Root Cause Analysis of Pump Failures…

WHY DID IT FAIL AND HOW DO WE ENSURE IT NEVER FAILS AGAIN… EVER!!!!!!!!!!!!

What is Root Cause Analysis (RCA)?

FAILURE DEFINITION:

The inability of any physical asset to meet a desired standard of performance

- **RCA is a systematic approach to determine the foundation causes of a failure.**
- **Goal is to find the cure…not just treat the symptoms**

WHY?

Why do we do root cause failure analysis?

To know what failed – which usually is obvious, but not always

To know what led up to the failure – what sequence of events had to line up

Any other reasons why we would do RCA?

So we can put actions in place to never repeat the failure

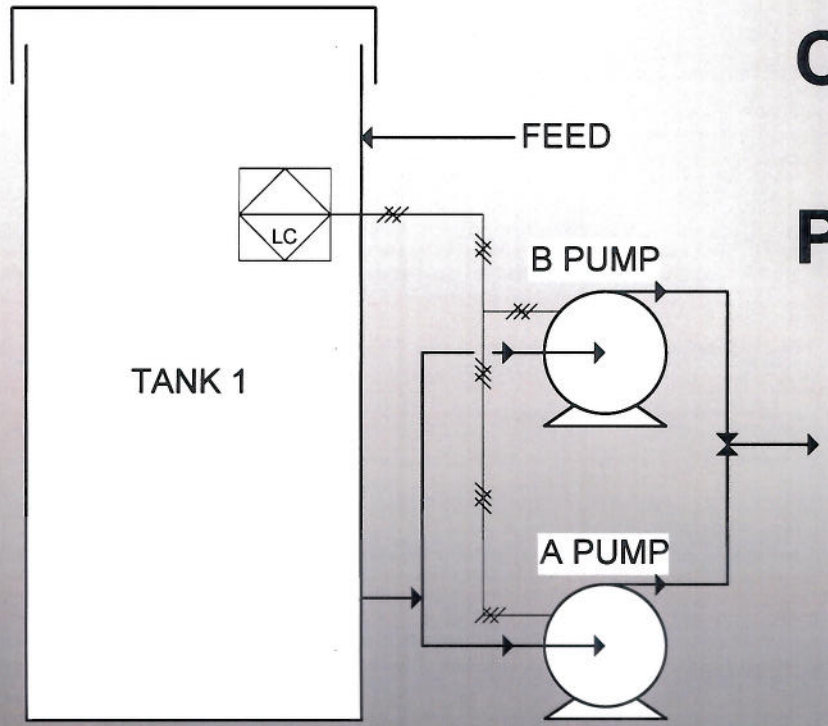
Ensure the actions we put in place do not create other modes of failures

There is almost always more than one root cause

If you can determine all of the root causes, you can eliminate (them) and never have a repeat failure

Finally, to learn from our mistakes and educate others!

EXAMPLE



Crude is pumped from a tank.

Pump A fails mechanically and pump B does not start fast enough to prevent the tank from overflowing.

What should the investigation consider?

How many failures here?

Systematic Approach (How Part 1)

