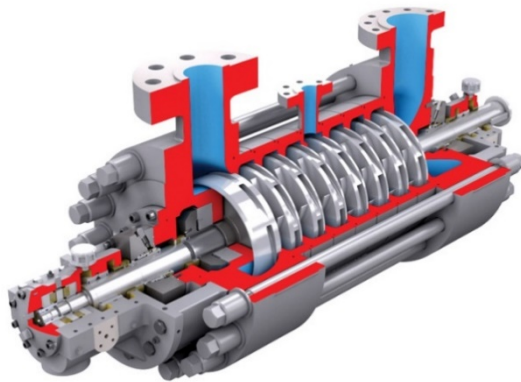


Root Cause Analysis Methodology in Troubleshooting of Pump Failures

Mubashshir Mirza



CALGARY PUMP SYMPOSIUM 2017

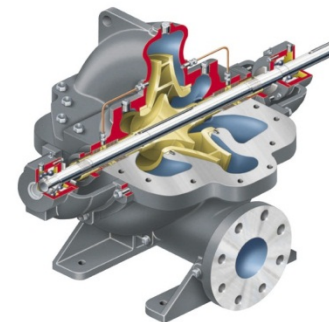
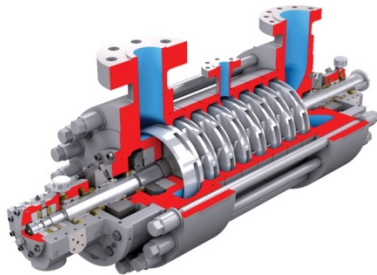
Presenter

Mubashshir Mirza



Mubashshir Mirza works as a Staff Maintenance Engineer for Husky Energy at the Lloydminster Upgrader. He has over 25 years of experience working mainly in the areas of Rotating Machinery, both at operating plants and EPC. He is a registered Professional Engineer with APEGA and APEGS and holds a bachelor's degree in Mechanical Engineering. He has a professional background working in the areas of steam turbines, centrifugal and reciprocating compressors and pumps, trouble shooting and root cause failure analysis.

Prior to joining Husky, he worked at Petro-Canada's Lubricants Refinery as Rotating Equipment Specialist for 10 years.



Agenda

1. Definitions
2. Root Cause Analysis Methodology
3. Common Root Causes
4. RCA Tree
5. RCA Case Studies



Incident

An unusual or unexpected event or emergency, which either resulted in, or had the potential to injure people, adversely impact the environment, damage property or assets, interrupt process operations or negatively affect the company's reputation. Usually involves an energy source and the release of energy or the occurrence of an action.



Root Cause

A root cause is an underlying cause (physical, human or latent) of an incident and should be permanently eliminated to prevent incident reoccurrence.



Root Cause Analysis

Root cause analysis is an approach for identifying the underlying causes (physical, human and latent roots) of an incident so that the most effective solutions can be identified and implemented to prevent incident recurrence.

The goal is to find a cure – not just treat the symptoms



Root Cause Analysis

Why

- Learn from our mistakes and educate others
- To know what failed, which is usually is obvious, but not always
- To know what led up to the failure; what sequence of events had to line up



Physical Roots

Are related to the physics of the incident (how the incident / failure occurred)

e.g.

- Fatigue
- Erosion
- Corrosion



Human Roots

Stem from Decision Errors (actions or inactions) that trigger the physical roots to surface (what error was committed)

e.g.

- Purchased poor quality material
- Procedures not followed
- OEM recommendations not followed



Latent Roots

Stem from Organizational or Management System Flaws (why the human made the error)

e.g.

- Training deficiencies
- Policy and Procedure deficiencies
- Paradigms or beliefs



RCA Methodology

RCA Process Steps:

1. **Preserve** Event Information – Parts, Position, People, Paradigms and Paper (**The Five Ps**)
2. **Order** the Analysis Team
3. **Analyze** – Describe the **Event**, Describe **Modes**, Hypothesize, Verify **Hypothesis**,
Determine and Verify **Physical Roots**,
Determine and Verify **Human Roots**,
Determine and Verify **Latent Roots**
4. **Communicate** Findings and Recommendations
– in the form of RCA reports and Bulletins
5. **Track** the Results



