



05



ANALYZE

Leverage a logic tree approach that will guide the team in assessing root cause hypotheses and utilize data to validate each hypothesis.



1

ROOT CAUSE ANALYSIS PROCESS STEPS

A systematic approach to uncover the true causes and drive lasting improvement.



01

IDENTIFY EVENTS

Identify undesirable events in the facility using human and digital data.



02

PRIORITIZE EVENTS

Identify the chronic events that account for 80% of the losses within the facility.



03

BUILD TEAM

Establish a cross functional team and appoint an unbiased RCA Facilitator.



04

COLLECT DATA

Gather data within the facility to validate the hypotheses put forth by the team.



05

ANALYZE

Leverage a logic tree approach that will guide the team in assessing root cause hypotheses and utilize data to validate each hypothesis.



06

COMMUNICATE ACTIONS

Convey RCA findings and corrective actions to stakeholders to ensure root causes are addressed.



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Practical Reliability Solutions



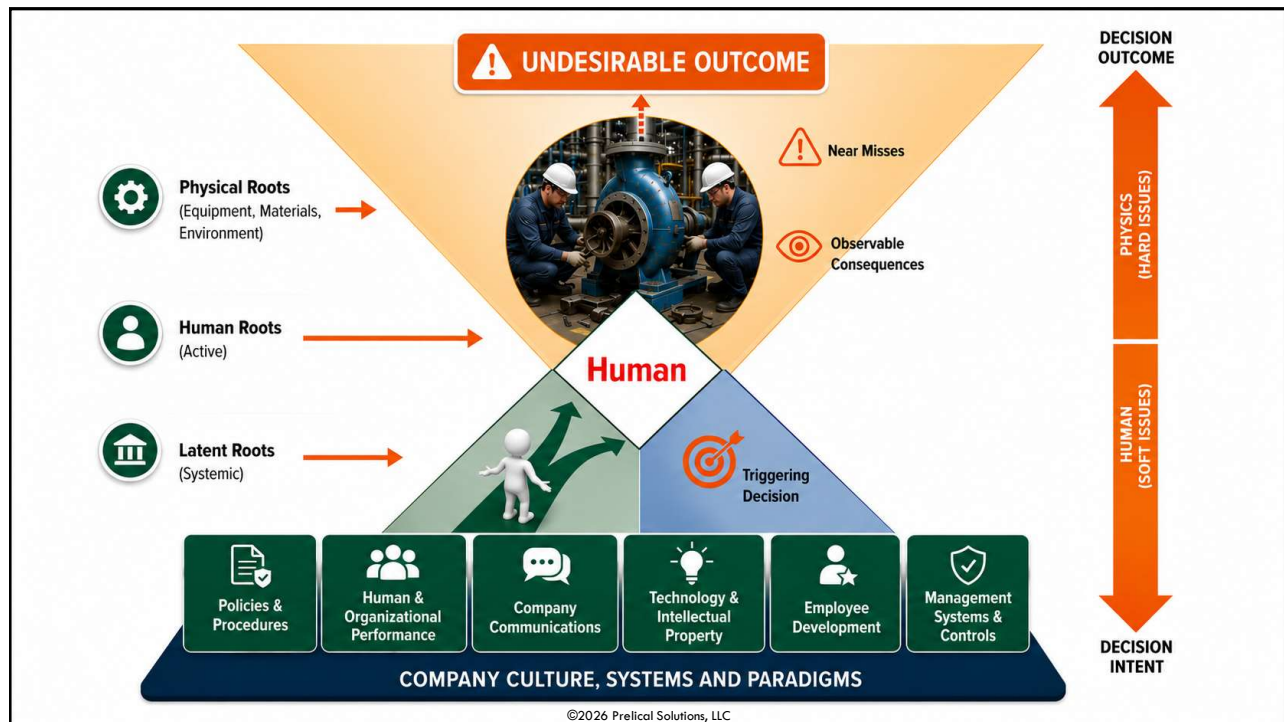
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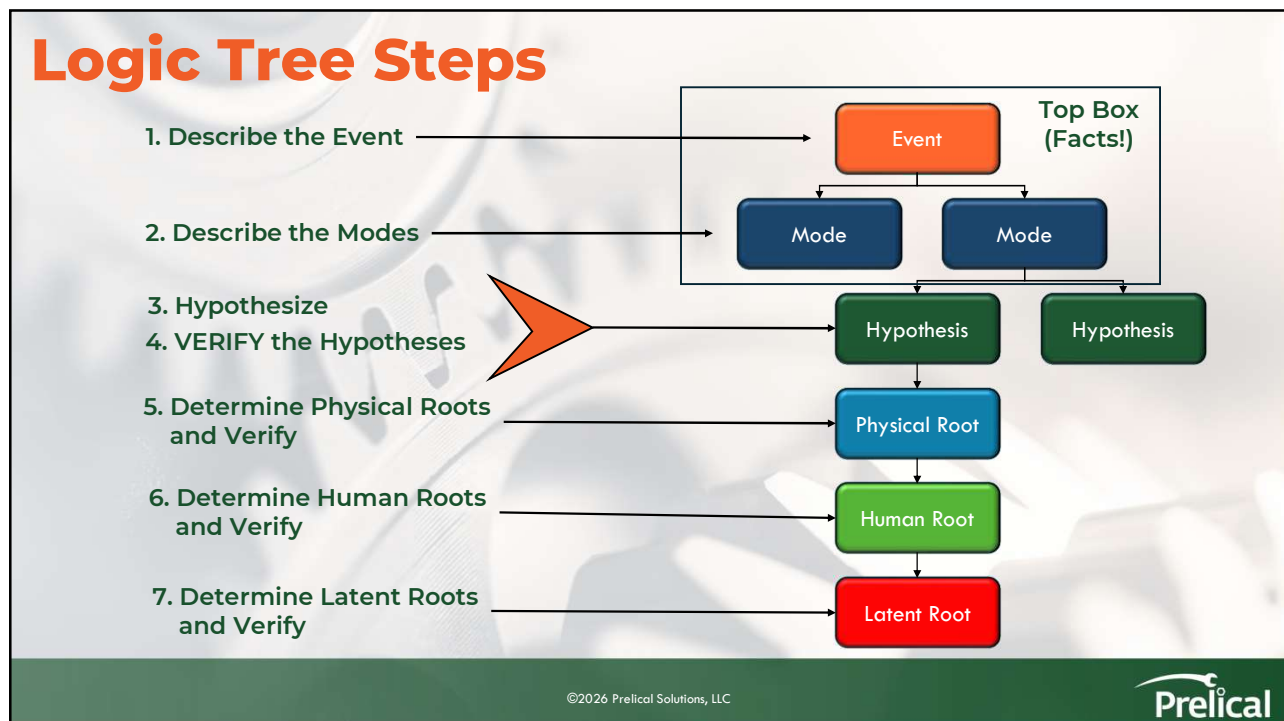
**Better Analysis.
Stronger Reliability.**

