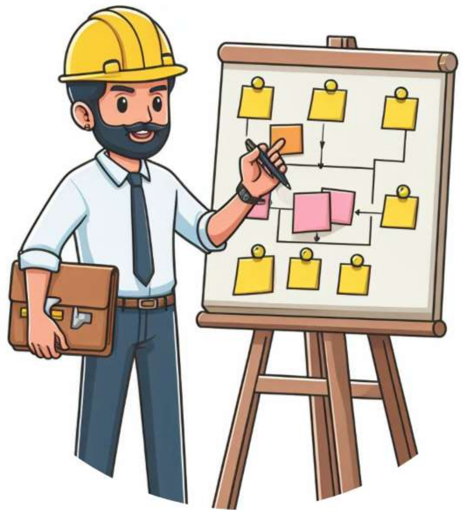
Analysis Tools

- Logic Tree
  - 5 Whys



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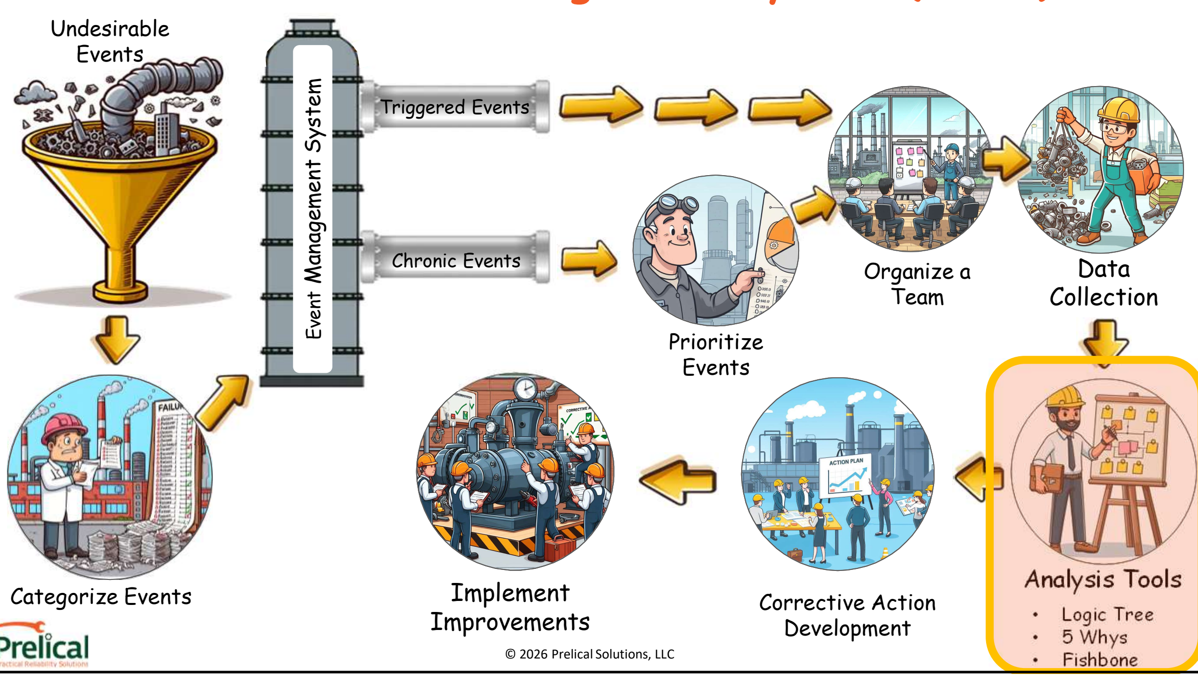
Prelical Event Management System (PEMS)



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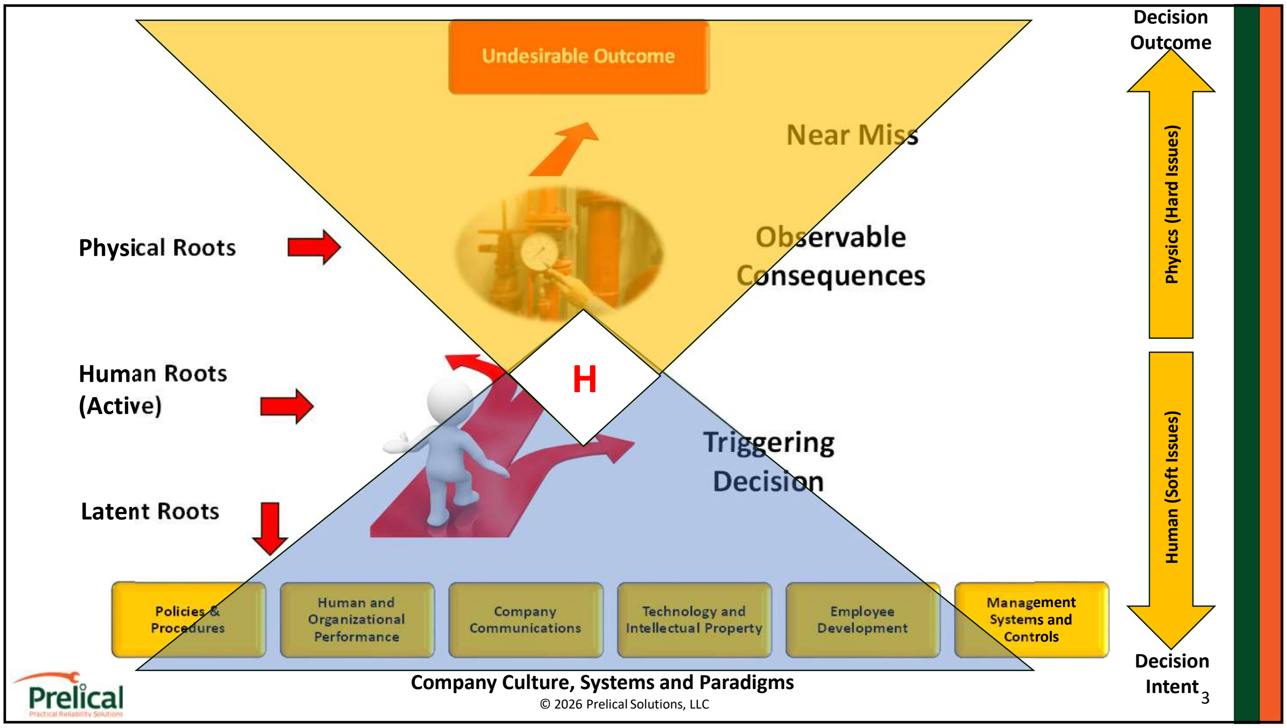

Undesirable Outcome
Near Miss
Observable Consequences
Physical Roots
Human Roots (Active)
Latent Roots
H
Triggering Decision
Policies & Procedures
Human and Organizational Performance
Company Communications
Technology and Intellectual Property
Employee Development
Management Systems and Controls
Company Culture, Systems and Paradigms
Decision Outcome
Physics (Hard Issues)
Human (Soft Issues)
Decision Intent
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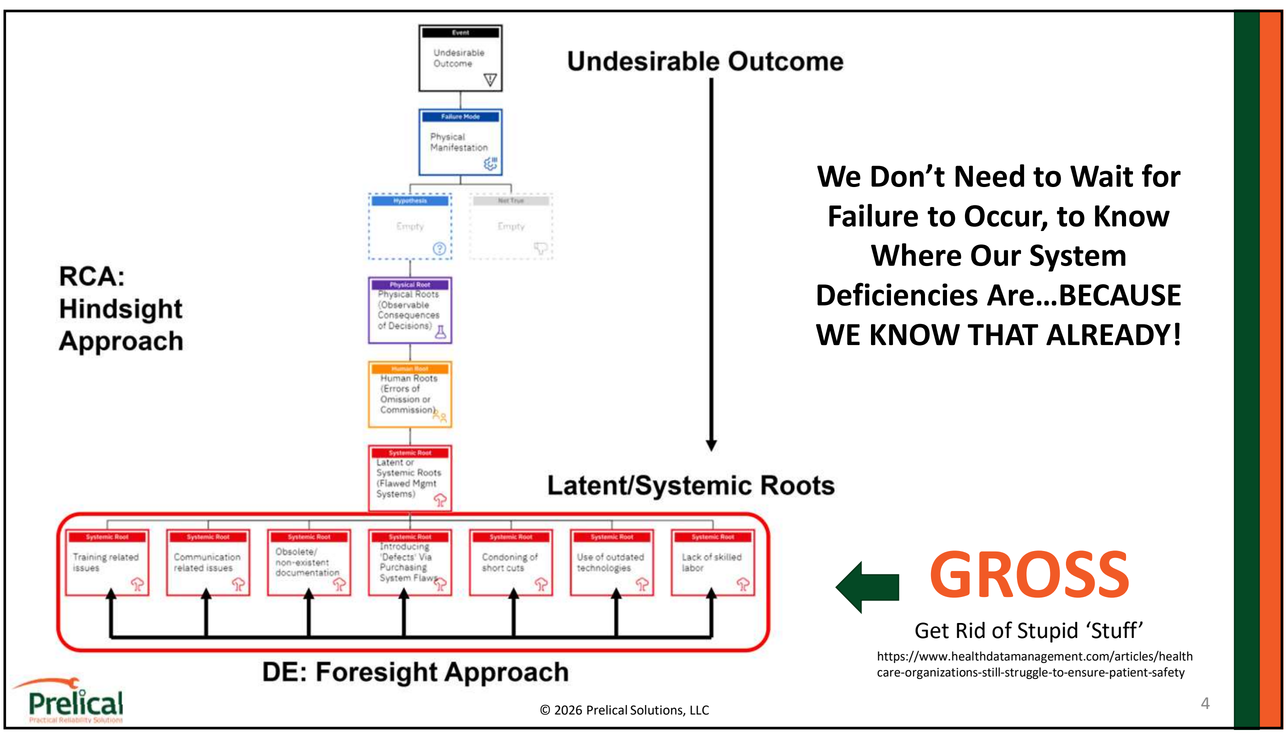