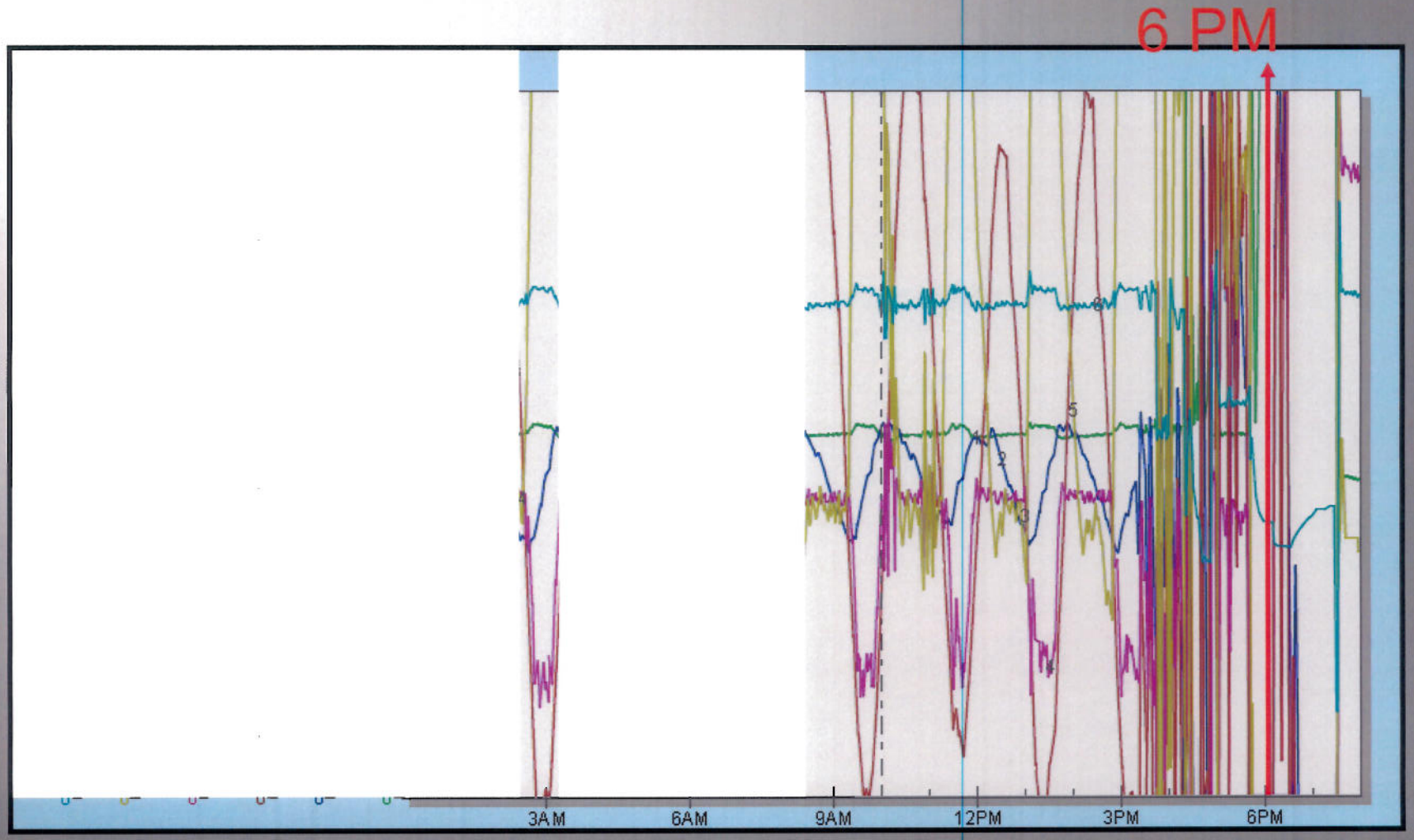
- Start by collecting data
  - Gather the Bits and Pieces (if you can)
  - Talk to Witnesses – take written statements and confirm
  - Scope may have to expand based on findings
- Understand the system – don't focus!
  - Process
  - People
  - Machinery

Data Collection Tips

- **Operations/Maintenance staff must know:**
  - **What information is useful for investigations, how to record and collect data as soon as the incident is under control:**
    - **Detailed reports of observations and actions prior to incident.**
    - **Original locations of broken or disturbed items.**
    - **Process parameters (before, during and after).**

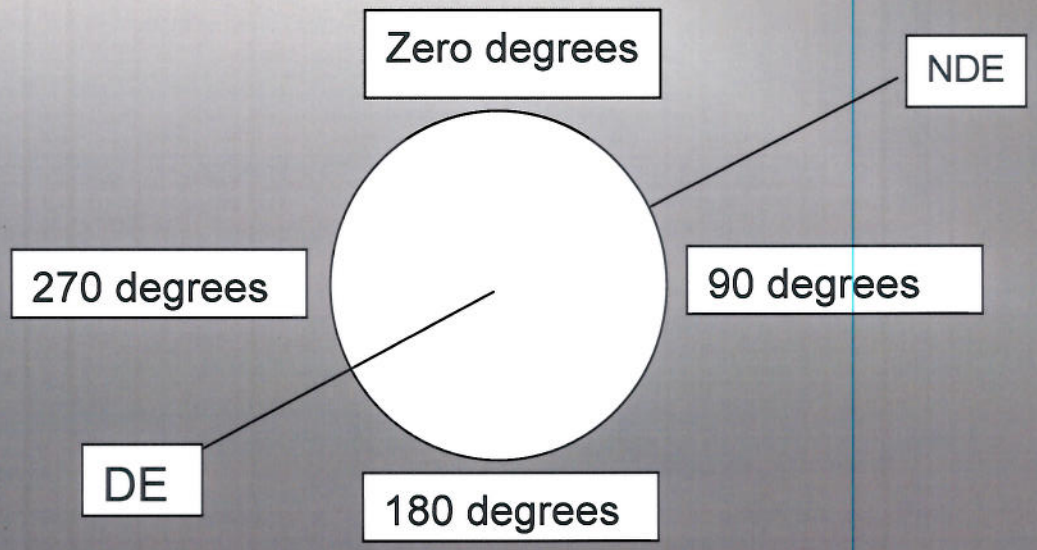
Speaking of data and observations---here are some pointers……