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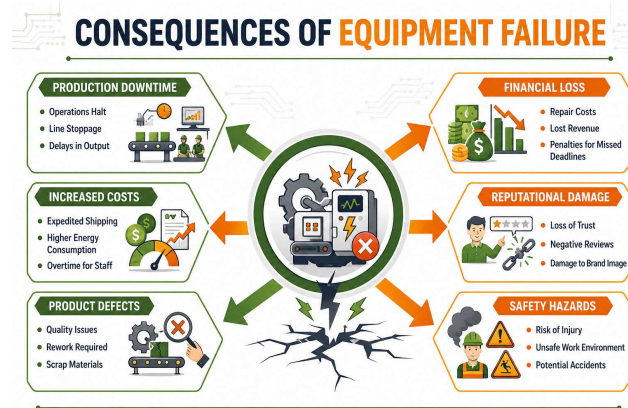
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1. Stating the Event

- The most important node on the logic tree
- Should reflect the key elements of the team's Problem Statement.
- "The Reason You Care"
- The Event description **MUST ONLY CONTAIN FACTS!!!!**



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2. Defining the Failure Mode

- Often the Mode is mistakenly identified as the Event.
- The Mode(s) are the observable failure mechanisms.
- The Mode(s) are anomalies that need to be explained.
- There can be more than 1 Mode on any given RCA.
- All Modes **MUST ONLY CONTAIN FACTS.**



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3. Hypotheses

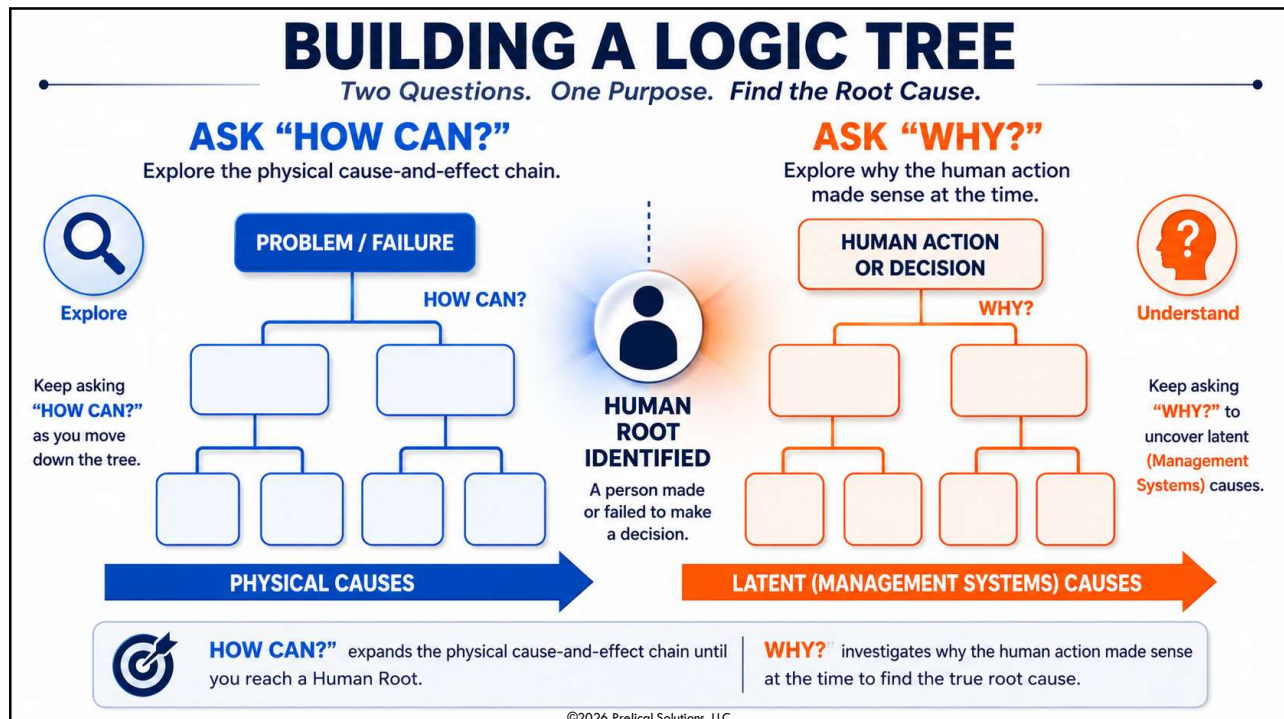
- Hypotheses are “educated guesses”.
- Ask How Can? And Why? to generate hypotheses
- The statement should reflect some type of deficiency (i.e. – lubrication Contamination vs. Lubrication)