Event
Undesirable Outcome
Failure Mode
Physical Manifestation
Hypothesis
Empty
Not True
Empty
Physical Root
Physical Roots (Observable Consequences of Decisions)
Human Root
Human Roots (Errors of Omission or Commission)
Systemic Root
Latent or Systemic Roots (Flawed Mgmt Systems)
Training related issues
Communication related issues
Obsolete/ non-existent documentation
Introducing 'Defects' Via Purchasing System Flaws
Condoning of short cuts
Use of outdated technologies
Lack of skilled labor
Undesirable Outcome
Latent/Systemic Roots
RCA: Hindsight Approach
DE: Foresight Approach
We Don't Need to Wait for Failure to Occur, to Know Where Our System Deficiencies Are…BECAUSE WE KNOW THAT ALREADY!
GROSS
Get Rid of Stupid 'Stuff'
https://www.healthdatamanagement.com/articles/health care-organizations-still-struggle-to-ensure-patient-safety
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What is HOP?

#	HOP* Core Principles
1	People make mistakes
2	Blame fixes nothing
3	Context drives behavior
4	Learning is vital
5	Response matters

HOP = Human and Organizational Performance

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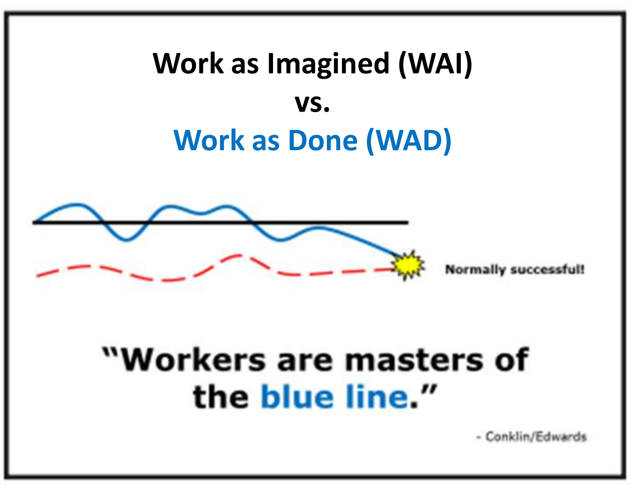
HOP* and the ‘Blue Line’



* **HOP** = Human & Organizational Performance

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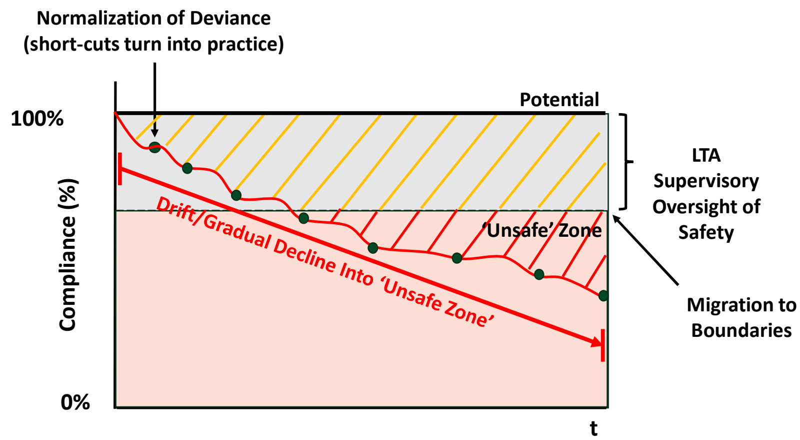
Drifting Into Complacency…
“Forgetting to be Afraid”



Are All RCA Tools Created Equal?

Source: Pixabay.com

Using the Right Tool for the Analysis at Hand

Logic Tree

5 - Whys

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Exploring the 2 Most Common RCA Tools

5-WHYS

Problem → Why? → Why? → Why? → Why? → Why?

Logic Tree

- Event
  - Mode
  - Mode
    - Hypothesis
      - Physical Root
        - Human Root
          - Latent Root
    - Hypothesis

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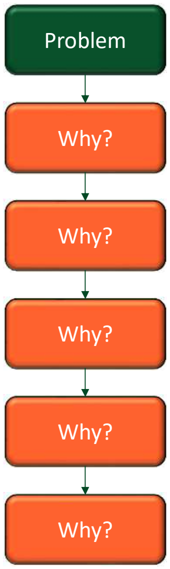
5-Whys



The "5 Whys" technique is a problem-solving and root cause analysis method aimed at uncovering the underlying reasons for an issue by repeatedly asking "why" questions.

Pros	Cons
Simple execution	Uses linear logic
Quick results	Concludes with 1 root cause
Individual and/or Team Based	'Why' questioning is limited
Limited data/evidence collection required	Seeks opinions
Reactive and proactive application	Lacks technical capability to explore multiple paths of failure
Big contributor to Defect Elimination (DE) Efforts	Often concludes with replacing parts and/or blaming decision-makers

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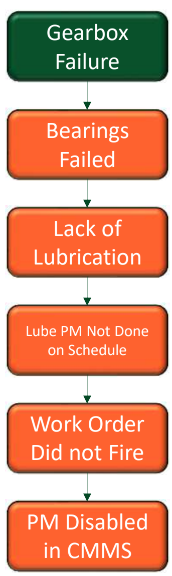
5-Whys Example



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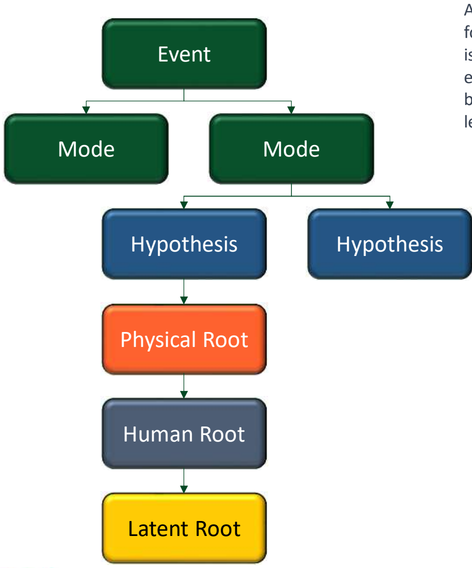
Logic Tree (a.k.a. Causal Factor Tree)



An RCA Logic Tree, or Root Cause Analysis Logic Tree, is a structured and hierarchical method for organizing and visually representing the causes and effects related to a specific problem or issue. It is a visual tool used in the context of Root Cause Analysis (RCA) to systematically explore and analyze the various causes (physical, human and latent) and contributing factors behind a problem. This tool helps in understanding the cause-and-effect relationships and will lead to the identification of root causes.