System Trend Data



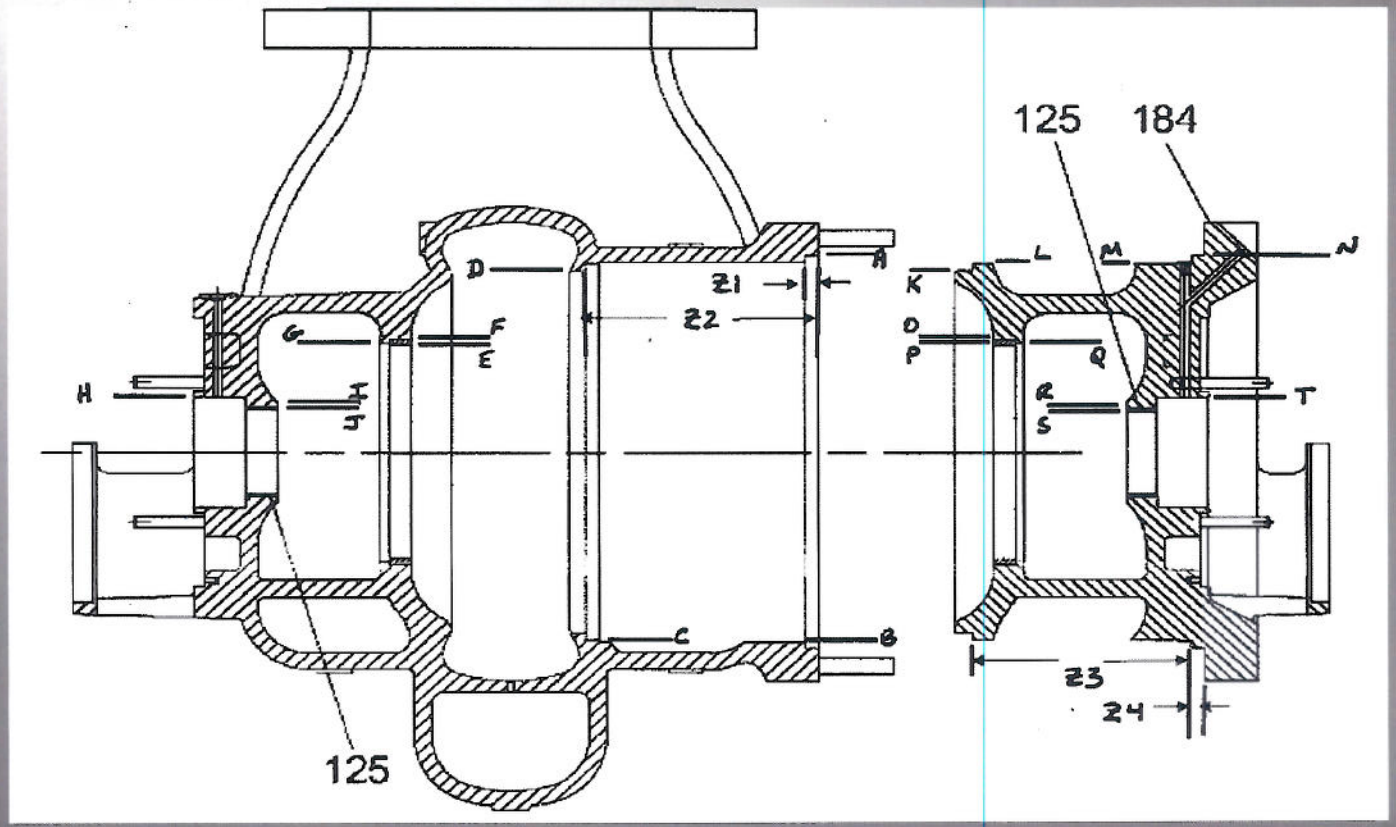
Tips continued…

- **When doing forensics, establish datum's so that the locations of defects, damage indications, broken pieces and dimensions are recorded clearly.**
  - **What is top, bottom, left , right, inside, outside**



Tips continued…

Use a sectional drawing to determine what key fits need to be measured during teardown.



Tips continued…

As lead investigator, quantify as much as possible but DON'T ignore qualitative observations by the investigation team or participants.

Don't ignore environmental factors

Review all work-orders performed on the failed equipment. Go back to the last full overhaul or initial installation if needed.

Methods (How Part 2)

- We are not going to talk about RCA methods, but…
  - 5 Why's (simplest and yet effective)
  - Reason Pro
  - Fishbone
  - Fault Tree Analysis

Methods (How Part 2)

- We are not going to talk about RCA methods, but…
  - KT (Kepner Tregoe)
  - TapRoot® and associated Equifactor®

You need one thing to ensure whatever RCA method you choose is effective?

PEOPLE

How (Part 3)

So you know what the root cause(s) are, now what?

Generate Solutions – management likes options!!!

How (part 3)

- When developing solutions consider if :
  - Doing predictive maintenance (monitor)…
  - Doing a restoration task (refurbish)…
  - Doing a scheduled discard task (replace)…
  - Doing a schedule failure finding task (PM)…
  - Re-designing the equipment or process…

Will fix the root cause

How (Part 3)

