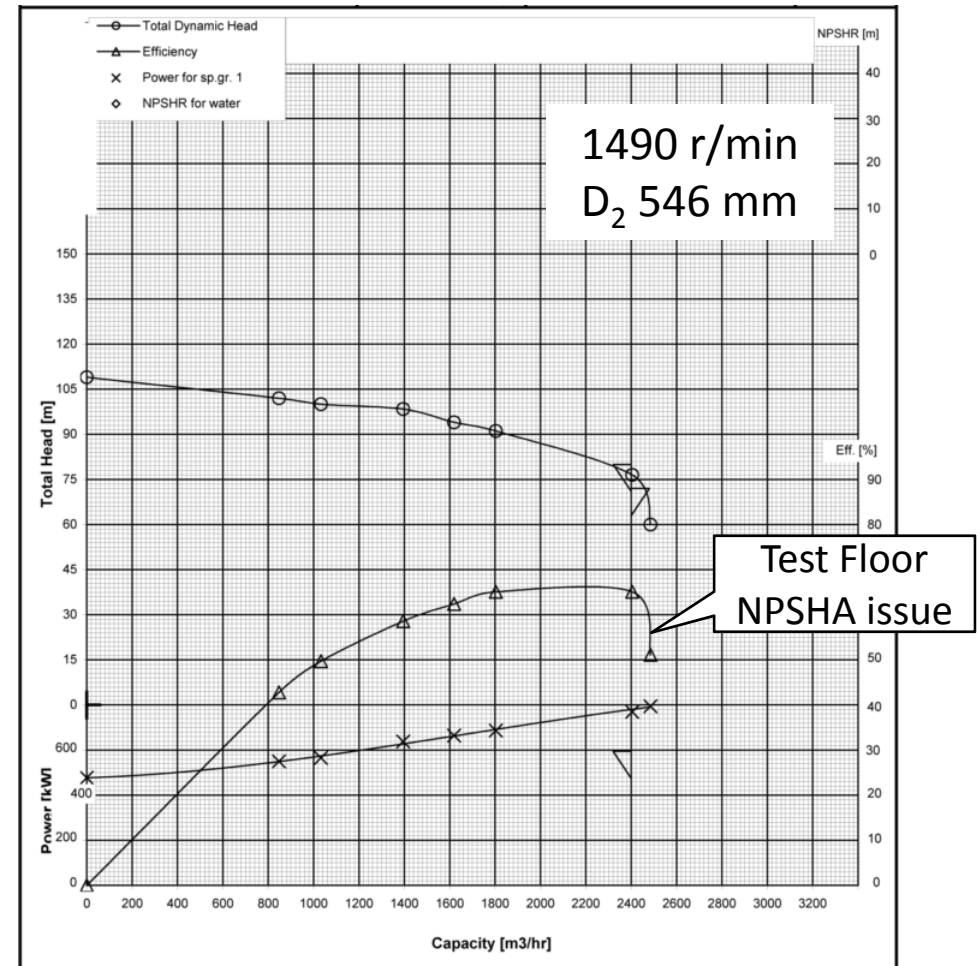
**BUT**, pump still not making expected performance

## Suspicion:

- Incorrect diffuser design?