Pros	Cons
Very disciplined	Time consuming
Requires extensive data collection	Requires extensive data collection
Requires diversity of team members	Requires SMEs as needed
Requires unbiased facilitator	Requires accountable team
Reactive and proactive application	Requires management support
Explores multiple, simultaneous paths to failure	
Explores how mgmt systems influence decision making	
Can explore Human and Organizational Performance (HOP) Issues	

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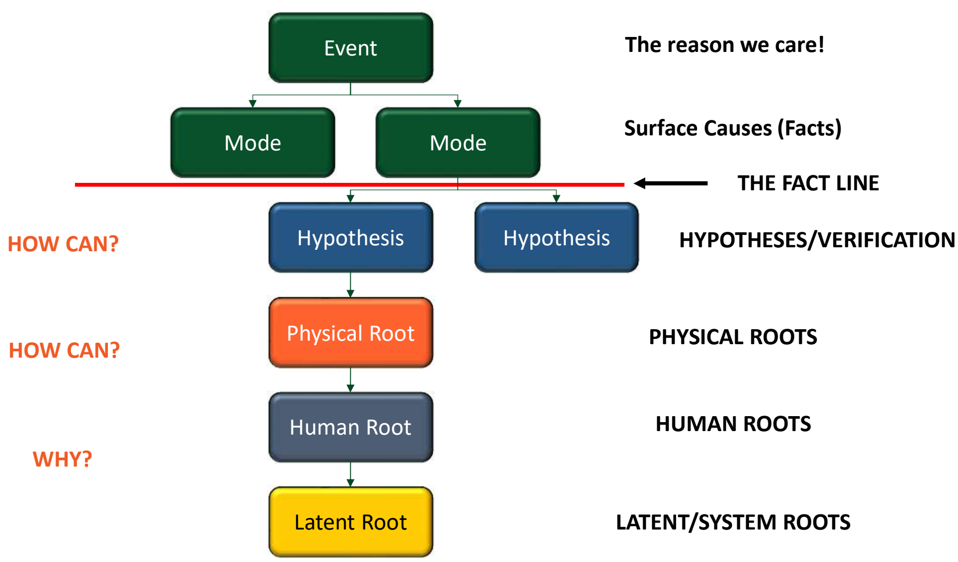
Basic Logic Tree Elements Used for Event Reconstruction



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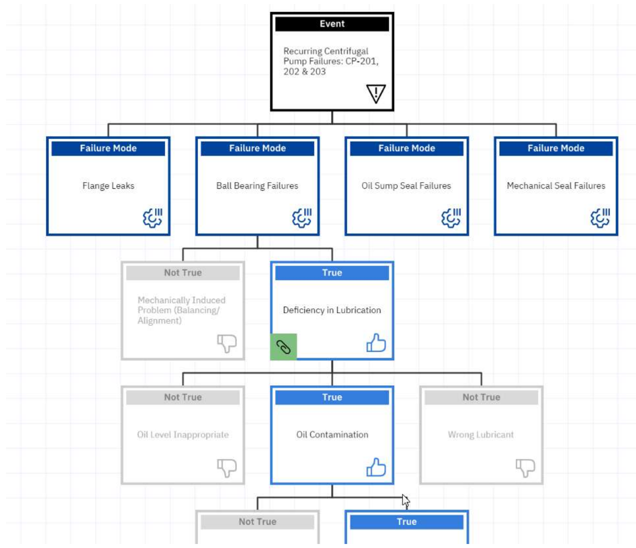
Group Exercise – Building a Logic Tree



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Stating the Event

On 11.1.2X at 2a ET we experienced an unexpected outage lasting 4 hours, and resulting in $525k of total aggregate losses

Example

Considerations When Stating the Event
The most important node on the logic tree. It is a direct link to leadership about the business impact of the Event, and why they should be interested in the RCA.
Should reflect the key elements of the team's Problem Statement.
At its core, the Event is the 'reason you care' enough to do an RCA.
Least acceptable consequence
The Event description MUST ONLY CONTAIN FACTS!!!!

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Stating the Mode(s)

Critical Pump (P-100)
Bearing Failure

Example

Considerations When Stating the Mode(s)
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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Exploring the Hypotheses

Hypothesis

Considerations When Exploring Hypotheses
Hypotheses are “educated guesses”.
When coming off facts (from the parent nodes), these are the potential answers to the question ‘How Could?’ and ‘Why?’. We will explore when it is appropriate to ask which questions in a few minutes.
The statement should reflect some type of deficiency (i.e. – lubrication vs. lubricant contamination, or frequency was less than adequate)

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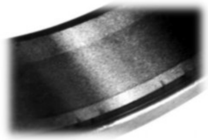
Exploring the Hypotheses

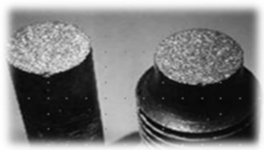
Erosion



Corrosion

Fatigue

Overload



"How Could P-100 Bearing Have Failed?"

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RCA Verification Techniques

Visual Techniques

- Metallurgical Analysis
- High Speed Photography
- Video Cameras
- Borescopes
- Human Observation/Rounds
- Strobe Lights

NDT Tools

- Laser Alignment
- Vibration Monitoring & Analysis
- Ultrasonics
- Infrared Thermography
- Lubrication Sampling/Analysis
- Scanning Electron Microscopy
- Experimental Stress Analysis
- Motion Amplification

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- Mechanical Failure
  - Corrosion
  - Fatigue
  - Overload
  - Erosion

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Overload Failures

- Ductile
- Brittle

Example of a Ductile Overload

A Brittle Overload would not
be deformed and would be fractured

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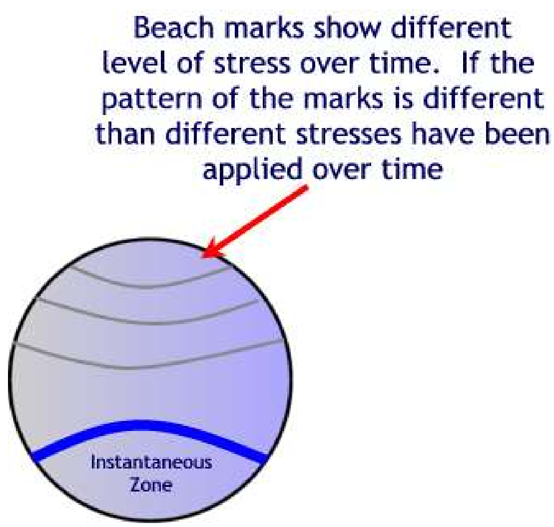
Fatigue Failures

- Bending
- Torsion
- Tension



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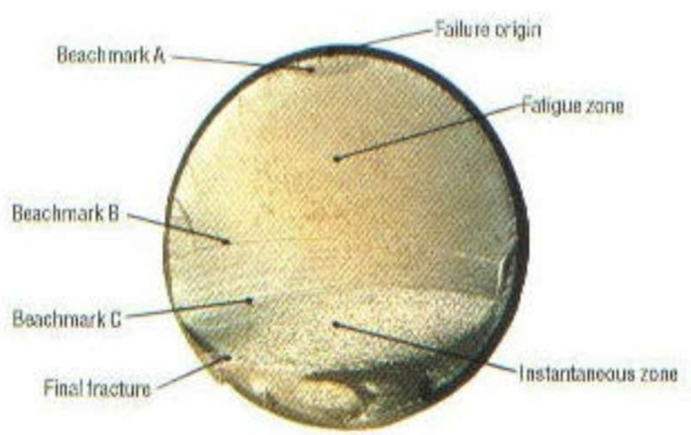
Fatigue Failures



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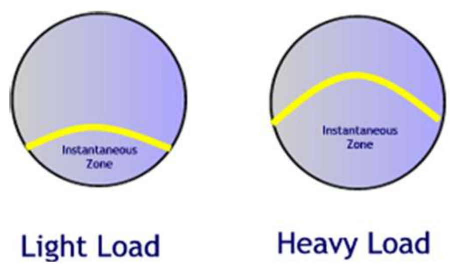
Fatigue Failures



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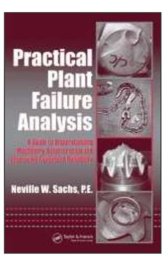
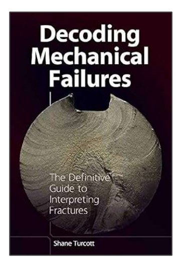
Reference Books



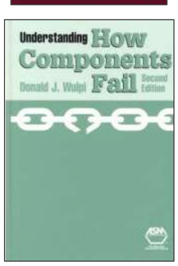
Practical Plant Failure Analysis

ISBN: 0849333768



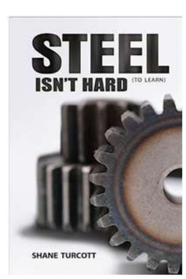
Decoding Mechanical Failures

ISBN: 1777157609



How Components Fail

ISBN: 0871701898



Steel Isn't Hard (to Learn)

ISBN: 978-1777157616

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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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RCA Verification Techniques

Reliability Data Analysis

Why use statistical analysis?