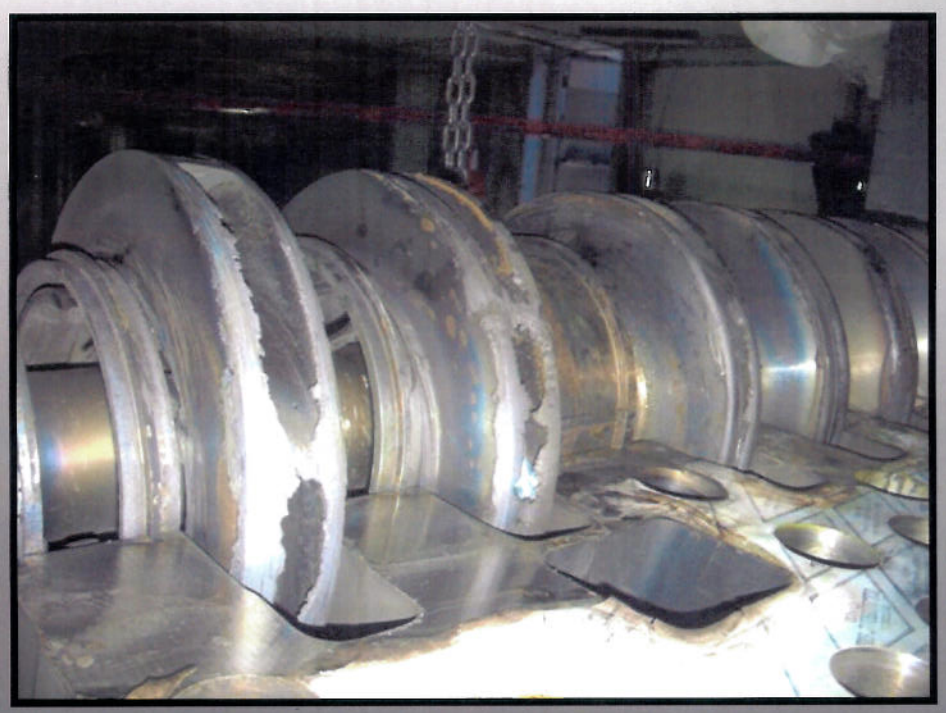
- Ensure the solutions do not create other (different) modes of failure
- Check to see if recommendations apply to other assets in the organization.
- Assign actions, Implement them and then Verify

Occam's Law:

Of two equivalent theories or explanations, all other things being equal, the simpler one is to be preferred

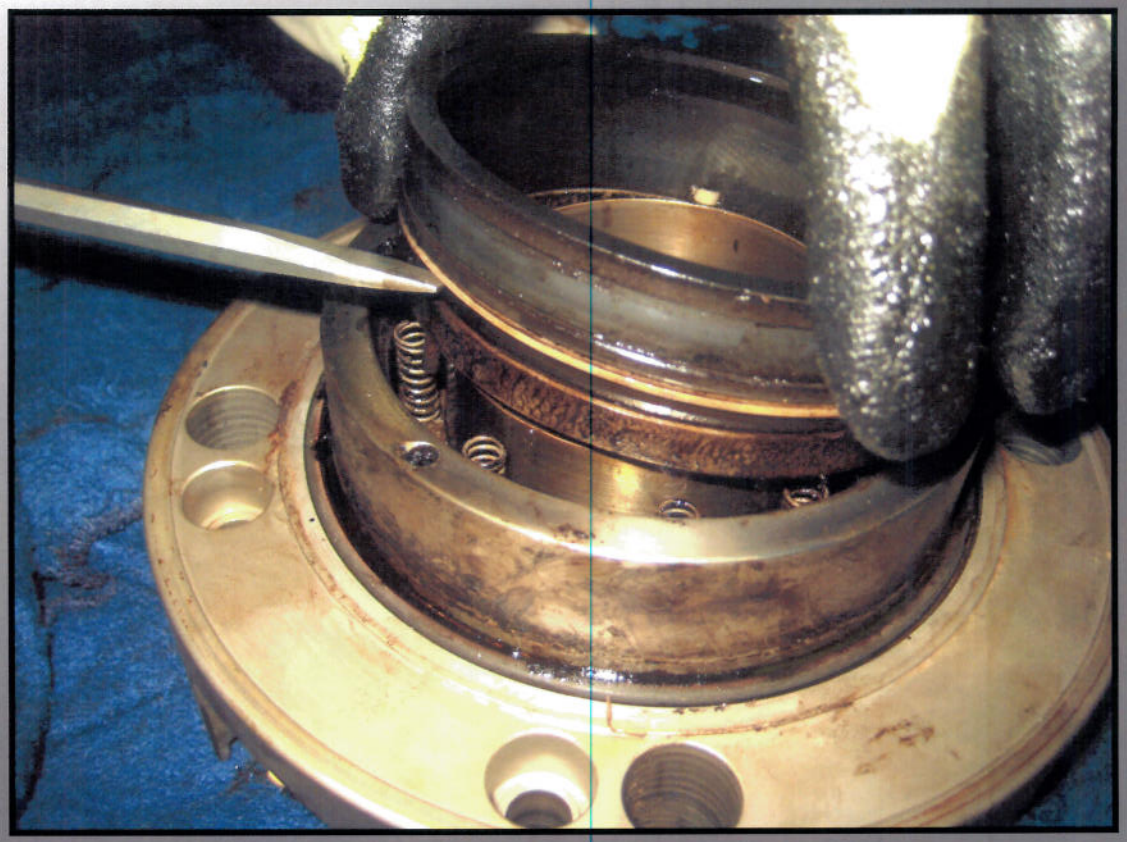
Pump Failure

- Where do you start?