## Remedy:

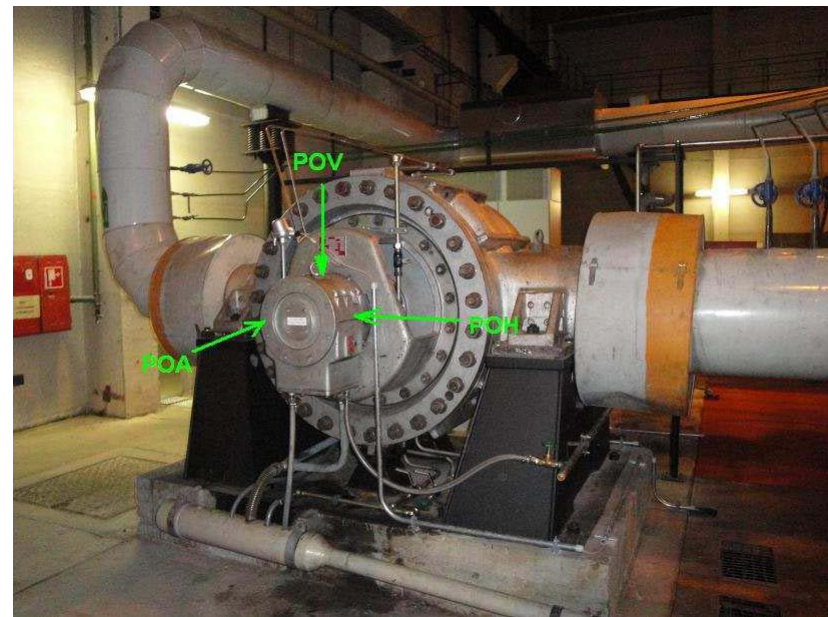
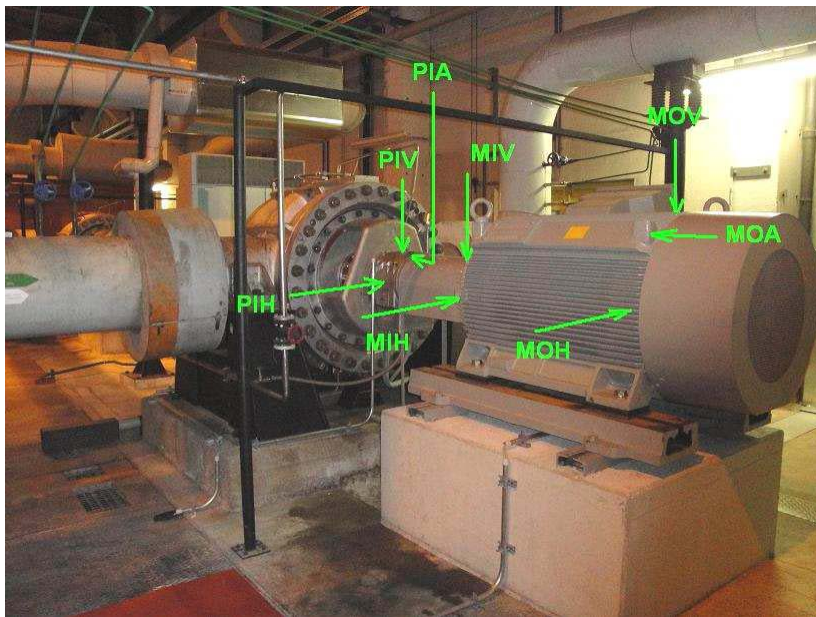
- Volute insert





# First Design

- While developing volute insert and manufacturing parts pump was shipped to site.
- At site an **8X vane pass vibration** issue @ PIH emerged when running **around 1200 r/min.**



