

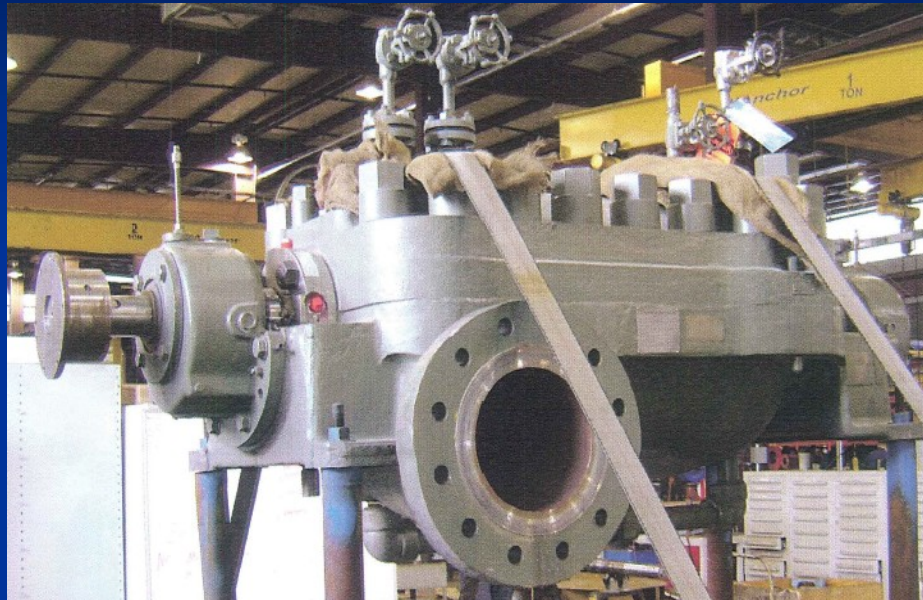
Bearing Failure on a Boiler Feed Water Pump

A Case Study by:

Kevin Karban

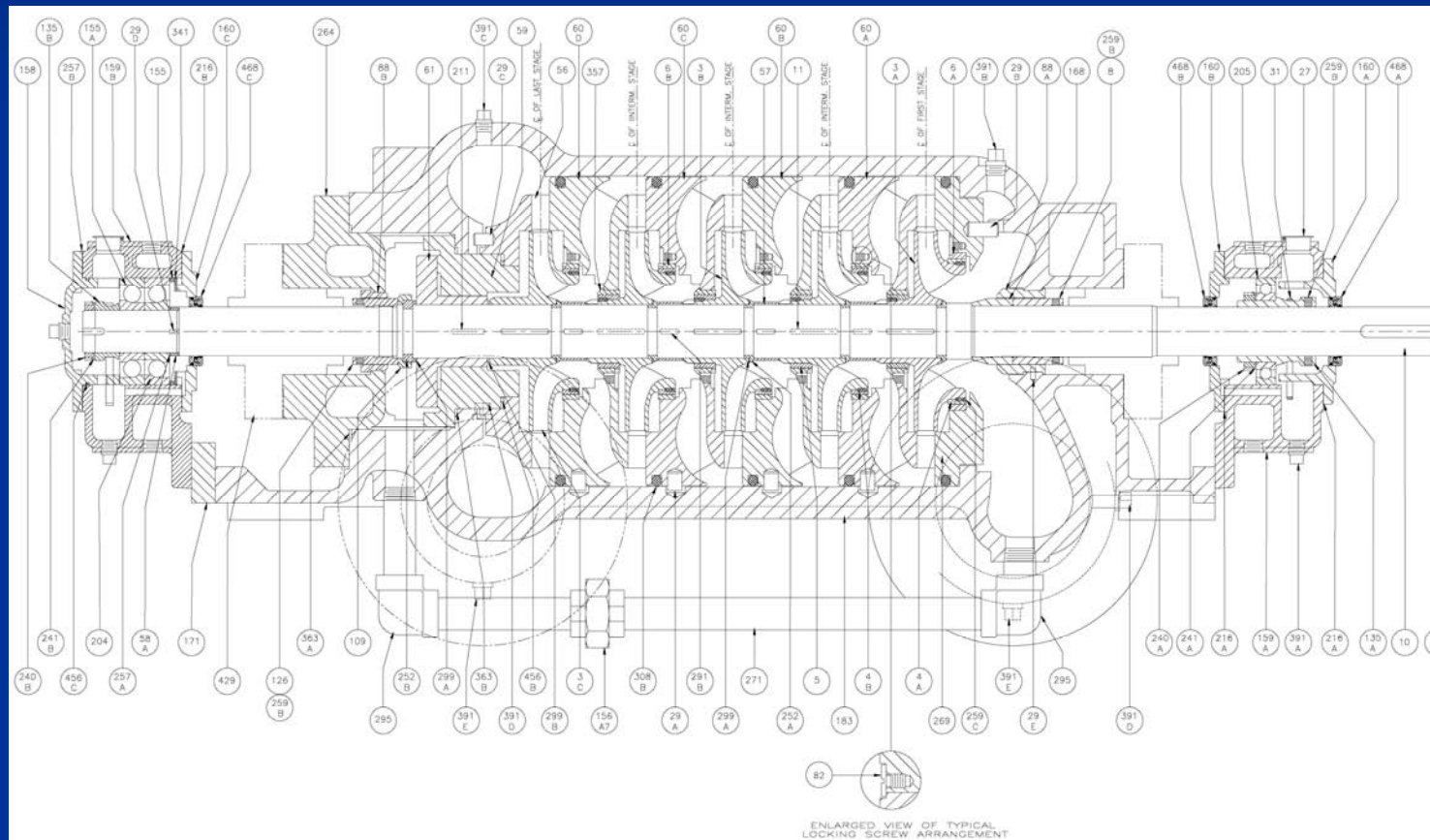
Kerry Gunn

Background Information



- BB3 Between bearing multistage centrifugal pump.
- Ingersoll-Rand 5-HMTA-5
- Service is Boiler Feed Water, 240F Operating Temperature, 10 PSIG Suction Pressure, 895 PSIG Discharge Pressure
- The pump was originally built for high pressure amine service at a different facility and was acquired in 1974 for use in the boiler feed water service.

Pump Cross Section Drawing



Failure Mode

- High outboard vibrations on the pump outboard bearing cause a shutdown for repair.
- Pump repair is attempted multiple times but continues to fail due to high outboard thrust bearing temperatures (250F+).

Maintenance Work Performed

- Problem started after the initial repair where the pump was sent offsite for a overhaul at a non-OEM shop. The rotor assembly was replaced with a storehouse spare.
- After the initial repair failed a field repair (outboard bearing only), 2nd shop repair (non-OEM, case not split) and 3rd (OEM, case split) were attempted. All failed with the same failure mode.