- To identify a failure pattern
- Provides capability to assess failure risk
- Provides accurate estimation of MTBF
- Helps make general assumptions about seemingly unrelated data
- Example: Weibull Analysis

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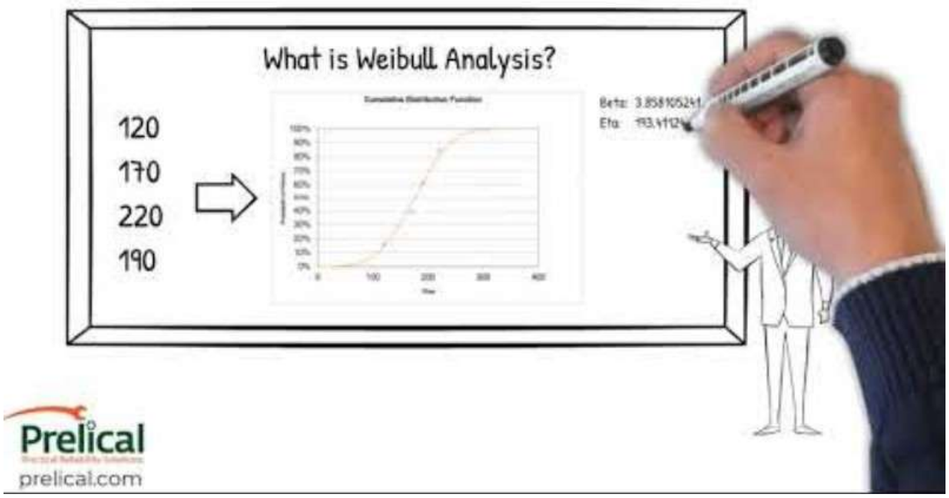
Weibull Analysis - Overview



Can you explain these calculations?

10 Oscillatory Motion Chap. 1

Another example is the free vibration of a multidegree-of-freedom system, to which the vibrations at each natural frequency contribute. Such vibrations result in a complex waveform, which is repeated periodically as shown in Fig. 1.2-1.

The French mathematician J. Fourier (1768–1830) showed that any periodic motion can be represented by a series of sines and cosines that are harmonically related. If $x(t)$ is a periodic function of the period τ, it is represented by the Fourier series

$$x(t) = \frac{a_0}{2} + a_1 \cos \omega_1 t + a_2 \cos \omega_2 t + \cdots + b_1 \sin \omega_1 t + b_2 \sin \omega_2 t + \cdots \tag{1.2-1}$$

where

$$\omega_1 = \frac{2\pi}{\tau}$$
$$\omega_n = n\omega_1$$

To determine the coefficients a_n and b_n, we multiply both sides of Eq. (1.2-1) by $\cos \omega_n t$ or $\sin \omega_n t$ and integrate each term over the period τ. Recognizing the following relations,

$$\begin{aligned}
\int_{-\tau/2}^{\tau/2} \cos \omega_n t \cos \omega_m t \, dt &= \begin{cases} 0 & \text{if } m \neq n \\ \tau/2 & \text{if } m = n \end{cases} \\
\int_{-\tau/2}^{\tau/2} \sin \omega_n t \sin \omega_m t \, dt &= \begin{cases} 0 & \text{if } m \neq n \\ \tau/2 & \text{if } m = n \end{cases} \\
\int_{-\tau/2}^{\tau/2} \cos \omega_n t \sin \omega_m t \, dt &= \begin{cases} 0 & \text{if } m \neq n \\ 0 & \text{if } m = n \end{cases}
\end{aligned} \tag{1.2-2}$$

all terms except one on the right side of the equation will be zero, and we obtain the result

$$\begin{aligned}
a_n &= \frac{2}{\tau} \int_{-\tau/2}^{\tau/2} x(t) \cos \omega_n t \, dt \\
b_n &= \frac{2}{\tau} \int_{-\tau/2}^{\tau/2} x(t) \sin \omega_n t \, dt
\end{aligned} \tag{1.2-3}$$

The Fourier series can also be represented in terms of the exponential function. Substituting

$$\cos \omega_n t = \tfrac{1}{2}(e^{i\omega_n t} + e^{-i\omega_n t})$$
$$\sin \omega_n t = -\tfrac{i}{2}(e^{i\omega_n t} - e^{-i\omega_n t})$$

Chap. 1.2 Periodic Motion 11

in Eq. (1.2-1), we obtain

$$\begin{aligned}
x(t) &= \frac{a_0}{2} + \sum_{n=1}^{\infty} \left[\tfrac{1}{2}(a_n - ib_n) e^{i\omega_n t} + \tfrac{1}{2}(a_n + ib_n) e^{-i\omega_n t} \right] \\
&= \frac{a_0}{2} + \sum_{n=1}^{\infty} \left[c_n e^{i\omega_n t} + c_n^* e^{-i\omega_n t} \right] \\
&= \sum_{n=-\infty}^{\infty} c_n e^{i\omega_n t}
\end{aligned} \tag{1.2-4}$$

where

$$\begin{aligned}
c_0 &= \tfrac{1}{2} a_0 \\
c_n &= \tfrac{1}{2}(a_n - ib_n)
\end{aligned} \tag{1.2-5}$$

Substituting for a_n and b_n from Eq. (1.2-3), we find c_n to be

$$\begin{aligned}
c_n &= \frac{1}{\tau} \int_{-\tau/2}^{\tau/2} x(t)(\cos \omega_n t - i \sin \omega_n t) \, dt \\
&= \frac{1}{\tau} \int_{-\tau/2}^{\tau/2} x(t) e^{-i\omega_n t} \, dt
\end{aligned} \tag{1.2-6}$$

Some computational effort can be minimized when the function $x(t)$ is recognizable in terms of the even and odd functions

$$x(t) = E(t) + O(t) \tag{1.2-7}$$

An even function $E(t)$ is symmetric about the origin so that $E(t) = E(-t)$, i.e., $\cos \omega t = \cos(-\omega t)$. An odd function satisfies the relationship $O(t) = -O(-t)$, i.e., $\sin \omega t = -\sin(-\omega t)$. The following integrals are then helpful:

$$\begin{aligned}
\int_{-\tau/2}^{\tau/2} E(t) \sin \omega_n t \, dt &= 0 \\
\int_{-\tau/2}^{\tau/2} O(t) \cos \omega_n t \, dt &= 0
\end{aligned} \tag{1.2-8}$$

When the coefficients of the Fourier series are plotted against frequency ω_n, the result is a series of discrete lines called the *Fourier spectrum*. Generally plotted are the absolute values $|2c_n| = \sqrt{a_n^2 + b_n^2}$ and the phase $\phi_n = \tan^{-1} b_n/a_n$, an example of which is shown in Fig. 1.2-2.

With the aid of the digital computer, harmonic analysis today is efficiently carried out. A computer algorithm known as the *fast Fourier transform*† (FFT) is commonly used to minimize the computation time.

†See J. S. Bendat & A. G. Piersol, *Random Data* (New York: John Wiley & Sons, 1971), pp. 305–306.

Can you interpret this graph?

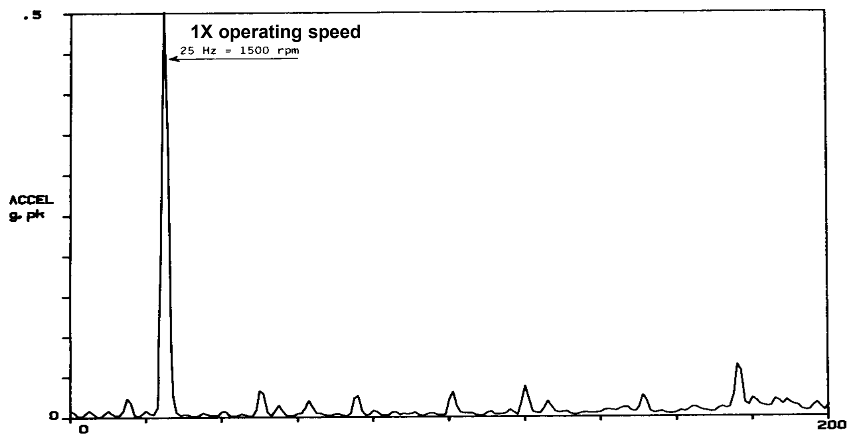


Figure 5.5 Spectrum of imbalance created in a tabletop demonstration machine turning at 1500 rpm (25 Hz).