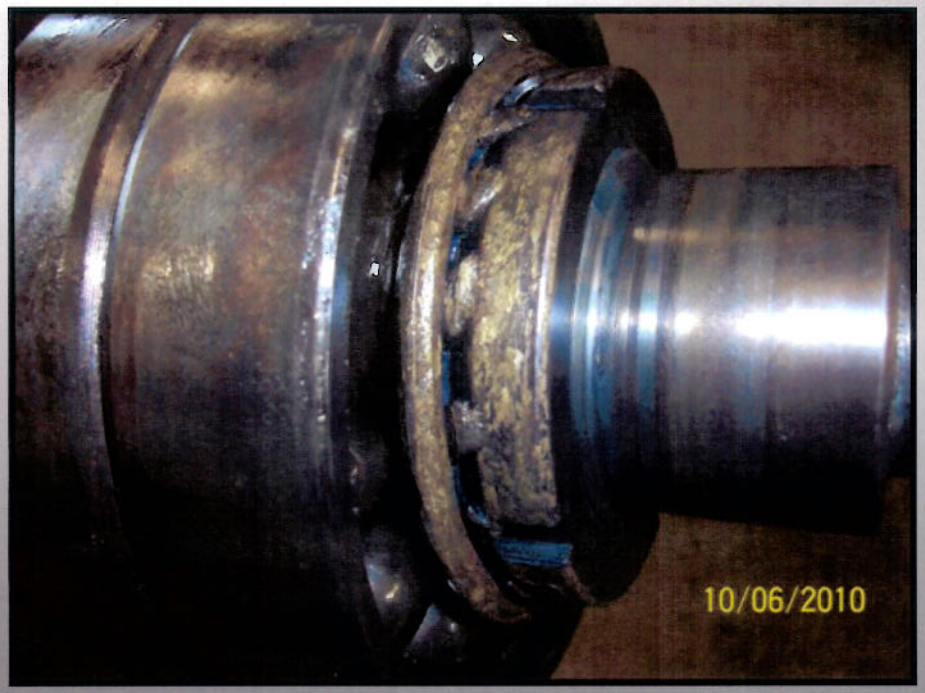


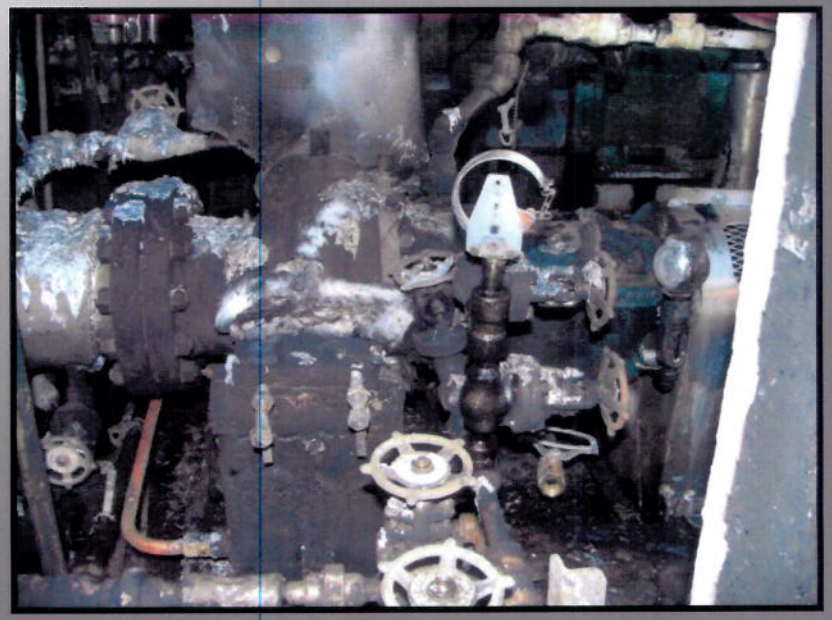
Seal Failure

Leakage to atmosphere



Bearing Failure

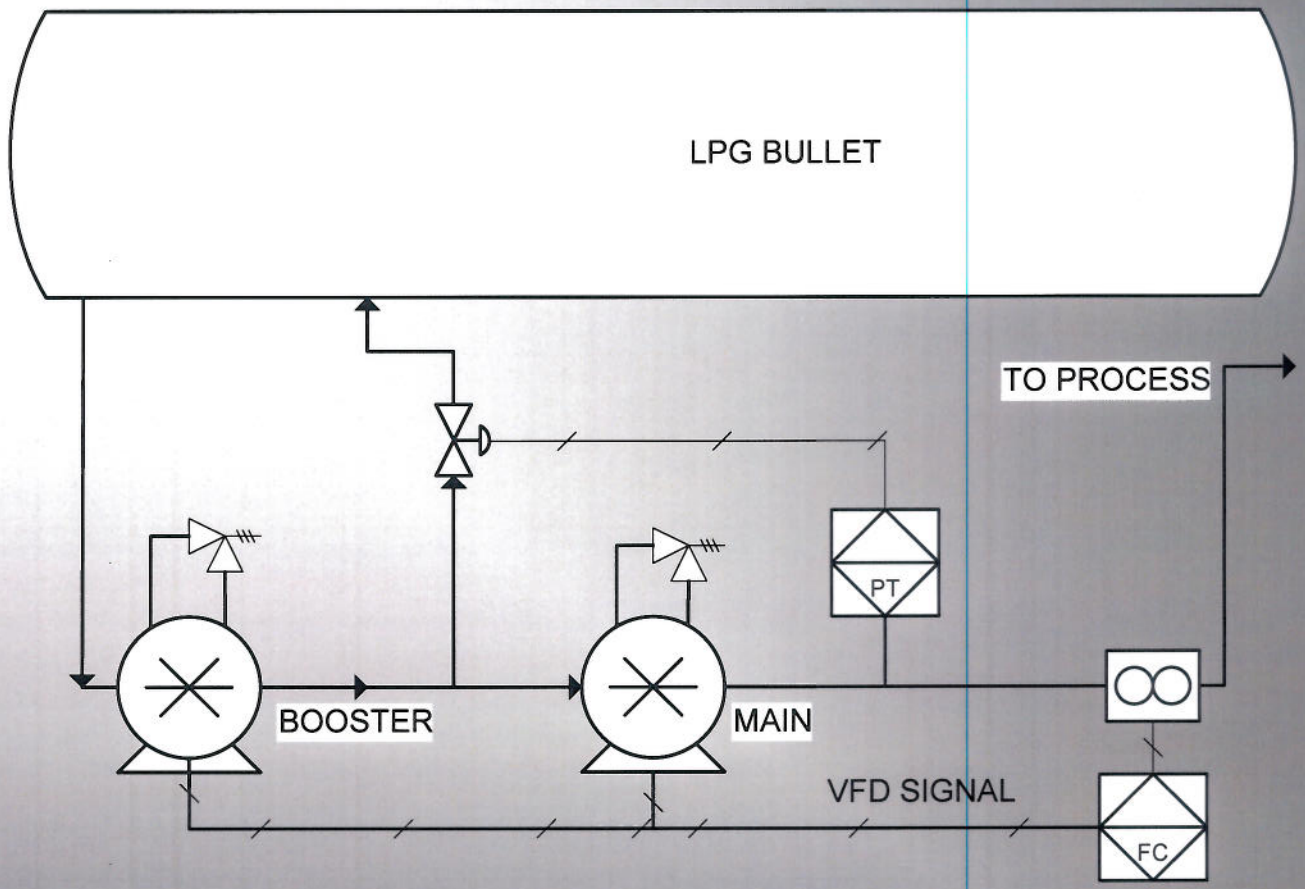




LPG Pump Failures

- **Problem:**
- **Two pumps in series**
- Pump Set 1: Main pump coupling fails 4 days after start-up.