**Vibration measurement locations**

# First Design

## Order Tracking

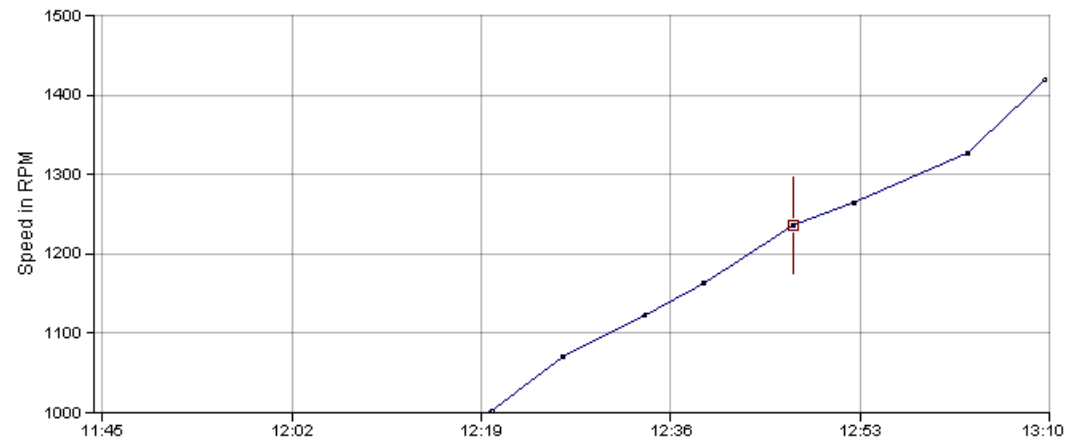
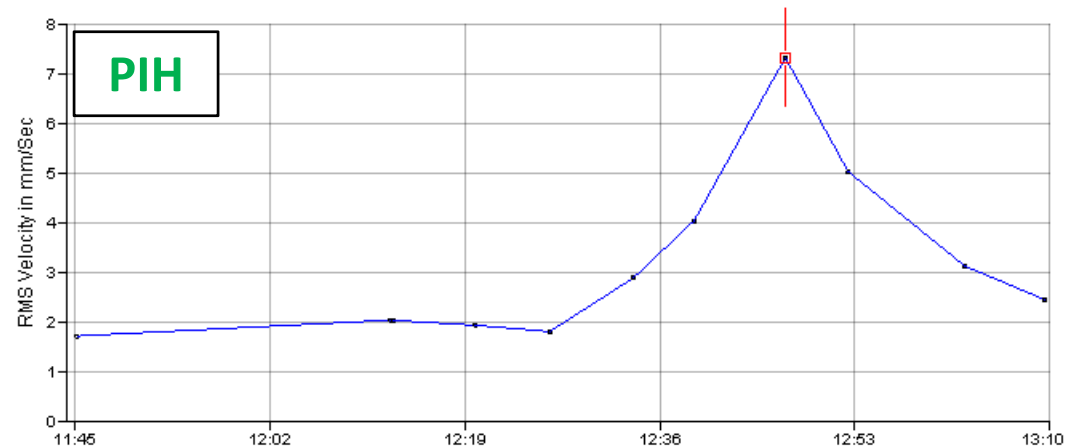
1000 – 1420 r/min



- **PIH: 7.3 mm/s**  
@1236 r/min  
(8X, or **165 Hz**)

## Bump Test:

- **169 Hz** natural  
(resonance)  
frequency (Hor.)