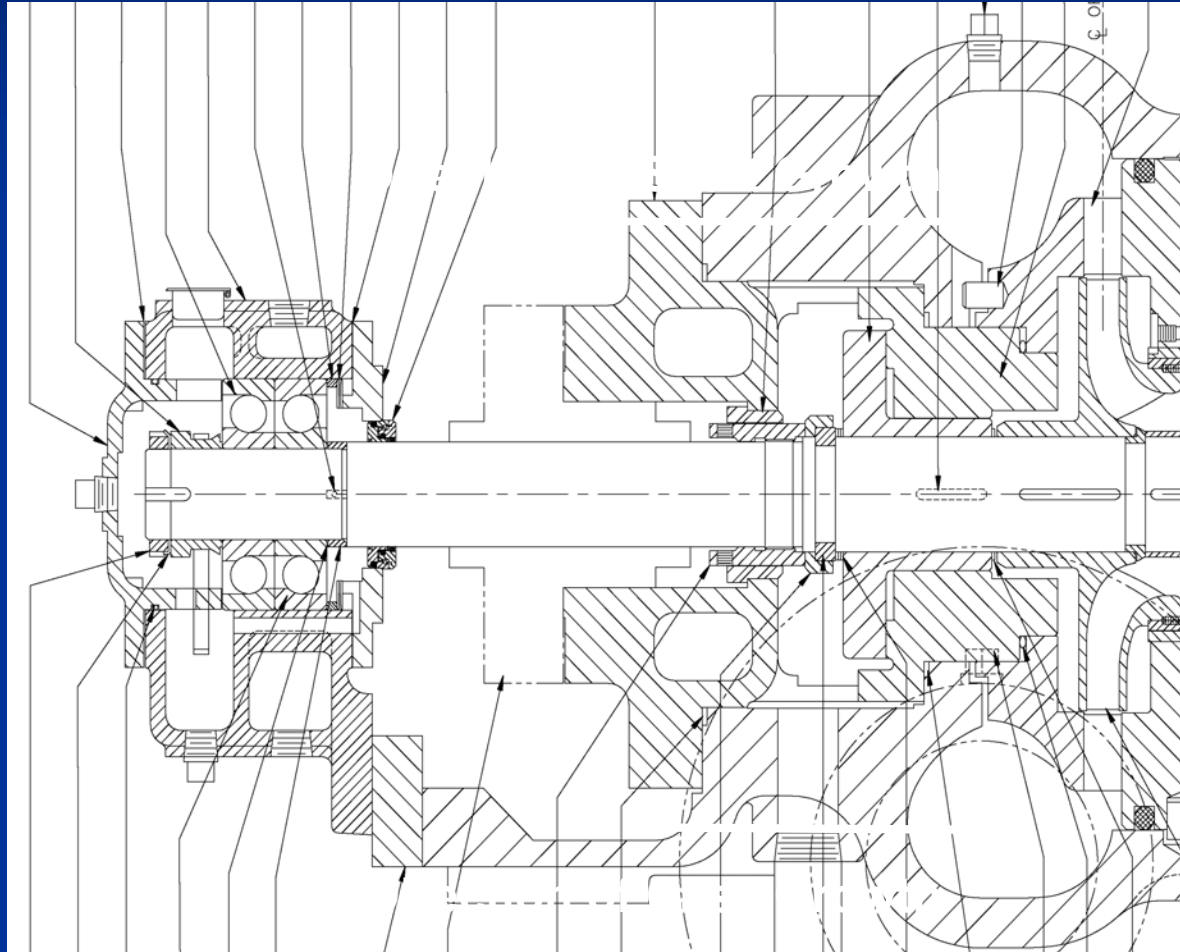
Maintenance Work Performed

- On the 4th repair the pump was sent to the OEM shop again.
- The following modifications where made to the pump.

Shaft Design Issue

- It was discovered that the installed shaft material was 410SS.
- The pump was originally designed with a 316SS shaft to match the 316SS casing.
- Thermal growth difference of 5.5×10^{-6} in/in F vs. 8.9×10^{-6} in/in F
- ΔL for 410SS = $5.5 \times (250\text{F} - 80\text{F}) \times 12 \text{ in} = 0.01122 \text{ in}$
- ΔL for 316SS = $8.9 \times (250\text{F} - 80\text{F}) \times 12 \text{ in} = 0.01815$
- Difference of 0.007 in