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What's the point?

- You don't have to know the FFT theory to benefit from Vibration Analysis.
- Likewise, you don't have to know statistical methods theory to benefit from statistical analysis of failure data.
- You just need know how to apply the methods and interpret the results!

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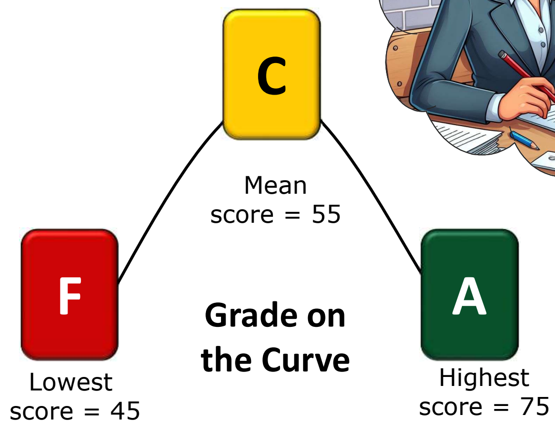
Our First Introduction to Statistics!

Grades	
Student	**Score**
Jack	45
Beth	55
Joe	60
Mike	60
Lisa	55
Fred	50
Lynn	50
Jason	75
Sara	55
Tina	55
Chris	65



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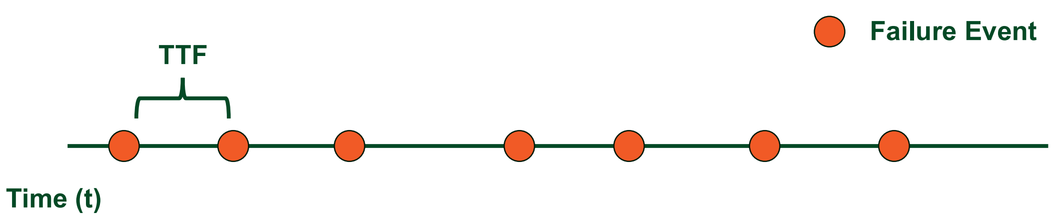
Distribution Analysis

Mean **T**ime **B**etween **F**ailure (**MTBF**)



$$\text{MTBF} = \frac{\text{TTF1} + \text{TTF2} + \text{TTF3} + \text{TTF4} + \text{TTF5} + \text{TTF6}}{6}$$

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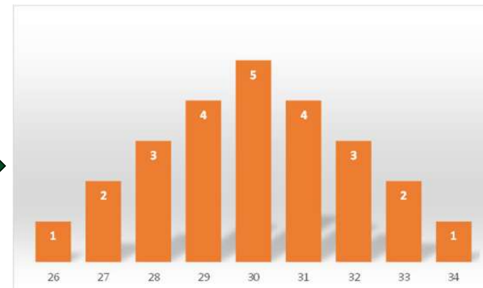
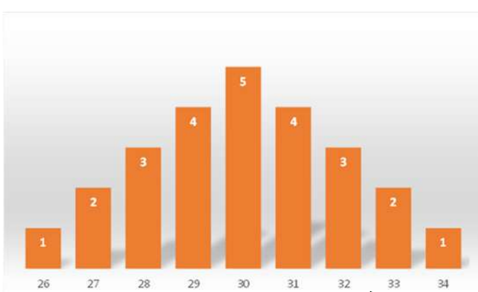
Normal Distribution

Asset ID	TTF
Asset101	26
Asset101	28
Asset101	33
Asset101	33
Asset101	27
Asset101	30
Asset101	32
Asset101	34
Asset101	28
Asset101	29
Asset101	30
Asset101	32
Asset101	27
Asset101	28
Asset101	30
Asset101	31
Asset101	29
Asset101	31
Asset101	31
Asset101	29
Asset101	30
Asset101	32
Asset101	30
Asset101	29
Asset101	31

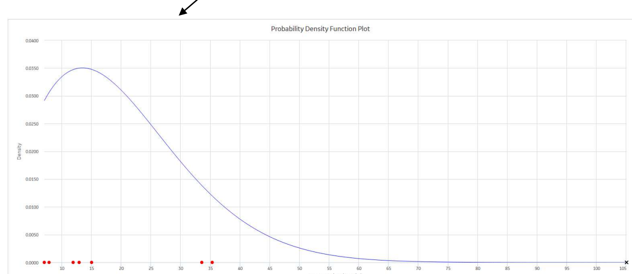
TTF	n
26	1
27	2
28	3
29	4
30	5
31	4
32	3
33	2
34	1



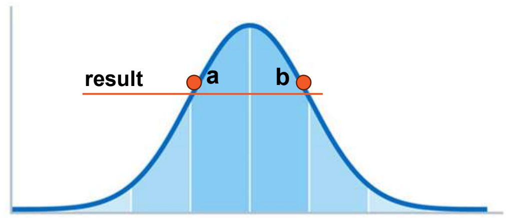
Normal Distribution



PDF = f(t)
Probability Density Function



Interpreting MTBF Results



PDF = f(t)

If you solve the **PDF** at points **a** and **b**, and you get the same results ... showing the probability of failing at points **a** or **b** ...

...But nothing about how many failures have occurred before points a or b!

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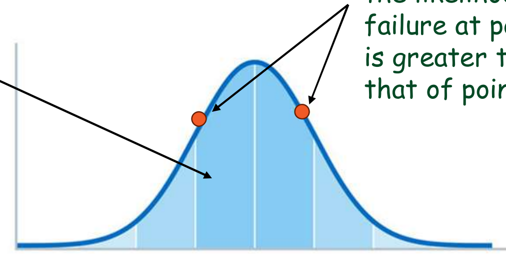
How does this distribution indicate reliability?

We'll calculate the area under the curve!



We can easily see the likelihood of failure at point **b** is greater than that of point **a**.

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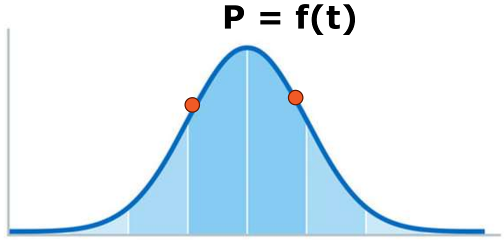
Weibull Distribution

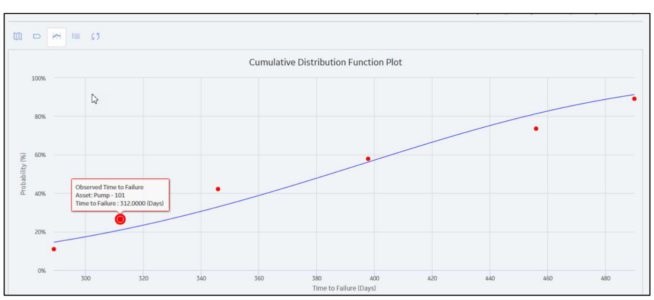
Probability of failure = Area under the curve

P = f(t)



PDF = f(t)

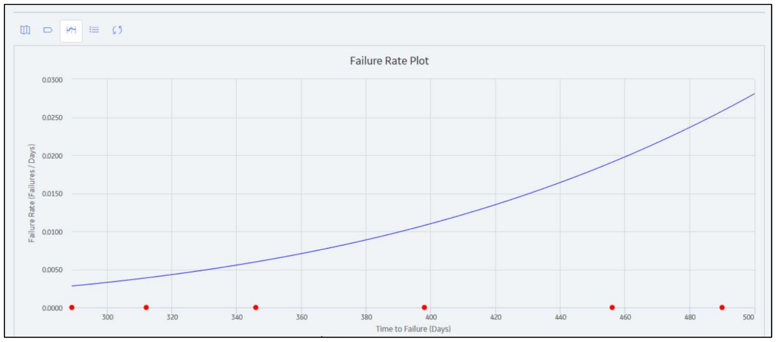
Weibull Distribution



P=F(t) is commonly known as the Cumulative Distribution Function or **CDF**

CDF = F(t)