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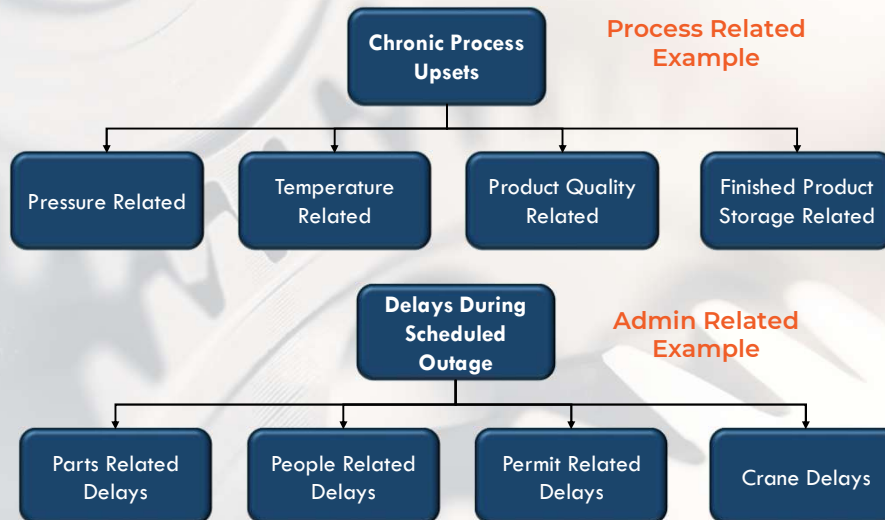
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Sample of Common Logic Tree Branches

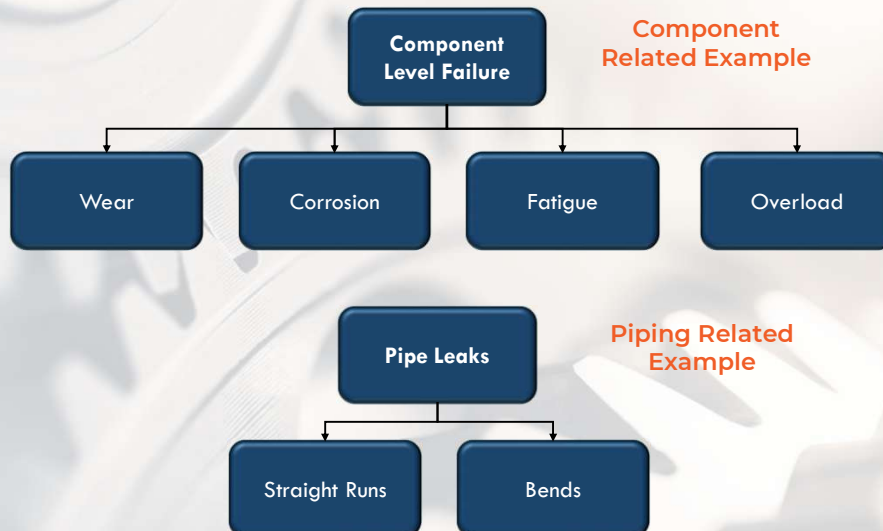


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Sample of Common Logic Tree Branches



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Sample of Common Logic Tree Branches

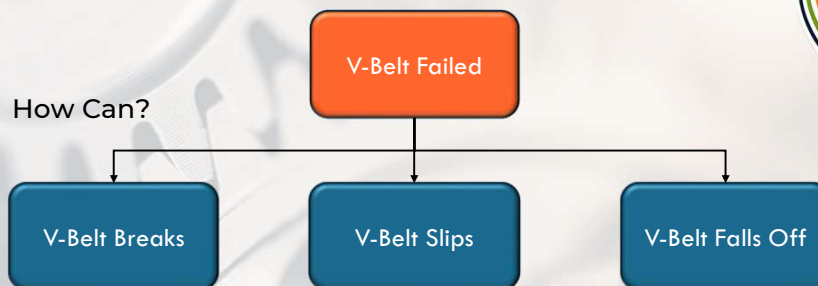


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Ensure Hypotheses are Broad and All Inclusive



The Test: Are **breaking, slipping, or coming off** the only ways a V-belt can fail?