- Pump Set 2 : Booster pump P-004B coupling fails 3 days after start-up.
- Couplings replaced but units will not produce flow when re-started.

- **SO WHAT CAUSED THE COUPLING FAILURES?**



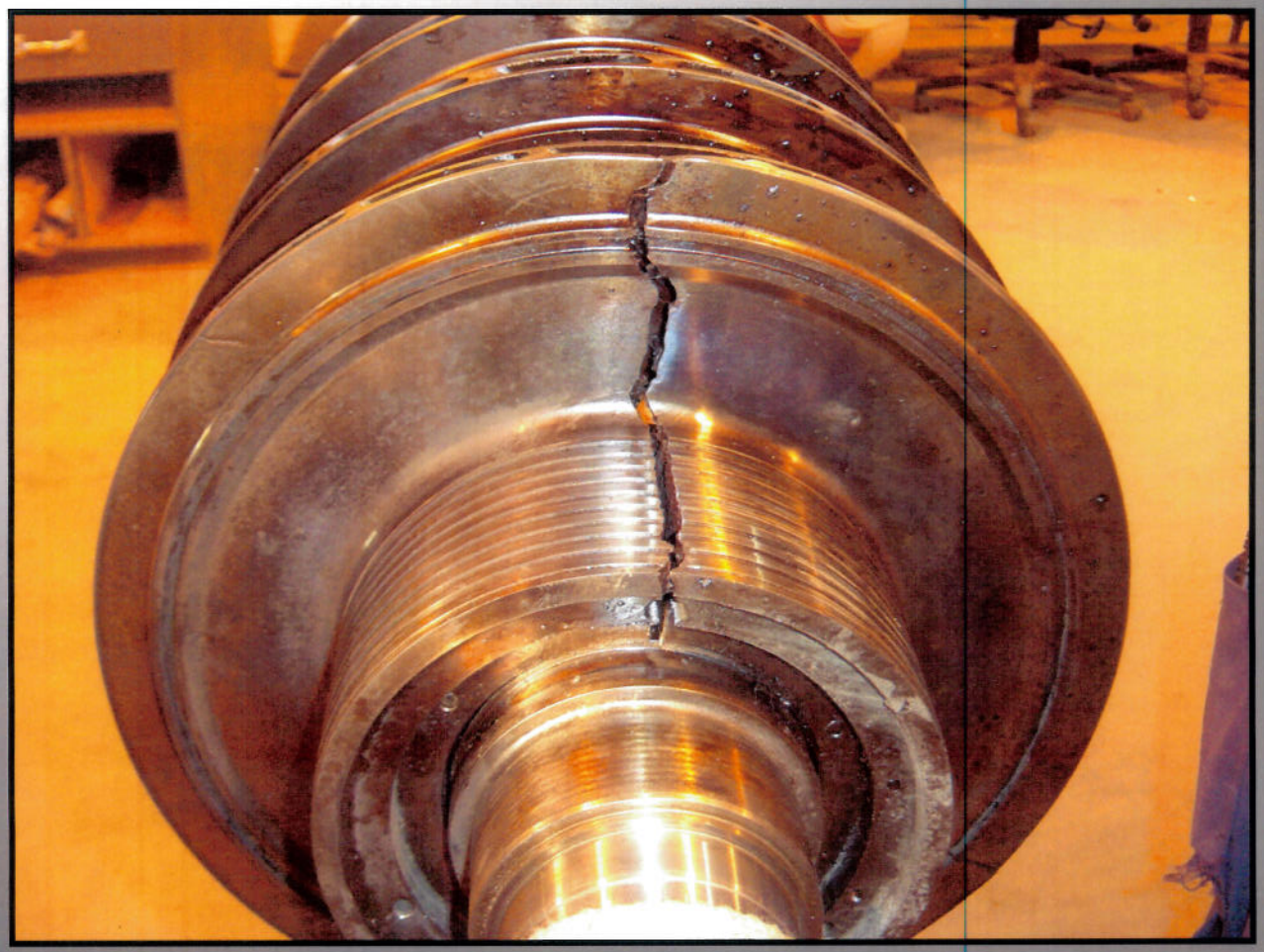
THERE IS NO CONTROL OVER THE INTERSTAGE PRESSURE!