RCA Methodology

PRESERVE

1. **Parts** – Failed components, product samples
2. **Position** – Pictures of failure
3. **People** – Interview personnel involved with the failure, Operator logs
4. **Paradigms** – Repetitive themes/common mindset
5. **Paper** – Drawings, failure reports, repair reports, procedures, manuals



RCA Methodology

ASSEMBLE ANALYSIS TEAM

DRAW IN ADEQUATE RESOURCES

- Principal analyst/facilitator
- Operator
- Tradesman
- Subject matter expert
- Other stakeholders

DEVELOP CHARTER



RCA Methodology

ANALYZE

- Define event (Why we care)
- Define failure modes (How did...)
- Brainstorm and verify hypotheses (How can..)
- Identify root causes
- Generate recommendations to overcome root causes



RCA Methodology

COMMUNICATE

- Check if the recommendations apply to other assets in the organization
- Report and bulletin is provided to incident owner
- Present recommendations and findings to review team; typically bulletin is shared site wide



RCA Methodology

TRACK

- Verify that recommendations are implemented to ensure execution
- RCA tracking spreadsheet
- Bottom line impact of implemented recommendations



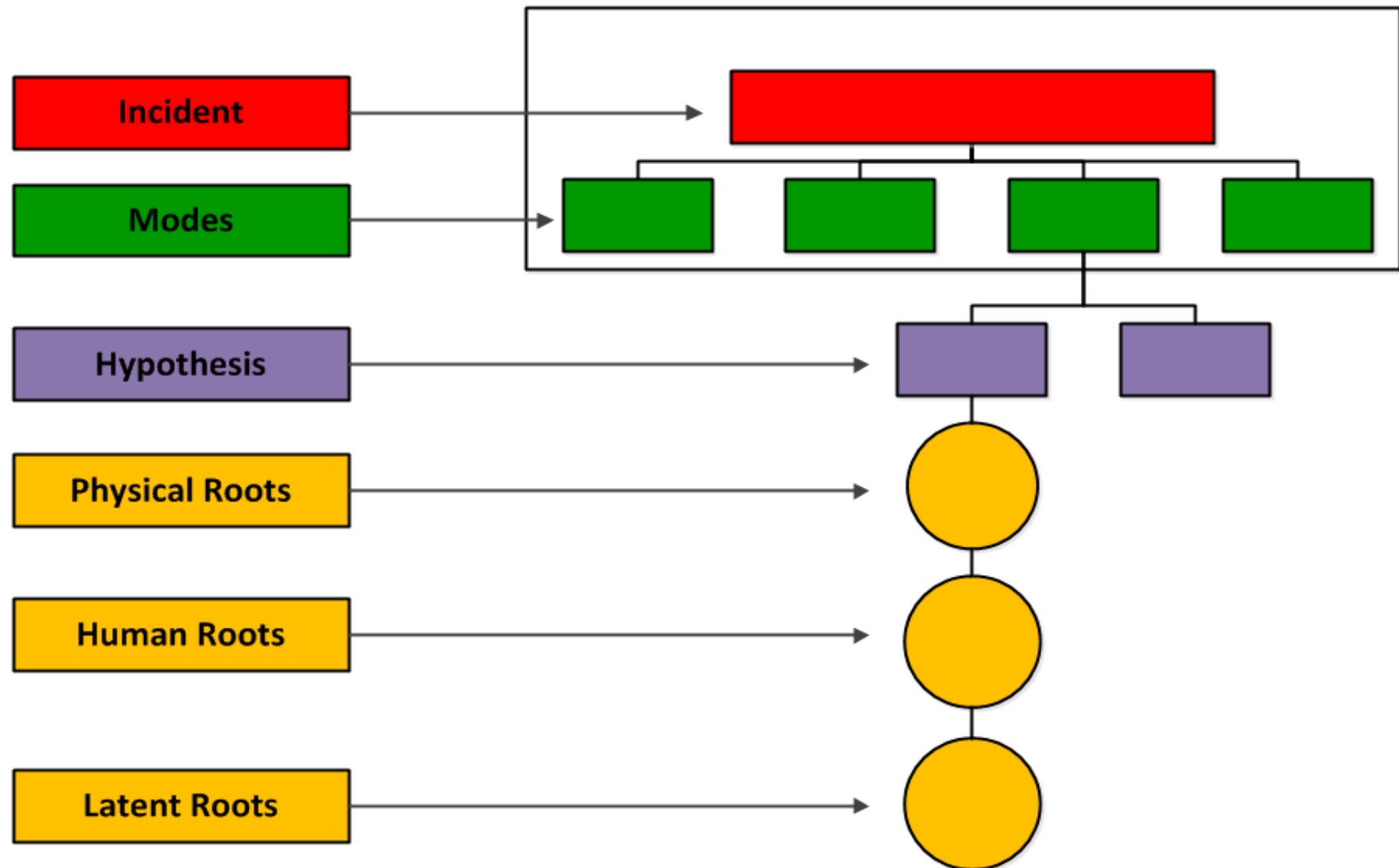
Common Root Causes

Human & Latent Roots

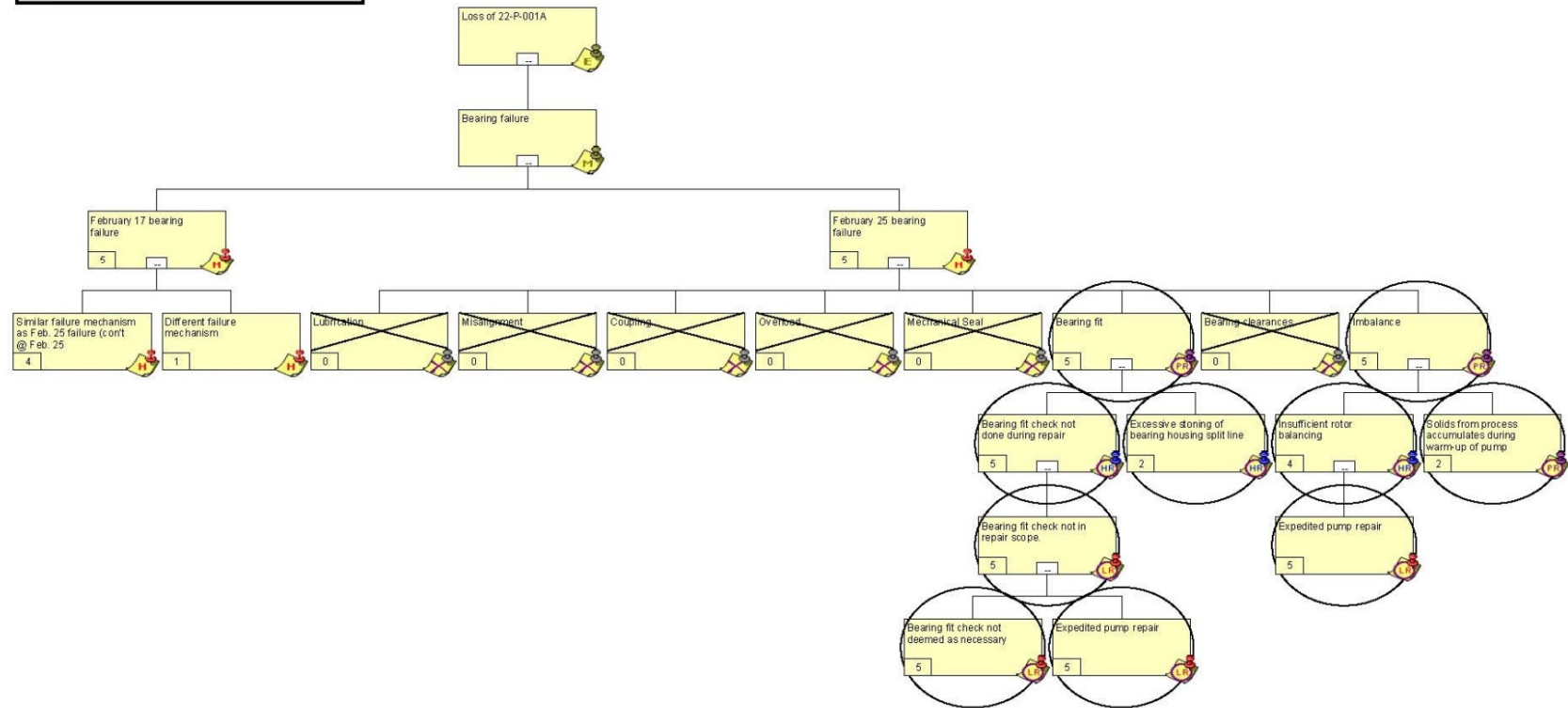
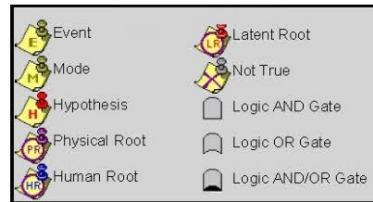
- **Operating outside design conditions (Human Root)**
Incorrect operating and maintenance procedures
(Latent Root)
- **Deficient designs (Human Root)**
Design criteria does not meet plant needs (Latent Root)
- **Lack of inspections (Human Root)**
No defined inspection interval/inspection interval too long
(Latent Root)
- **Poor documentation (Human Root)**
Documentation requirements for MOCs, EWRs, etc. not well
defined (Latent Root)