Weibull Distribution



Failure Rate Plot

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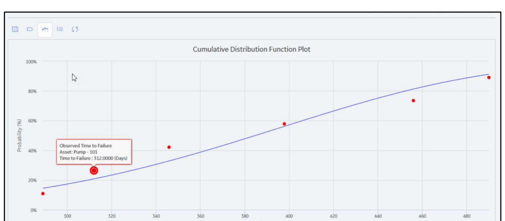
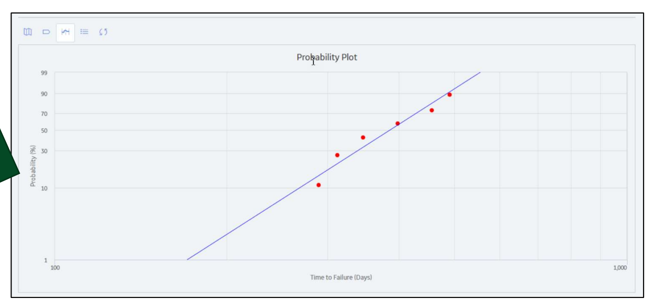
Practical Reliability Solutions

Weibull Distribution



A straight-line results when the CDF is plotted on log paper.



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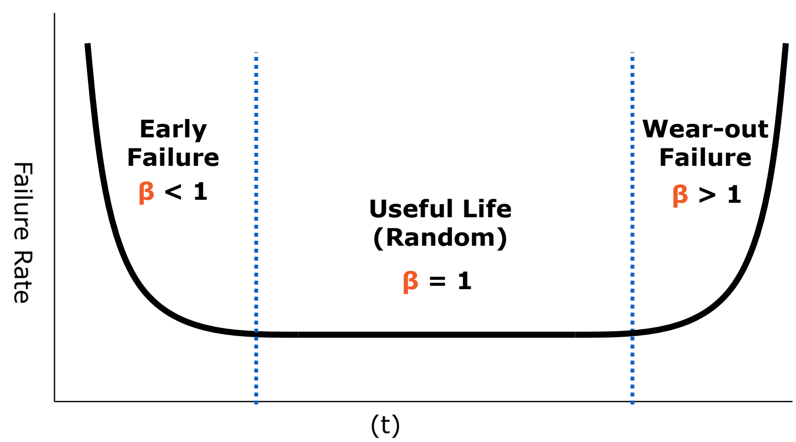
Practical Reliability Solutions

Weibull Distribution

Two Parameters:

- **β (Beta)** = Shape Factor
  - Indicates failure pattern
  - Slope of probability plot
- **η (Eta)** = Characteristic Life
  - Indicates expected life
  - Point where 63.2% of population has failed

Beta and the Bathtub Curve



Weibull Distribution

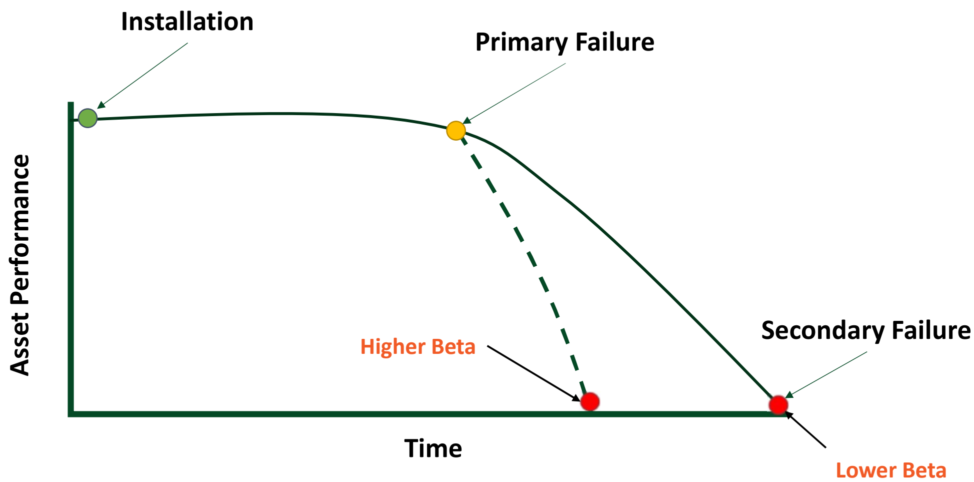
General Rules for Beta:

$\beta < 1$ Indicates infant mortality

$\beta = 1$ Indicates random failure

$1 < \beta < 4$ Indicates early wear-out failure

$\beta > 4$ Indicates rapid wear-out failure



Weibull Distribution

- Extremely applicable to most every failure mode
- Will produce good results even with a small amount of data
- Best starting point for reliability analysis
- **95%** of the time, Weibull is the best tool
- Requires quality data for meaningful results

Weibull Distributions can only be used on one failure mode at a time

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Risk Manager

- Allows you to estimate probability of failure
- Good for short-term planning
- Helps predict which machines will make it to the next scheduled maintenance

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Risk Manager

Q201 Failures
Last modified by Kenneth.Latino@contractor.p66.com on Wednesday, December 13, 2023 12:36 PM

Report | Site: RB01

Future Age | Future Probability

ASSET ID	INSTALLATION DATE	LAST REPLACEMENT	PRESENT AGE	FUTURE AGE	PRESENT FAILURE PROBABILITY	FUTURE FAILURE PROBABILITY
RB01-COK0050-67-Q201		2023-06-22T17:04:47.000	68.0948	268.0948	12.3582	21.1840

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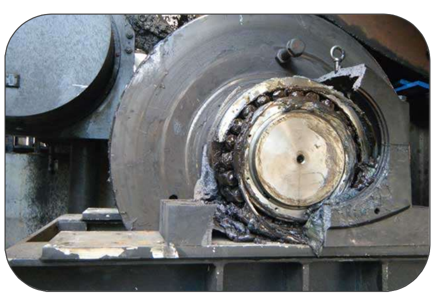
Identifying Physical Roots

Excessive Vibration

Considerations When Labeling a Physical Root (PR)
Physical roots are often the primary, observable consequences of decisions.
A decision often triggered this condition to become observable (i.e. – I chose to put in more lubricant than was specified, in the hopes I would not have to come back as often to do my rounds – Physical Root: Too Much Lubricant).
There can be multiple Physical roots in any given RCA.



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Identifying Human Roots

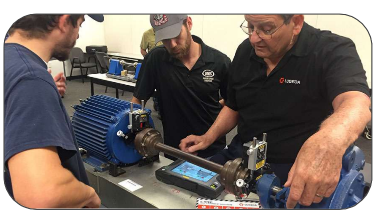
P-101 Bearing Not Aligned Properly

Considerations When Labeling a Human Root (HR)
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!!**

Identifying Latent/Organizational System Roots

Less Than Adequate (LTA) Oversight of Field Qualifications

Field Tech Not Properly Trained in Latest Alignment Best Practices



Considerations When Labeling a Latent Root
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.
Latent roots can encompass varying levels of depth, that may or may not include socio-technical factors (i.e. – external factors like regulatory and insurance influences) as well as cultural norms (i.e. – we've always done it that way).

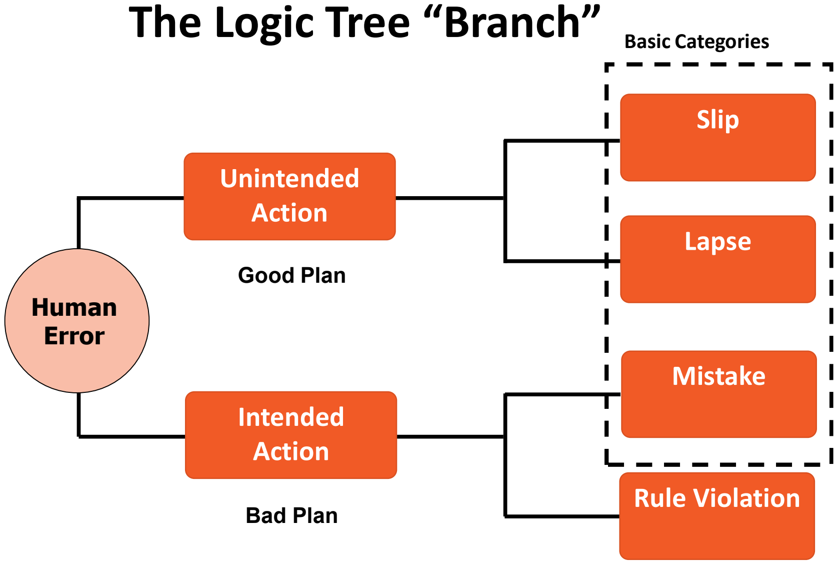
Image provided by Ludeca

Identifying Contributing Factors

On 1.28.86, at Launch of Mission 51-L it was 36F at Cape Canaveral FL

Considerations When Labeling a Contributing Factor
Conditions that existed the day of the Event, but may not be in the control of the organization to change (i.e. – it was freezing that day, which was uncharacteristic for the region)
May more may not be actionable, must be explored (i.e. – a lightening strike triggered an automated shutdown, but was the facility properly grounded [mitigation exploration])

Human Error
The Logic Tree "Branch"



Why Do Mix-Ups Occur?