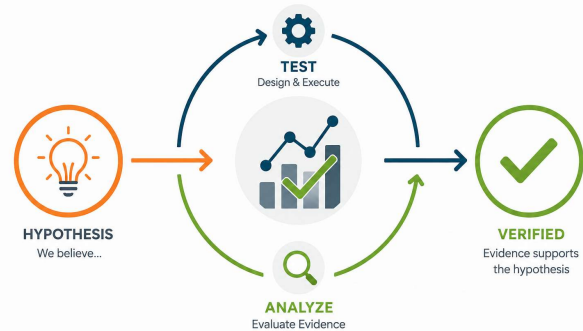
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4. Verify Hypotheses

- Every hypothesis on a logic tree should be verified true or untrue
- Utilize **whatever it takes** to ensure that your logic tree results are accurate
- Verifications can be aided by collecting the 5Ps in your data collection step
- There are numerous technologies that can be used to verify hypotheses

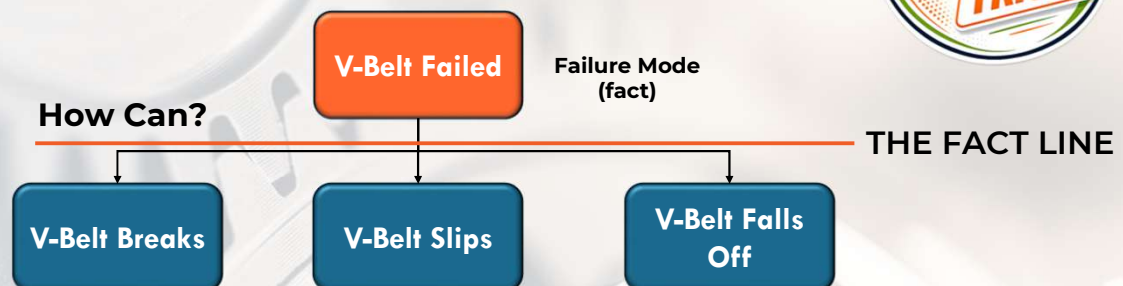


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Managing the Fact Line Verifications

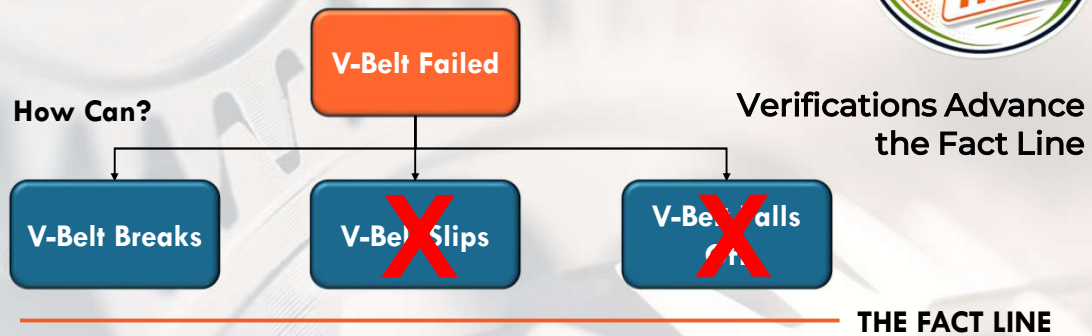


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Managing the Fact Line Verifications



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Maintain a Verification Log



Hypotheses	Verification Method	Resp.	Due Date	Completion Date	Verification Outcome
High Vibration on CP-235 Outboard Bearing	Review Vibration Alarm Limits and Histories	KCL	10.31.25	11.1.25	Review of Alarm Limits and Histories Reveals a Trending of Increased Vibration Starting on 9.23.25

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VISUAL VERIFICATION TECHNIQUES

Visual methods to verify hypotheses on an RCA logic tree



1. HIGH SPEED PHOTOGRAPHY

Captures fast events and transient phenomena to reveal failure sequences and mechanical behavior.



2. VIDEO CAMERAS

Documents operation and abnormal conditions in real time for review and correlation with event data.



3. BORESCOPIES

Inspects internal components and difficult-to-access areas without disassembly.



4. HUMAN OBSERVATION / ROUNDS

Uses trained senses and experience to detect visual clues, environmental factors, and operational anomalies.



5. STROBE LIGHTS

Freezes motion to identify vibration, worn components, misalignment, and other high-speed issues.



The right visual technique provides the evidence to confirm or eliminate hypotheses and drive your RCA to the true root cause.

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NDT VERIFICATION TOOLS

NDT techniques used to verify hypotheses on an RCA logic tree



1. LASER ALIGNMENT

Ensures proper alignment of rotating equipment to prevent vibration, wear, and premature failure.



2. VIBRATION MONITORING & ANALYSIS

Detects abnormal vibration patterns to identify mechanical issues such as imbalance, misalignment, or bearing defects.



3. ULTRASONICS

Uses high-frequency sound waves to detect internal flaws, thickness loss, and material discontinuities.



4. INFRARED THERMOGRAPHY

Identifies temperature variations to detect overheating, friction, electrical issues, and insulation problems.



5. LUBRICATION SAMPLING / ANALYSIS

Analyzes lubricant condition and contamination to assess equipment health and predict failures.



6. SCANNING ELECTRON MICROSCOPY

Provides high-resolution imaging to examine microstructure, fracture surfaces, and wear mechanisms.



7. MOTION AMPLIFICATION

Makes subtle vibrations visible in real time to identify dynamic movement and hidden structural issues.



The right NDT technique provides the evidence to confirm or eliminate hypotheses and drive your RCA to the true root cause.

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COMPREHENSIVE FAILURE ANALYSIS & MATERIAL TESTING

Advanced Testing. Accurate Answers. Root Cause Solutions.

A complete suite of analytical techniques to identify failure mechanisms, validate root causes, and support informed corrective actions.



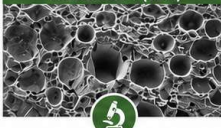
VISUAL EXAMINATION

Macroscopic inspection of components to identify visible features, damage, wear, and failure characteristics.



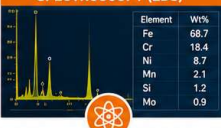
OPTICAL FRACTOGRAPHY

Detailed examination of fracture surfaces using stereo and metallurgical microscopy.