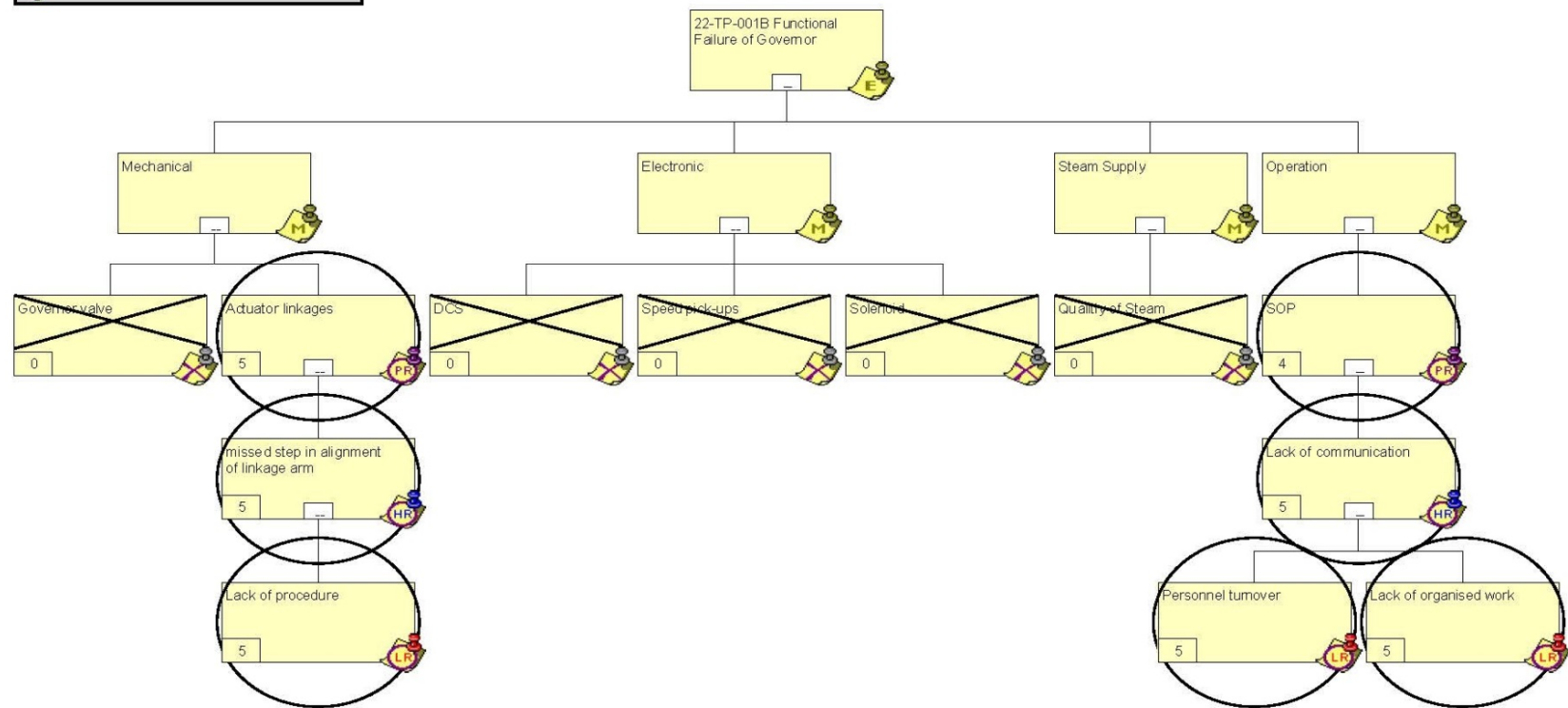
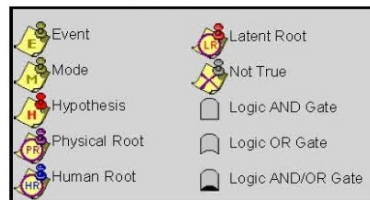
RCA Tree