Human Factors in Design – Medication Labeling and Procedure Writing

<u>Procedure Writing – Mixed Case:</u>
The attending surgeon shall record in the medical record the correct side for and name of the surgical procedure

<u>Procedure Writing – All Upper Case:</u>
THE ATTENDING SURGEON SHALL RECORD IN THE MEDICAL RECORD THE CORRECT SIDE FOR AND NAME OF THE SURGICAL PROCEDURE

Medication	Unique Pattern
MEDICATION	Generic Pattern

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Human Factors in Design – Brain Processing Capability

10 Chunks

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

804-548-0645

3 Chunks

Of all the signals that reach our sensory register, we focus on a few that seem important (normal capacity is about seven “chunks” of information).

Source: Making Connections: Teaching and the Human Brain (Caine and Caine 1991)

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What Do You See? The Mind is a Mysterious Thing (#1)

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.

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What Do You See? The Mind is a Mysterious Thing (#2)

I cdnuolt blveiee taht I cluod aulaclty uesdnatnrd waht I was rdanieg. The phaonmneal pweor of the hmuan mnid Aoccdrnig to a rscheearch at Cmabrigde Uinervtisy, it deson't mttaer 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. The rset can be a taotl mses and you can sitll raed it wouthit a porbelm. Tihs is bcuseae the huamn mnid deos not raed ervey lteter by istlef, but the wrod as a wlohe. Amzanig huh?

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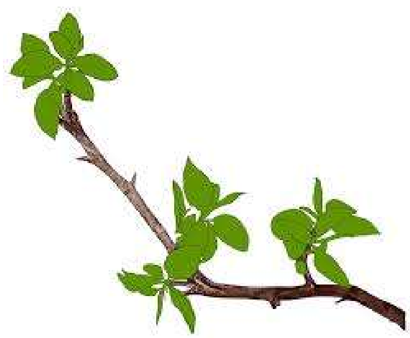
Developing Common Branches



Source: Pixabay.com

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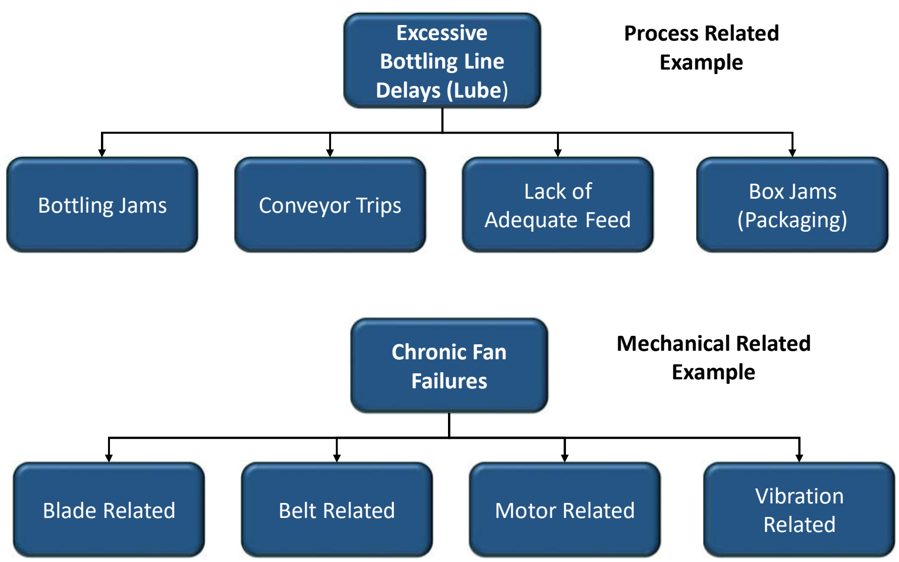
Sample of Common Logic Tree Branches



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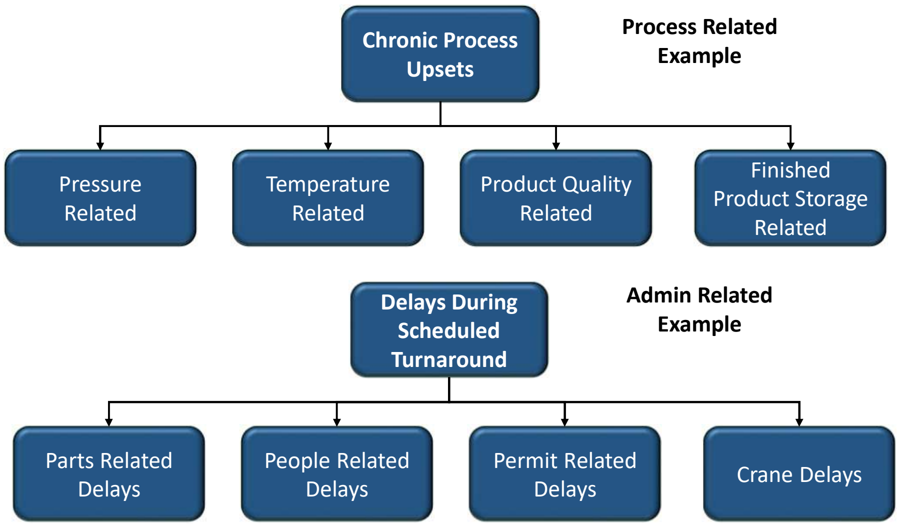
Sample of Common Logic Tree Branches



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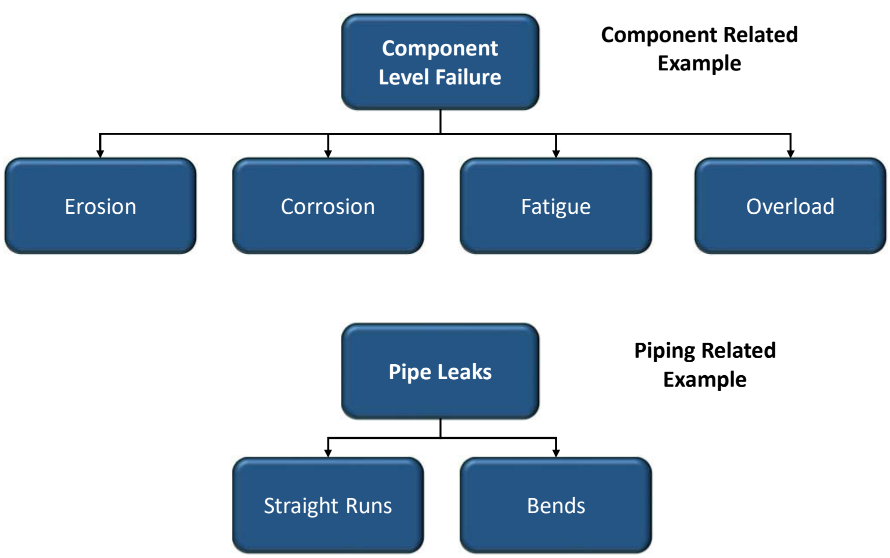
Sample of Common Logic Tree Branches