SCANNING ELECTRON MICROSCOPY (SEM)

High-resolution imaging to reveal microstructural details and fine fracture features.



ENERGY DISPERSIVE SPECTROSCOPY (EDS)

Element	Wt%
Fe	68.7
Cr	18.4
Ni	8.7
Mn	2.1
Si	1.2
Mo	0.9

Elemental analysis and composition at specific locations or areas of interest.



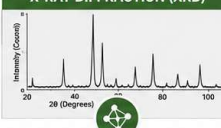
HARDNESS TESTING

Measurement of material hardness to assess strength, heat treatment, and material condition.



MECHANICAL TESTING

Evaluation of mechanical properties including tensile strength, yield strength, and elongation.



X-RAY DIFFRACTION (XRD)

Identification of crystalline phases and structural information in materials.



CHEMICAL ANALYSIS

Determination of elemental composition to verify material grade and detect contaminants or impurities.



METALLOGRAPHY

Preparation and examination of microstructures to evaluate grain structure, phases, and material integrity.

WHY IT MATTERS

- ✓ Identify true root causes
- ✓ Prevent repeat failures
- ✓ Support design improvements
- ✓ Ensure reliability and safety
- ✓ Protect assets and reputation

Science-based results. Industry-proven methods. Actionable solutions.

 **TESTING PERFORMED PER INDUSTRY STANDARDS**

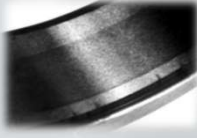
Including: **ASTM E2332**
Standard Practice for Investigation and Analysis of Physical Component Failures

 All testing performed in ISO 9001 registered laboratories using applicable specialized procedures.

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Quick Lesson in Component Failure Metallurgy 101

Wear



Uniform Loss of Metal

Corrosion



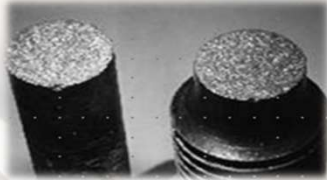
Pitting (Electrical Phenomena)

Fatigue



Cyclic Failure

Overload



Instantaneous Fracture

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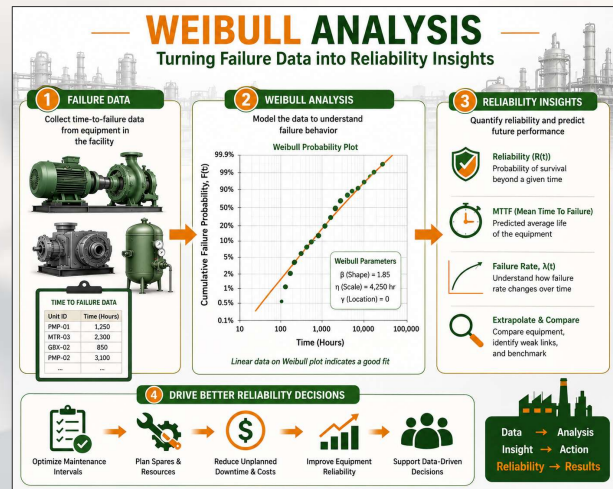
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RCA Verification Techniques

Reliability Data Analysis

Statistical analysis

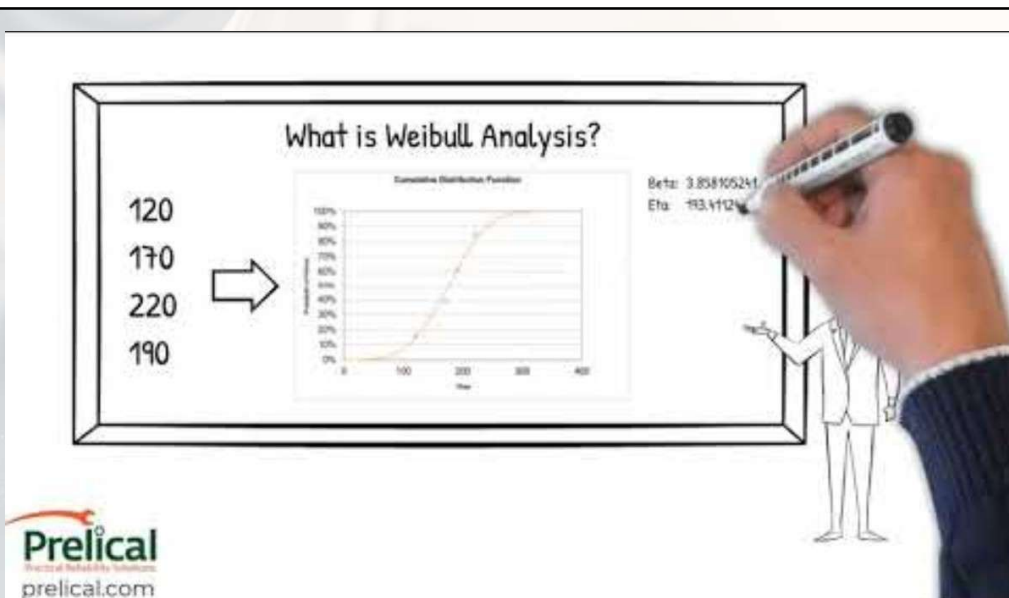
- Distribution analysis
 - Normal
 - LogNormal
 - **Weibull (used 95% of the time for reliability analysis)**
- Trend Tests
 - Army Material Systems Analysis Activity (AMSAA)



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<https://www.youtube.com/watch?v=u4S0qhFJO0Y>

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Sample Weibull Data for AI Analysis

Perform a Weibull analysis on this data. Single pump, bearing failures, data is in days. Make sure to include a cumulative distribution function.