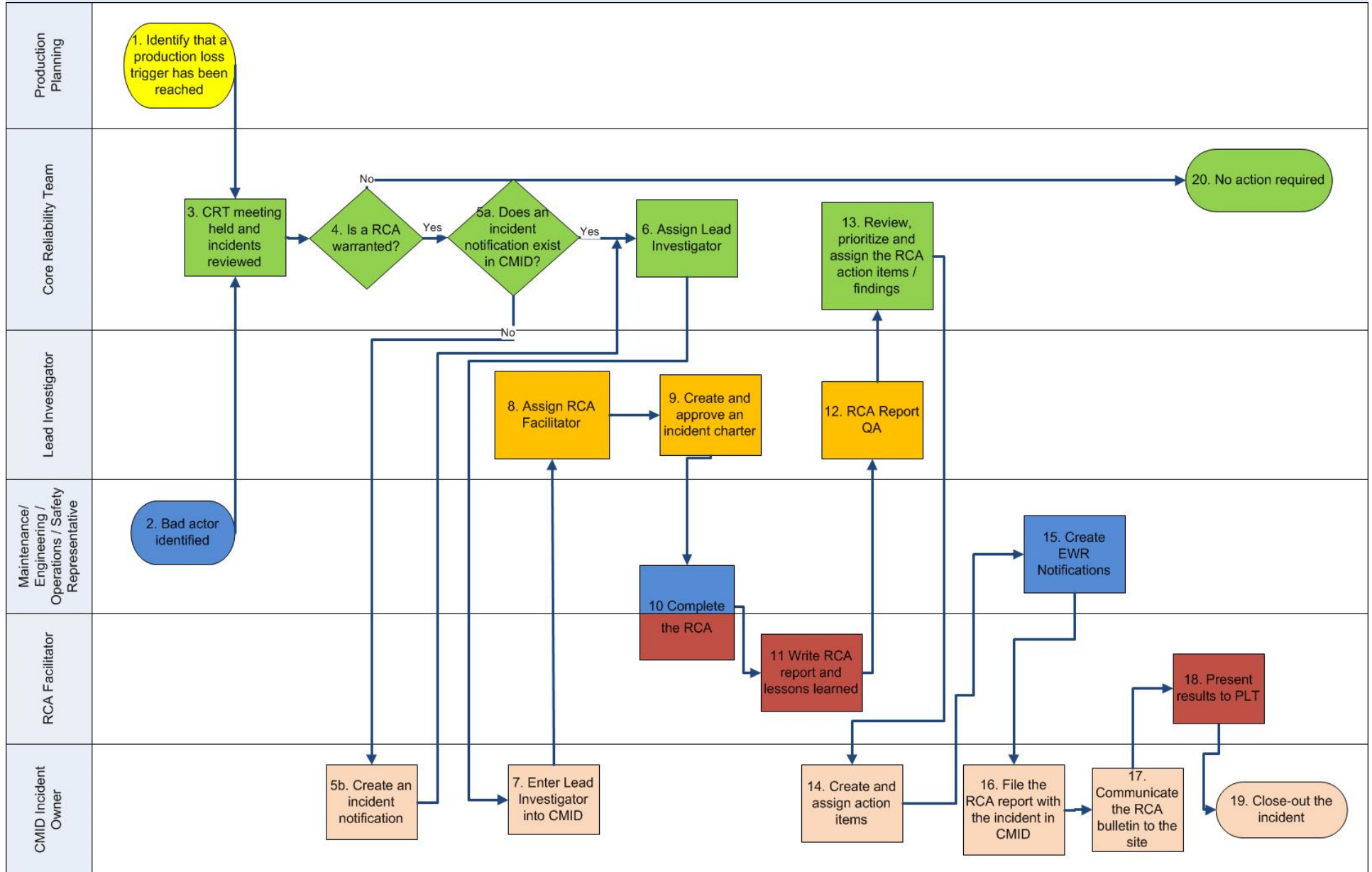
RCA Tree



RCA Tree



Root Cause Analysis Work Flow



RCA Tools

- Five “Whys”
- Reason Pro
- Fishbone
- Cause and Effect Analysis
- Fault Tree Analysis
- KT (Kepner Tregoe)
- TapRoot® or Equifactor®
- PROACT®