Shaft Design Issue



Balance Drum Setting

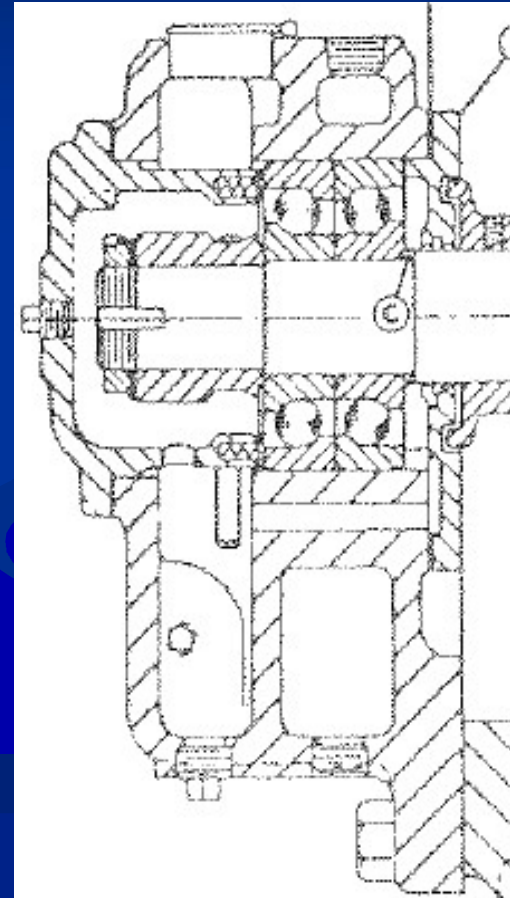
- Existing design balance drum setting relied on a fairly tedious and vague thrust
- A spring was added in the thrust bearing assembly which allowed the balance drum to close as needed to balance the load and not be constrained.

Balance Drum and Balance Piston Pictures



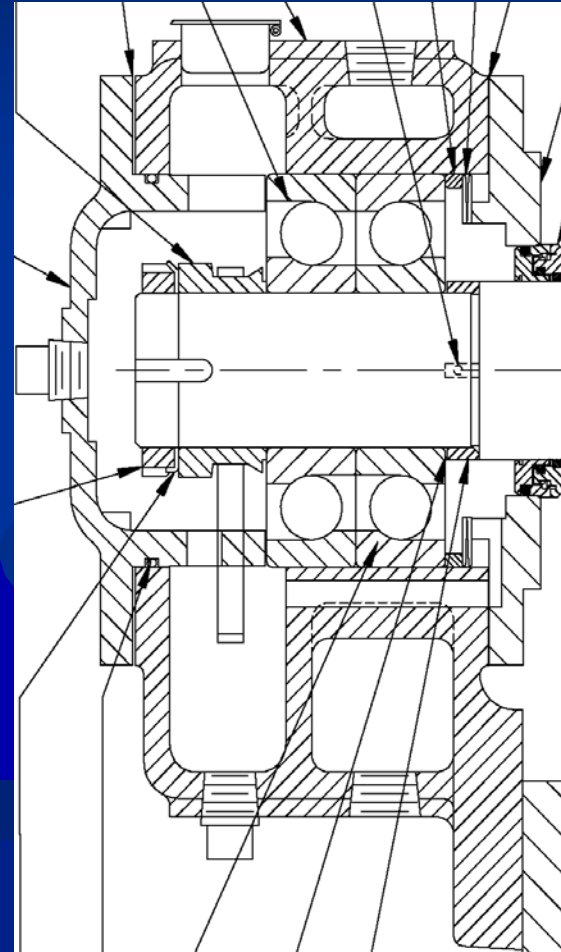
Existing Design

- Thrust bearing is contained on both ends in a traditional manner.
- A spacer is used between the bearings and inboard cover to set the balance piston gap at 0.002" to 0.005".