TTF (Days)	TTF (Days)	TTF (Days)
118	576	1049
156	607	1102
173	639	1158
201	673	1217
219	708	1280
238	744	1346
255	782	1415
274	821	1488
292	863	
315	906	
333	952	
351	999	
372		
394		
417		
441		
466		
492		
519		
547		

Question 1

Perform a Weibull analysis on this data. Single pump, bearing failures, data is in days. Make sure to include a cumulative distribution function.

Question 2

What is the probability of failure considering the pump has been running successfully for 250 days and we need another 250 before our next planned outage.

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5. Determine Physical Roots and Verify

- Physical roots are often the primary, observable consequences of decisions.
- A decision often triggered this condition to become observable (i.e. Too much lubricant).
- There can be multiple Physical roots in any given RCA.



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6. Determine Human Roots and Verify

- Human roots are the choices/decisions people make, that trigger observable consequences.
- Human roots are acts of decision-making that are typically based on good intent, and often common business practices.
- Human roots are NOT the end of an analysis; they are often the beginning of the analysis.
- Unless there is malice with intent (sabotage), **BLAMING SOMEONE WILL RESULT IN A SHALLOW CAUSE ANALYSIS, NOT A ROOT CAUSE ANALYSIS!!**



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Human and Organizational Performance (HOP) Principles



Error is Normal

Mistakes are part of the process.



Blame Fixes Nothing

Focus on solutions, not on fault.



Learning is Vital

Improve through shared knowledge.



Context Drives Behavior

Understand the work environment.



How Leaders Respond Matters

Support and guide the team.

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Work as planned vs. work in practice

Normally successful!

“Workers are masters of the blue line.”

- Conklin/Edwards

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Drifting Into Complacency... “Forgetting to be Afraid”

Normalization of Deviance
(short-cuts turn into practice)

Potential

LTA
Supervisory
Oversight of
Safety

Migration to
Boundaries

Compliance (%)

100%

0%

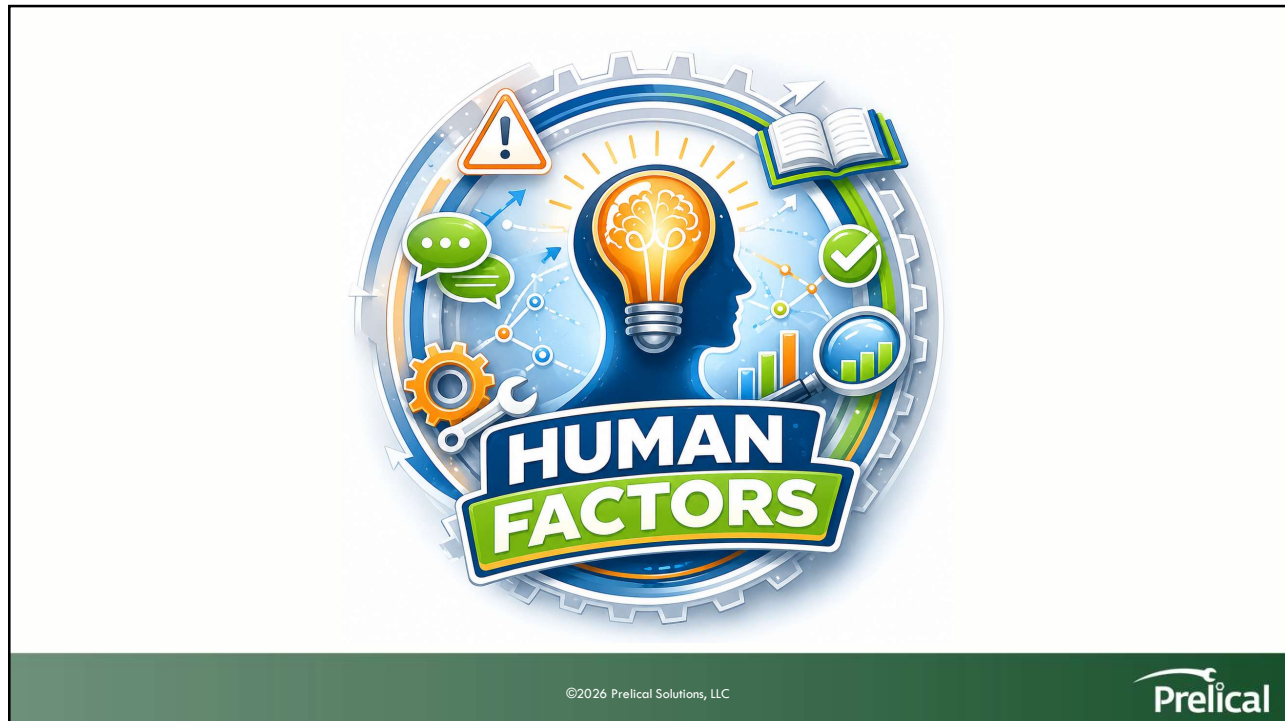
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Drift/Gradual Decline Into 'Unsafe Zone'