RCA Case Study 1

High thrust bearing temperatures upon startup of a pump

Incident: Operations attempted several times to put the pump back on line; however, was forced to shut down due to observed high thrust bearing temperatures.



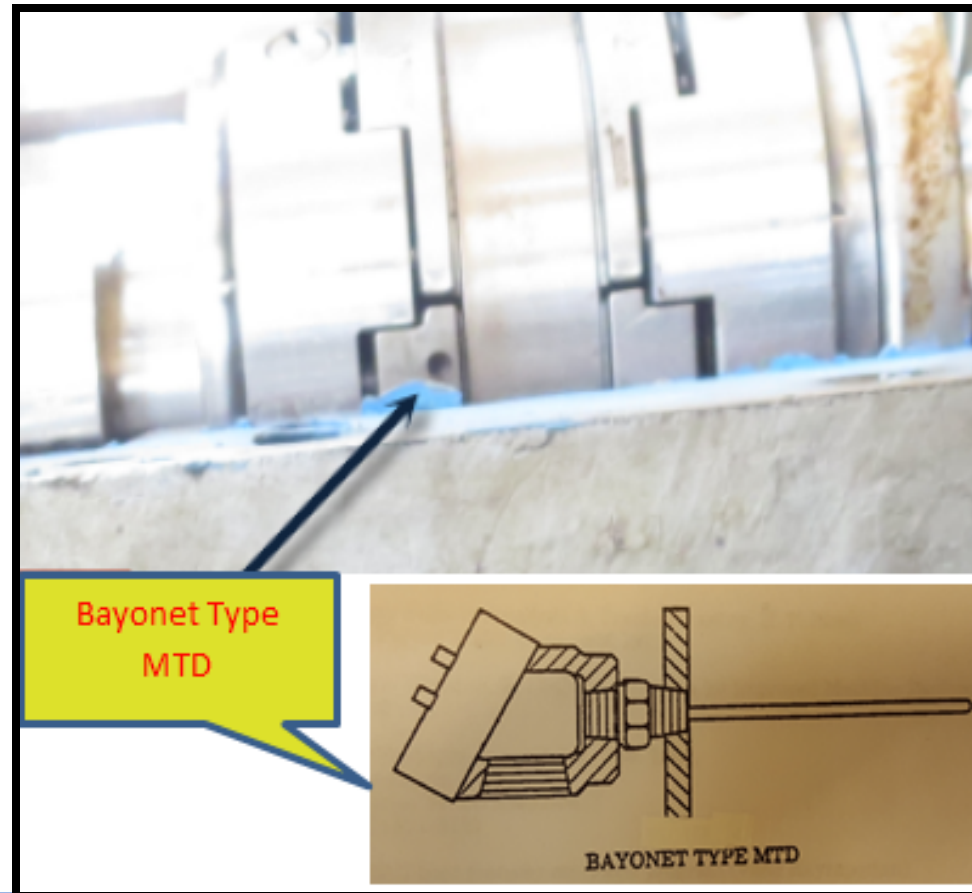
Physical Root Findings

- The Physical Root cause of these higher thrust bearing temperatures was found to be the RTD change incorporated in the thrust pads of the bearings.
- The temperatures as measured by the old style temperature device were far lower than the new embedded type.
- This was verified by pump OEM and the bearing manufacturer
- When the change was implemented on the sister pump, similar rise of bearing temperatures observed.