# First Design

## Elevated vibration levels due to:

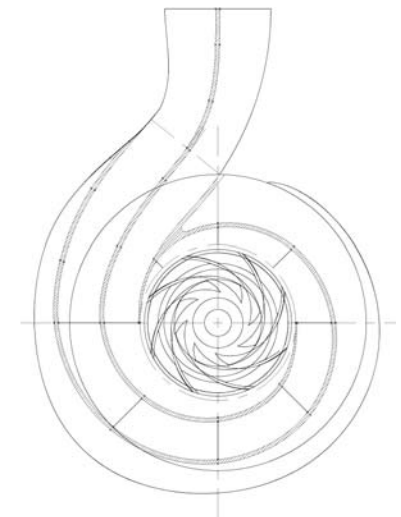
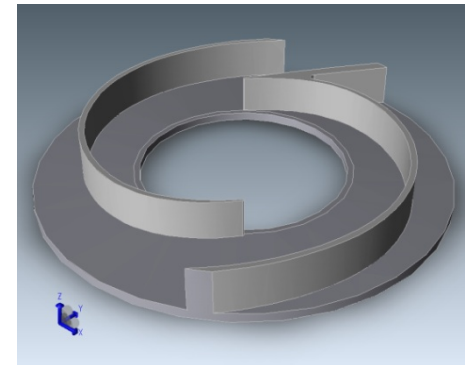
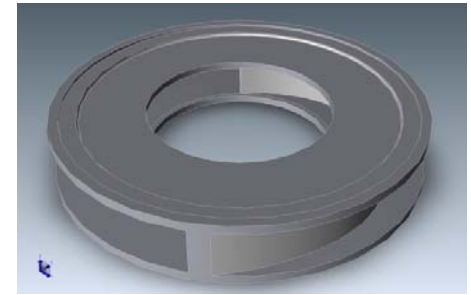
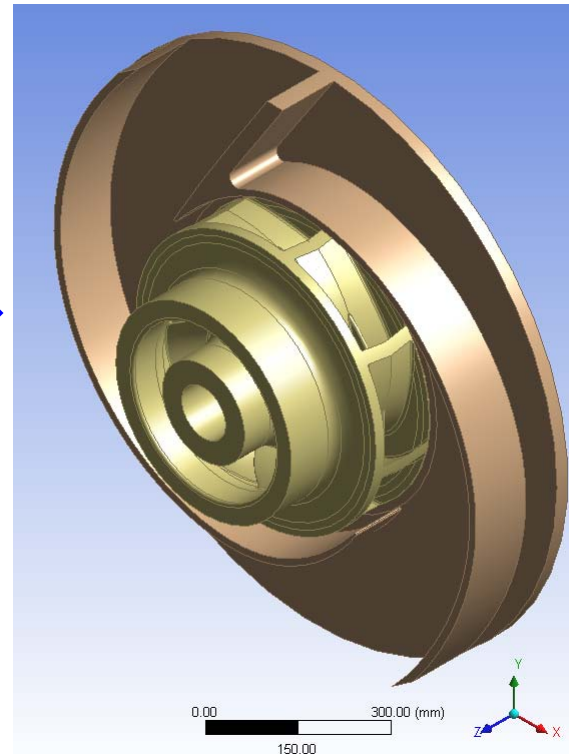
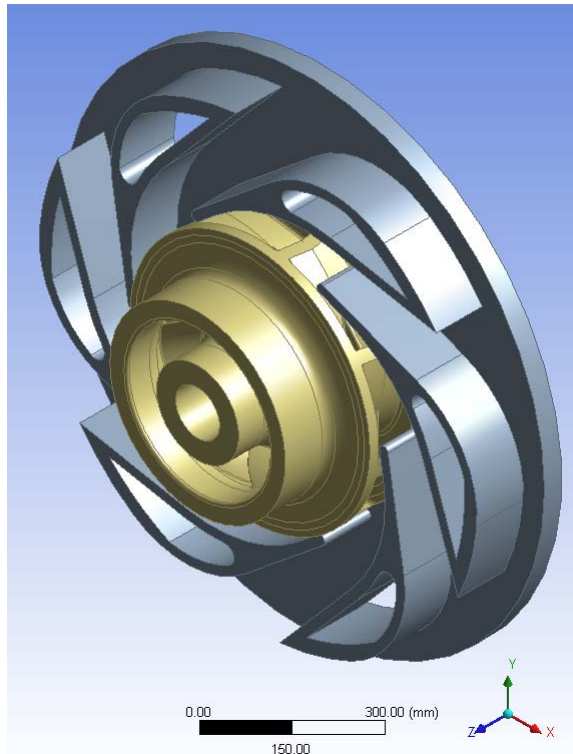
- 8X vane passing excitation forces @ **165 Hz**
- Natural (resonance) frequency in horizontal plane @ **169 Hz**.
- **Very small impeller tip (“Gap B”) clearance**, causing **strong vane passing excitation forces**

$$(D_3 - D_2) / D_2 = 553 - 546 / 546 = 0.013 \text{ or } \underline{\underline{1.3\%}} (!)$$



# Second Design

- Keep new high capacity impeller
- Replace diffuser with (dual) volute insert
- Increase impeller tip clearance