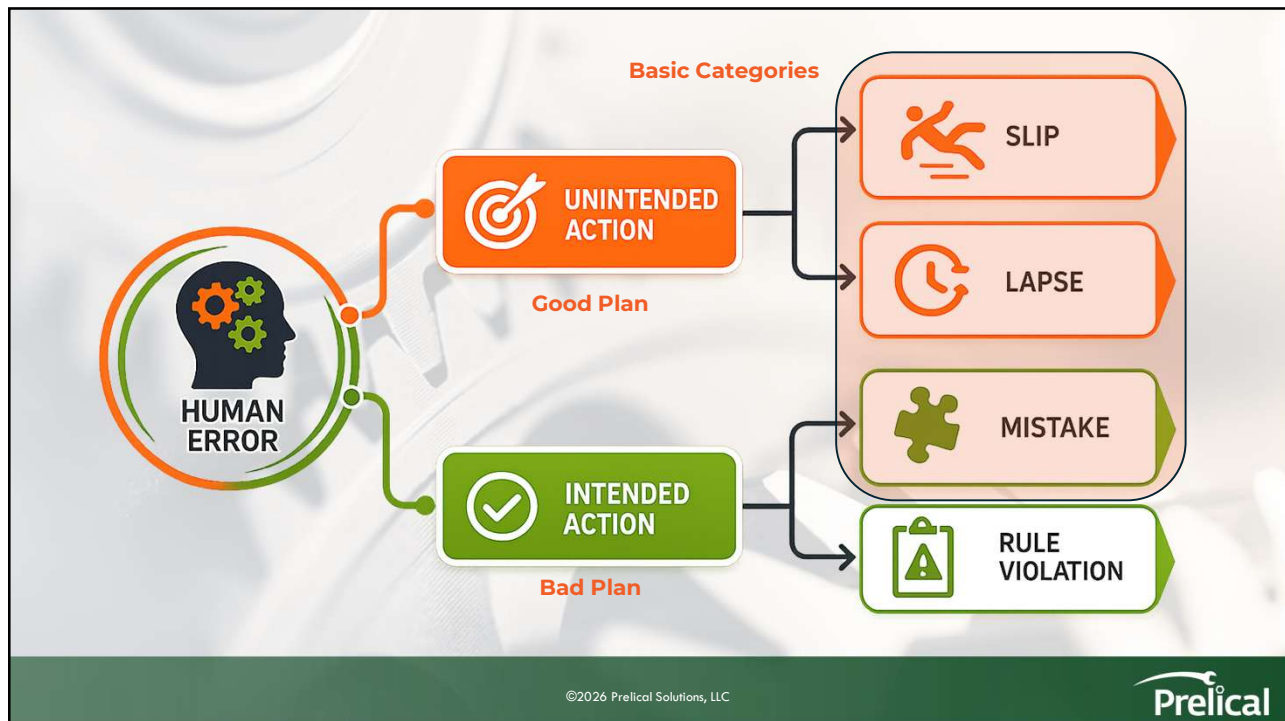
Unsafe Zone

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Why Do Mix-Ups Occur?

Human Factors in Design – Medication Labeling and Procedure Writing

Procedure Writing – Mixed Case:

The attending surgeon shall record in the medical record the correct side for and name of the surgical procedure

Procedure Writing – All Upper Case:

THE ATTENDING SURGEON SHALL RECORD IN THE MEDICAL RECORD THE CORRECT SIDE FOR AND NAME OF THE SURGICAL PROCEDURE



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8 0 4 5 4 8 0 6 4 5

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10 CHUNKS

8 | 0 | 4 | 5 | 4 | 8 | 0 | 0 | 6 | 4 | 5

3 CHUNKS

804 – 548 – 0645

EASIER TO REMEMBER.
Chunk it. Recall it.

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**A bird in the
the **hand** is
worth **two** in
the bush**

Perceptions are mental models
developed in the brain to
interpret incoming information
the way it **SHOULD BE**
versus the way that **it IS**.

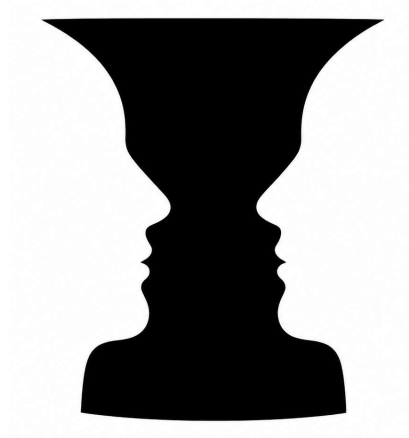
vs.

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What do you see?



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Perception Shapes Reality

She sees
a vase



We don't see things as they are.
We see them as we are.



He sees
two faces



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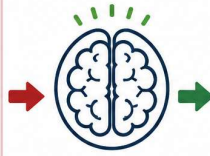
WE DON'T READ INDIVIDUAL LETTERS.

Your brain reads the words, not the letters

LETTERS OUT OF ORDER...

I cdnuolt blveiee taht
I cluod aulactly uesdnatnrd
waht I was rdanieg.
The phaonmneal pweor of
the hmuan mnid Aoccrdng
to a rscheearch at Cmabrigde
Uinervtisy, it deson't mtttaer
in waht oredr the ltteers in
a wrod are, the olny iprmoatnt
tihng is taht the frist and lsat
ltteer be in the rghit pclae.

Amzanig huh?



Your brain instantly
recognizes words
and fills in the rest.

EASILY READ AND UNDERSTOOD!

I couldn't believe that
I cloud actually understand
what I was reading.
The phenomenal power of
the human mind According
to a research at Cambridge
University, it doesn't matter
in what order the letters in
a word are, the only important
thing is that the first and last
letter be in the right place.

Amazing huh?



FAST. AUTOMATIC. EFFORTLESS.
That's the power of your brain.



We don't read every letter.
We understand the whole.