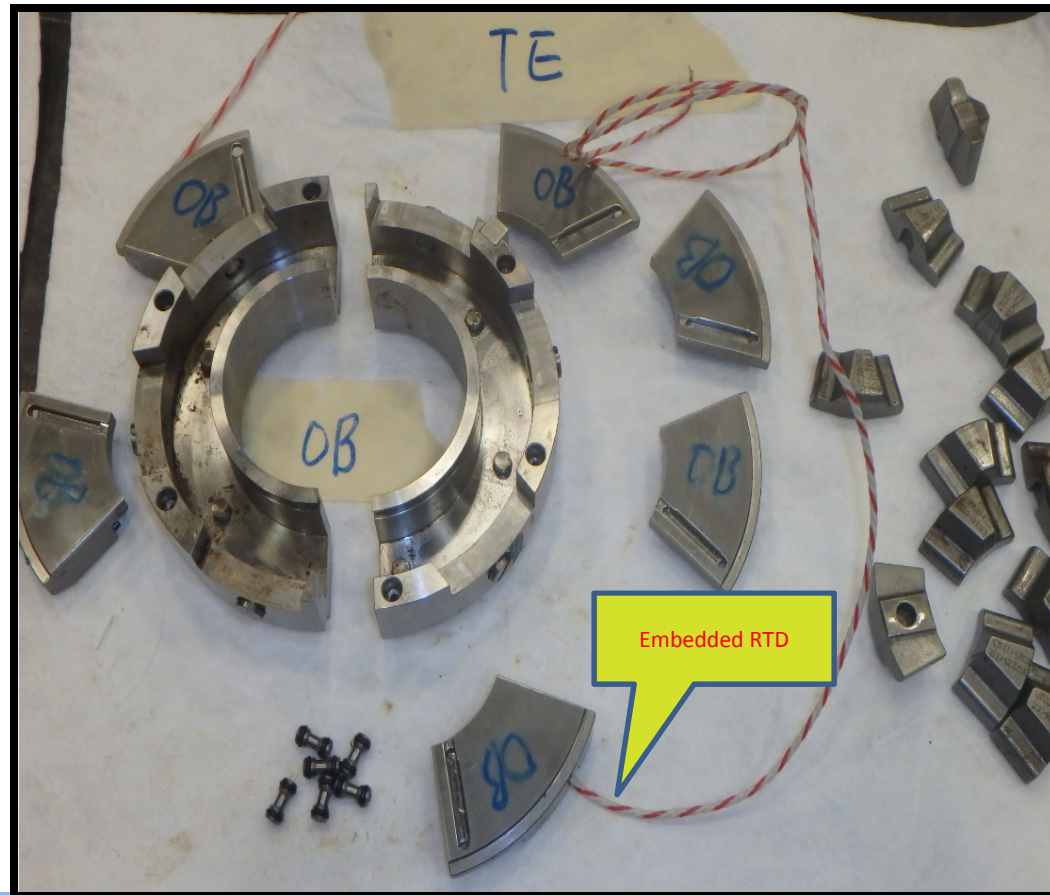
Bayonet Type MTD

Existing Temperature Measurement Device was Bayonet Type



Embedded RTD Thrust Pad

Changed Temperature Measurement Device to Embedded RTD



Human and Latent Roots Findings

- The Human Root was that change was not carried out following the proper MOC process.
- The Latent Root was that OEM failed to inform that higher temperatures will be observed upon changing to embedded type RTDs from existing Bayonet Type (A paradigm belief that client knows and will adjust the settings)



Recommendations

- Set the temperature alert and danger limits higher to accommodate changed bearing RTD conditions
- Follow proper Management of Change (MOC) business process for any changes in equipment



RCA Case Study 2

Bearing Failures

Incident:

Subsequent to major overhaul of a pump by a pump vendor, the pump installed and started with high drive end bearing temperatures and high vibrations. Pump taken off line and inspection of Drive End bearing revealed babbit wipe off on all five pads.