<u>System destined to fail</u>

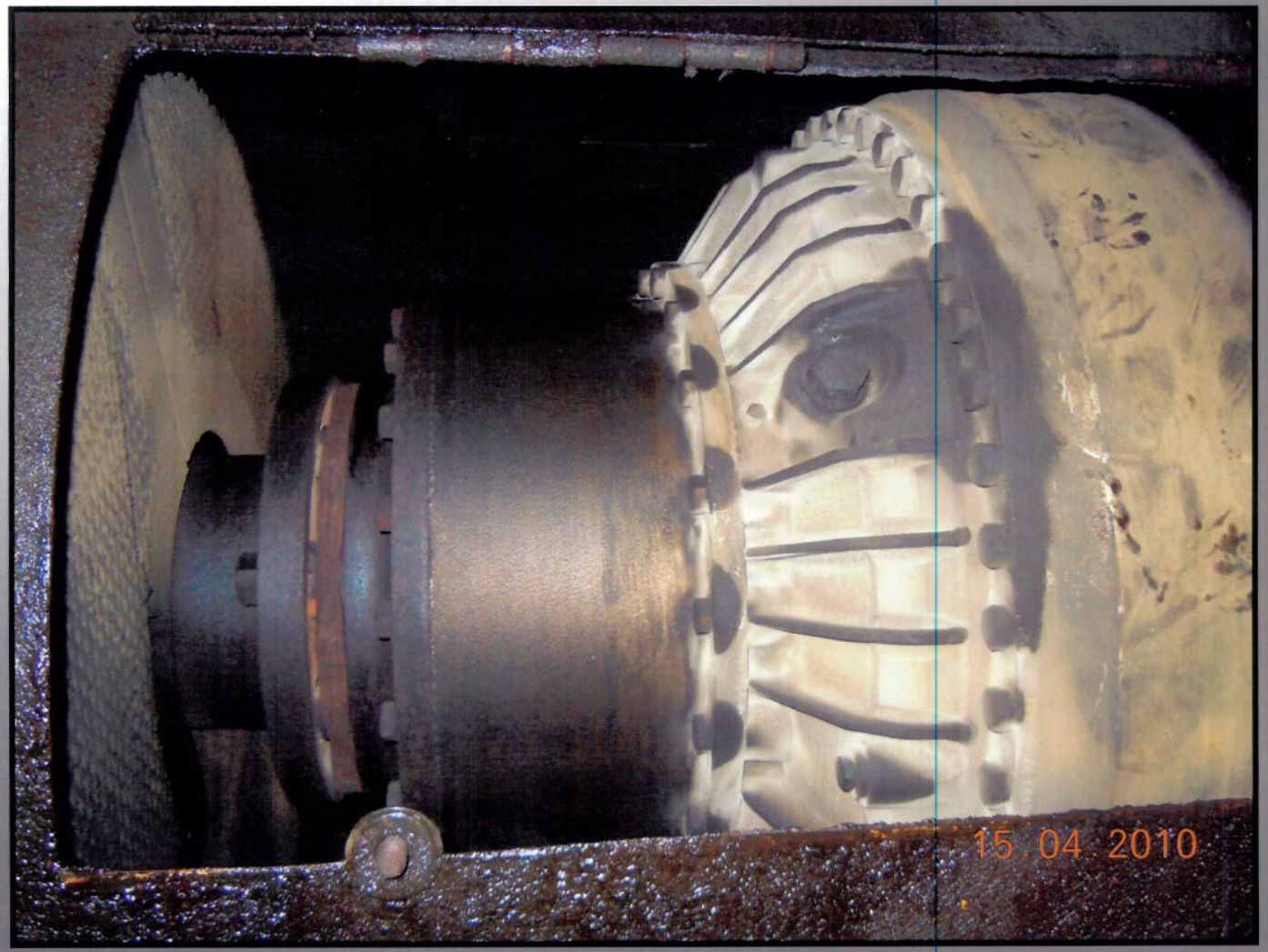
Other Machinery

This systematic approach can be used for other types of machinery

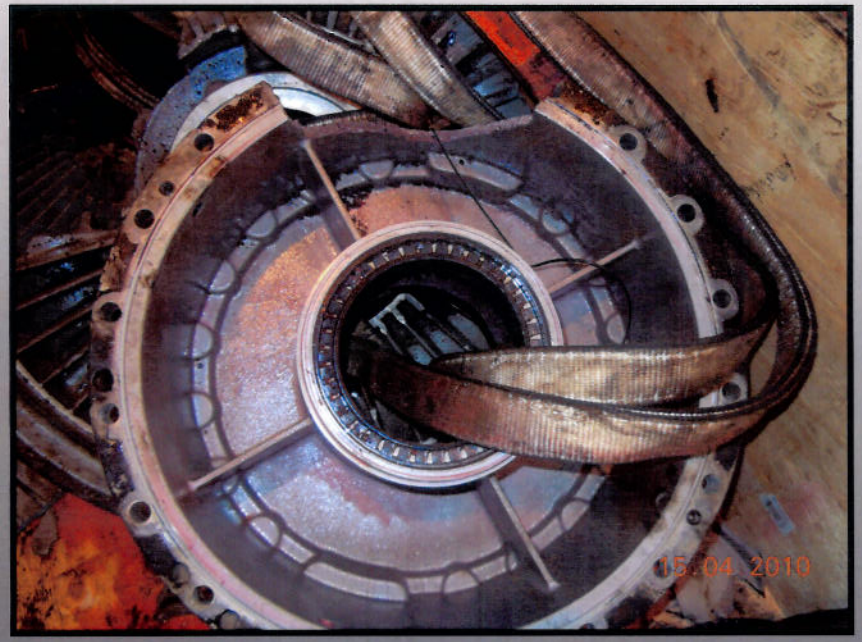
Again, what happened?

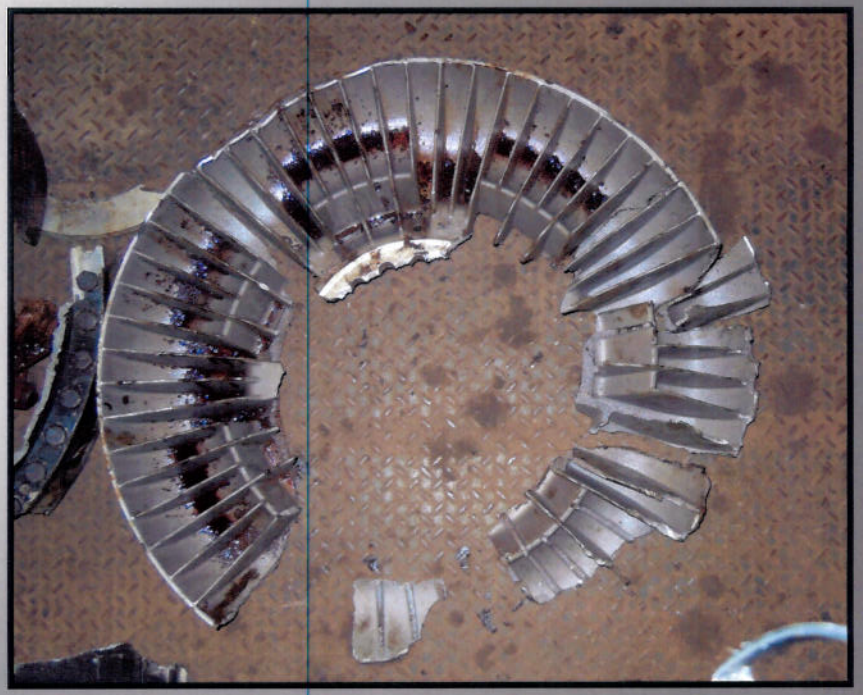


Hydraulic Coupling



Hydraulic Coupling Failure





Recip Connecting Rod Failure

Summary

- Freeze the scene
- Gather data
- Have the people trained before an event happens
- Draw in adequate resources
- Understand the machine, but more importantly, the overall system

Summary (cont'd)

- Utilize an appropriate RCA method to determine the root cause(s)
- Implement actions and verify they are appropriate
- Ensure solutions do not result in other modes of failure
- Confirm no systemic problems exist