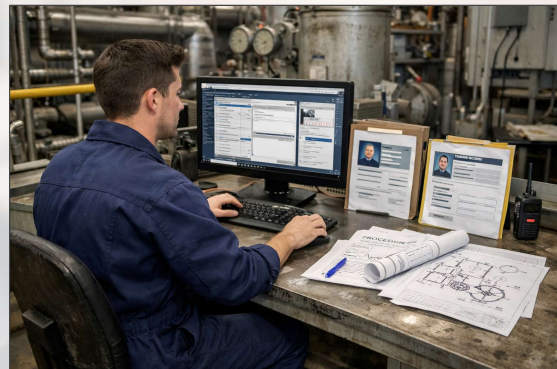
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7. Determine Latent (Systemic) Roots and Verify

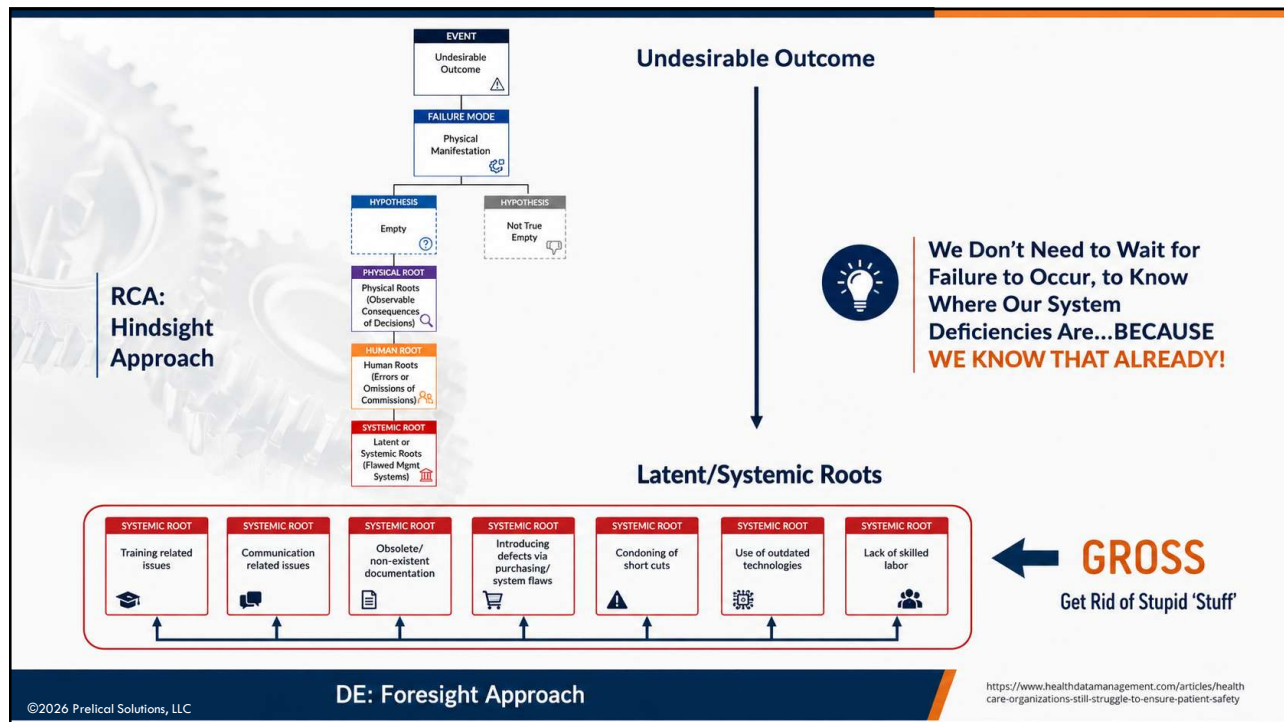
- Latent roots represent the human reasoning for a decision error.
- These are the answers to 'WHY?' people made the decisions they did, that day.
- Latent roots are often the flawed organizational systems that decision-makers relied on, to make their decision.
- Such organizational systems could be inadequate, insufficient, or non-existent.



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IT'S TIME FOR
EasyRCA
SOFTWARE TRAINING!

Learn • Explore • Apply • Solve

EASY TO LEARN
Powerful & Intuitive

BUILT FOR RCA
Structured & Effective

BETTER TOGETHER
Collaborate & Share

DRIVE RESULTS
Find Root Causes & Prevent Recurrence

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GROUP EXERCISE



FLASHLIGHT

WILL NOT TURN ON





YOUR TASK

Build a logic tree to identify **ALL** potential causes for why the flashlight will not turn on.

- Start broad.
- Ask questions.
- Follow the evidence.
- Look for physical, human, and latent (system) causes.



SCENARIO

During a power outage, this emergency flashlight was needed but did not turn on.



INVESTIGATE



BUILD LOGIC TREE



FIND ROOT CAUSES

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01

BEGIN LOGIC TREE CONSTRUCTION

Using the Problem Statement, condense into an Event Statement

02

VALIDATE HYPOTHESES USING DATA PREVIOUSLY COLLECTED (VIRTUALLY)

Using the 5-Ps as evidence, prove or disprove hypotheses

03

CONTINUE DOWN LOGIC TREE UNTIL LATENT/SYSTEM ROOTS ARE IDENTIFIED

Properly identify the Physical, Human, and Latent Root Causes

04

PROPOSE CORRECTIVE ACTIONS FOR ACTIONABLE ROOT CAUSES

Focus of Corrective Actions that mitigate or eliminate the identified roots

05

PRESENT CASE STUDY TO LEADERSHIP (REST OF CLASS)

Share findings, root causes, and corrective actions



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