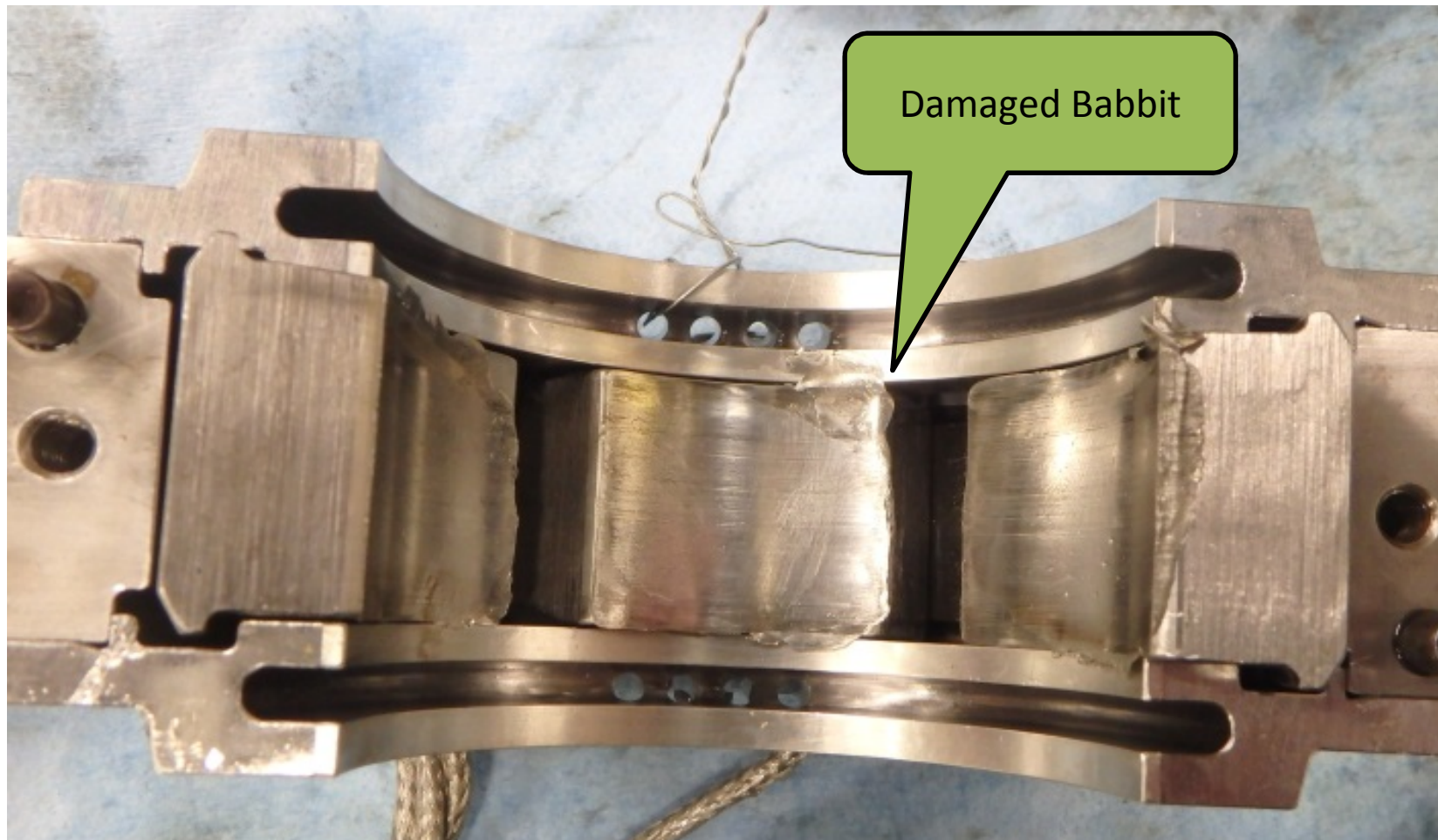
Physical Root Findings

- The Physical Root cause of the bearing failure was found to be insufficient clearance between the bearings and the bearing housing.
- The condition of the bearing housing at the time of the failure was such that there was an interference fit between the drive end bearing and the spherical bore of the bearing housing.
- This housing crush would prevent the bearing from self-aligning, resulting in clearance loss (bearing ID to shaft), rubbing and bearing failure.

Self-Aligning Tilt Pad Spherical Seat Journal Bearing



Damaged Babbit Due to Rubbing and Clearance Loss



Human and Latent Roots Findings

- The Human Root was that repair checks to compare required versus as left interference fit were not recorded.
- The Latent Root was that the Vendor failed to establish fit diameter checking criteria / procedure



Recommendations

- Include bearing fit checks in the repair scope
- Pump vendor to develop clear written step-by-step procedure and record required versus as left fits



Summary

- Root cause analysis helps to identify underlying causes of an incident so the most effective solution can be implemented
- Five steps are taken when completing a root cause analysis
- Completing RCA lets us learn from our mistakes while identifying what failed and what led to the failure to prevent recurring incidents

Questions?



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