New Design

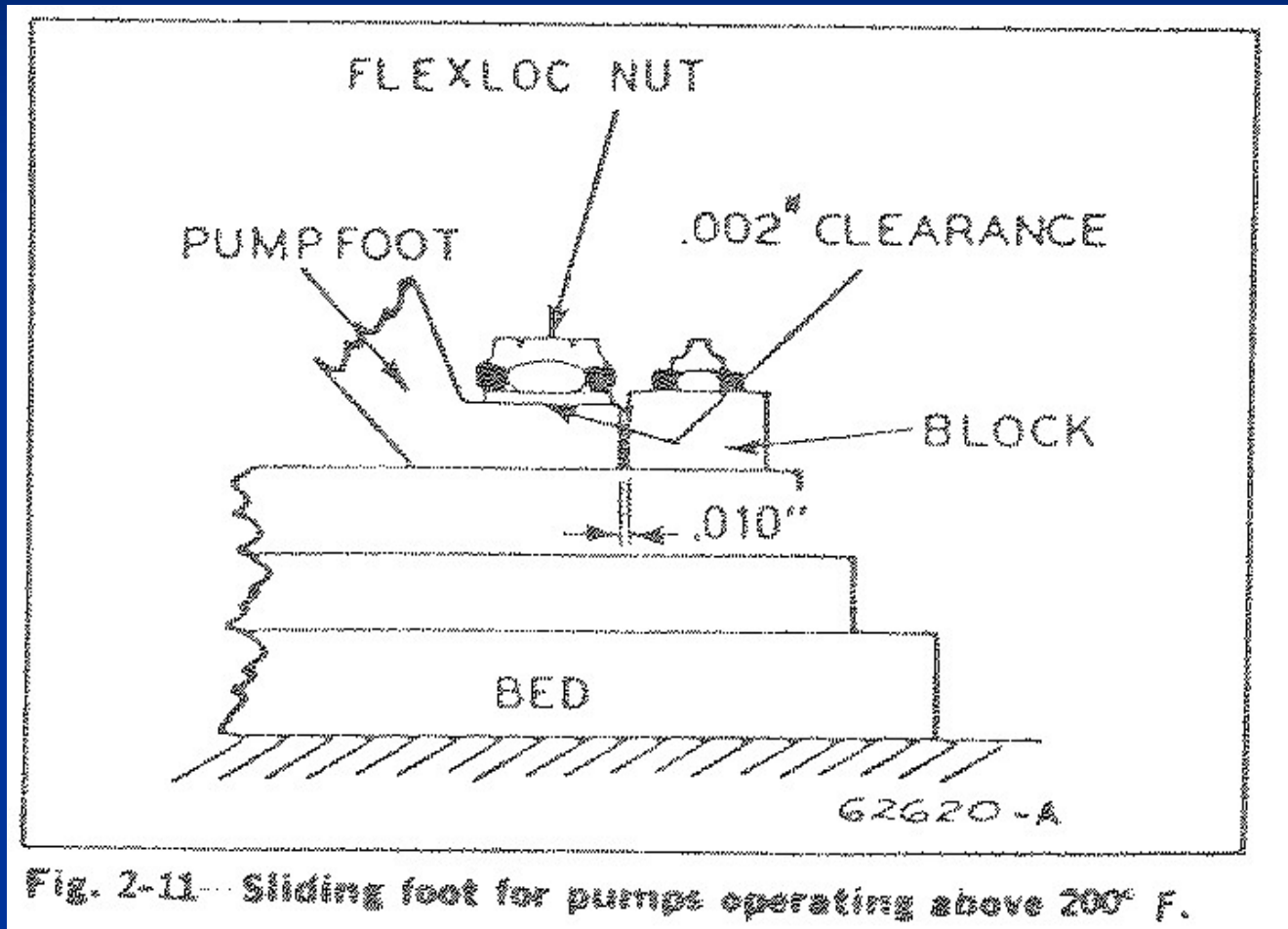
- Outboard bearing bracket was modified to install a wavy spring.
- This allows for the thrust force to close the gap to balance itself out rather than a fixed gap.
- Originally meant for use in pumps where the balance piston would wear and the spring will compensate for this wear.



Pump Installation Issue

- One issue identified after the 2nd shop repair was possible thermal growth of the casing binding the pump.
- The pump was not installed per the OEM recommendations for 200F and higher applications.
- On each repair after the 2nd shop repair the base bolts were loosened after heating with an indicator placed on the bearing housing.
- Thermal growth was found as high as 0.025”.

OEM Recommended Mounting



Field Results

- Before shaft material change and bearing housing redesign the thrust bearing was running over 200F. Pump was taken out of service at less than a 24 hour run time.
- After modifications the bearing housing runs between 160F to 180F and has been in service for nearly one year without any repairs.

Conclusions and Recommendations

- Recognize issues with material selection and changes during repairs
- Effects of thermal growth, especially with pumps that were not designed originally for the temperature
- Complications of using equipment that was not designed for the service
- API 610, 11th Edition, para 6.7.1 prohibits close axial clearance from being used to balance thrust.