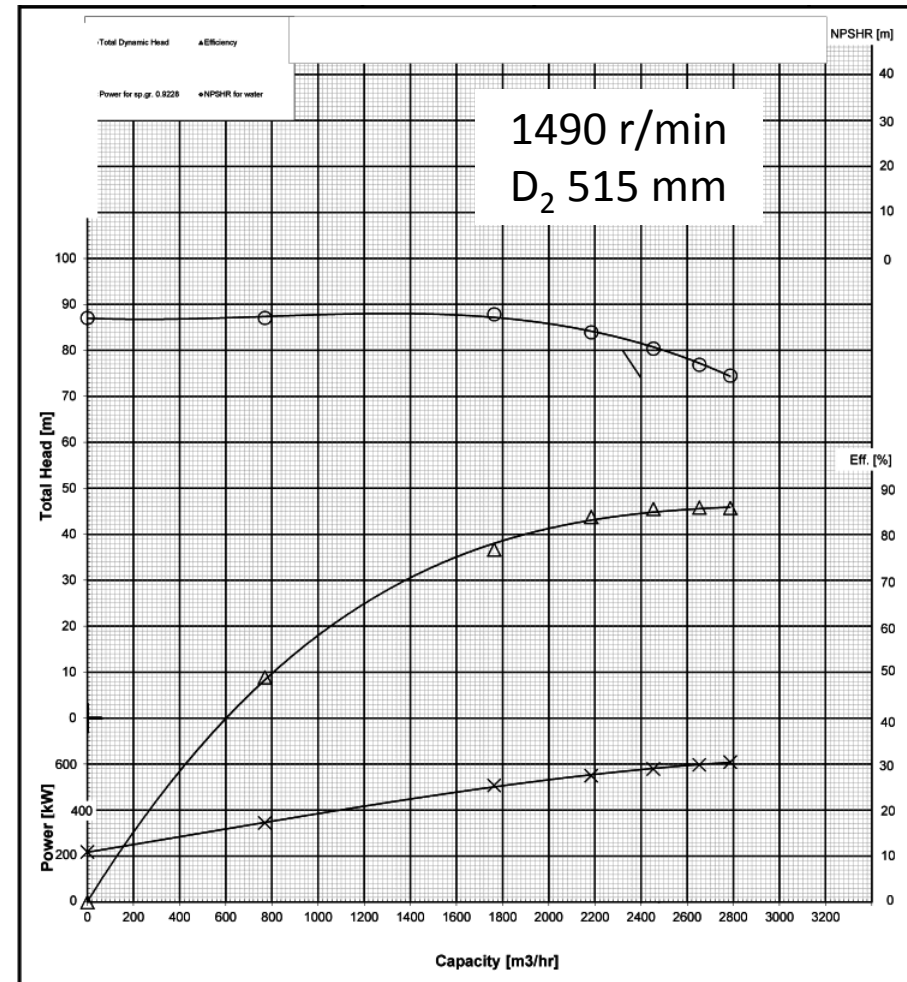
# Second Design

## Test result:

- ✓ Head okay
- ✓ Efficiency okay
- ✓ Power okay
- ✓ Tip clearance (Gap B) okay

$$\begin{aligned} (D_3 - D_2) / D_2 &= \\ 578.2 - 515 / 515 &= \\ 0.123 \text{ or } \underline{12.3\%} \end{aligned}$$

- ✓ No 8X vane pass vibration issue anymore



# Concluding Remarks

- Pumps have been upgraded with new hydraulic end.
- First design iteration with new impeller and new diffuser was not successful:
  - Hydraulic performance failure
  - Vibration issue
- Second design iteration with same new impeller and volute insert proved to be successful.
- Pumps with new impeller and volute insert are running trouble-free at site for more than 2 years now, performing fully to customer satisfaction.

# **Thank you for your attention**

## **Questions?**