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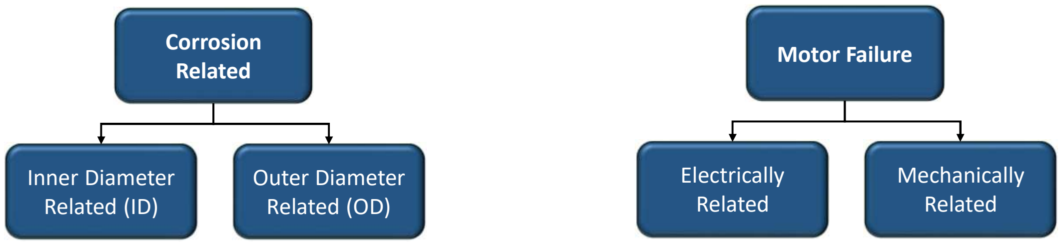
Sample of Common Logic Tree Branches



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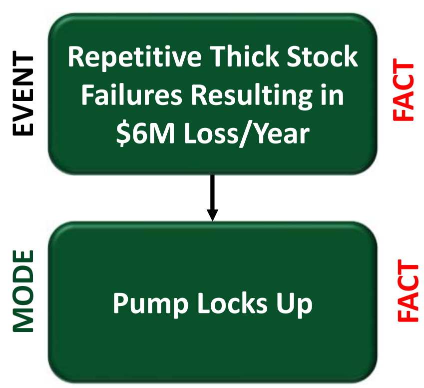
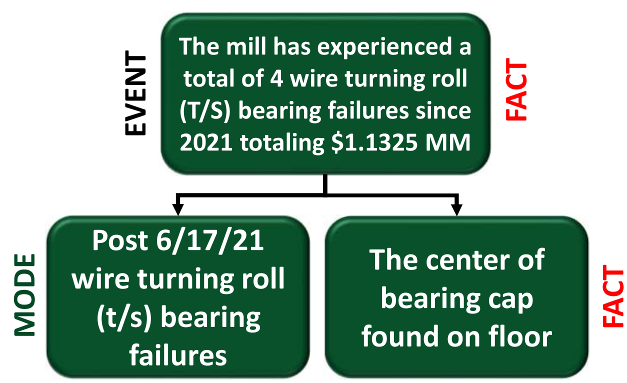
Top Box – Definition



Thick Stock Pump – Top Box



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Logic Tree Facilitation – Tips and Tricks

Considerations When Labeling a Latent Root
Biggest Bang for Your Buck!
The 'Broad and All-Inclusive' Test
Draw a Sketch of the Event Being Analyzed
Construct a Timeline of the Event
Managing the FACT Line
Maintaining the Verification Log (VL)
Node Confidence Factors (0 – 5 Scale, 5=True and 0 = Not True)
Beware Conventional Wisdom

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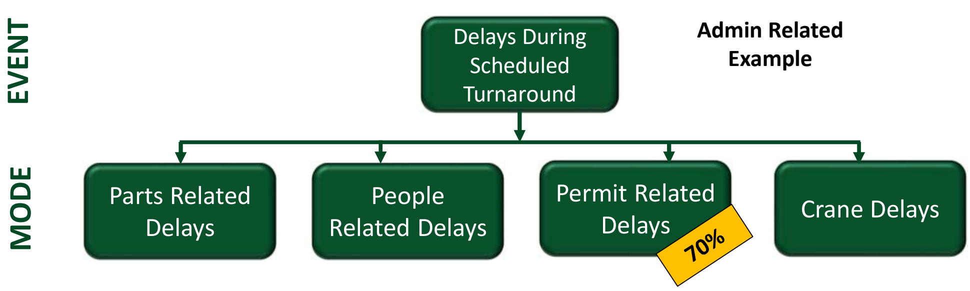
Logic Tree Facilitation – Tips and Tricks



Admin Related Example

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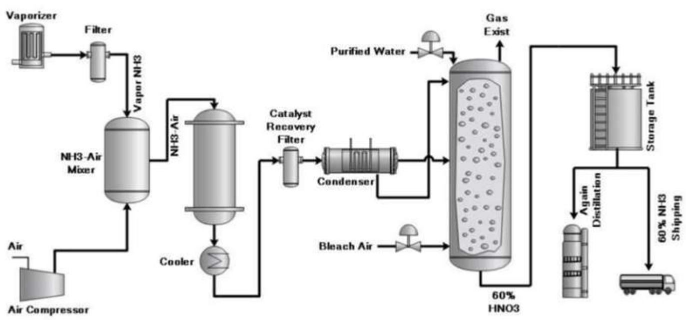
Logic Tree Facilitation – Tips and Tricks

Draw a Sketch of the Event Being Analyzed

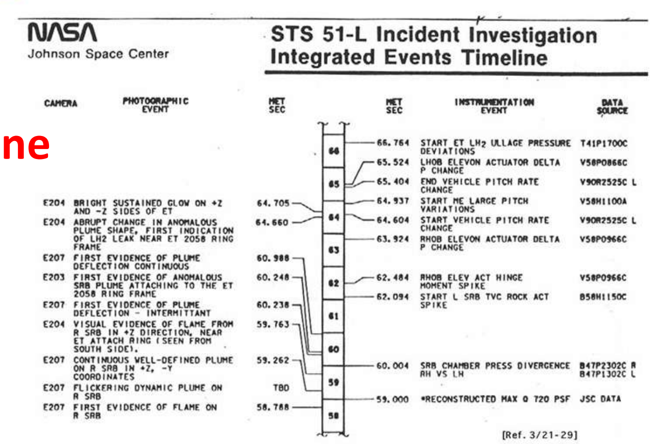


Source: https://chemicalengineeringworld.com/process-flow-diagram-pfd/

Logic Tree Facilitation – Tips and Tricks

Construct a Timeline of the Event

Put in a better timeline



Logic Tree Facilitation – Tips and Tricks

The 'Broad and All-Inclusive' Test

How Could?

V-Belt Failed

- V-Belt Breaks
- V-Belt Slips
- V-Belt Falls Off

The Test: Is the only the V-belt could have failed,
from: breaking, slipping and/or falling off?

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Event Reconstruction Using a Logic Tree Tips & Tricks

"Wide" Logic Trees (Bushes)

"Tall" Logic Trees (Redwoods)

Which Tree Structure is Desired?

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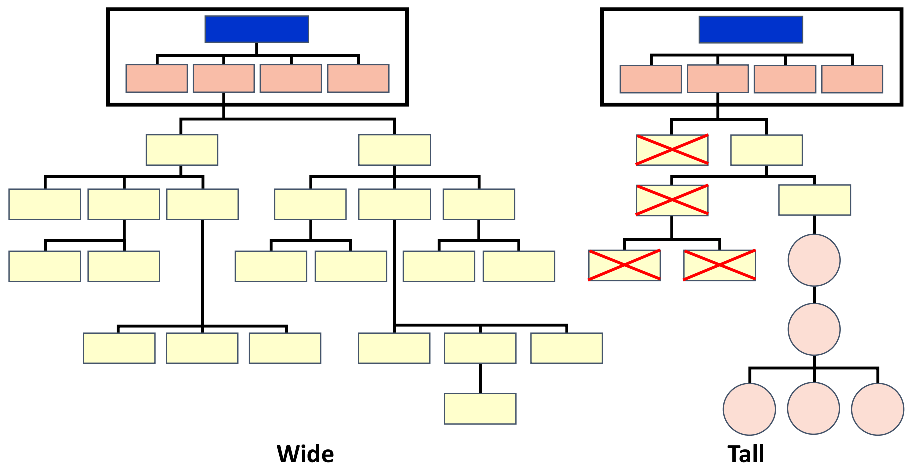
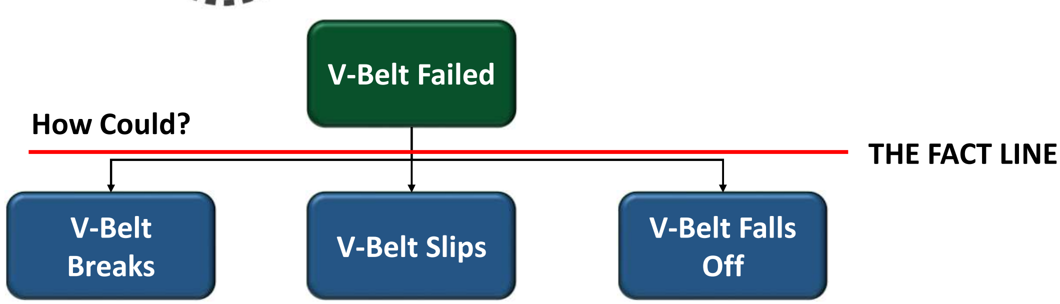
Event Reconstruction Using a Logic Tree
Tips & Tricks



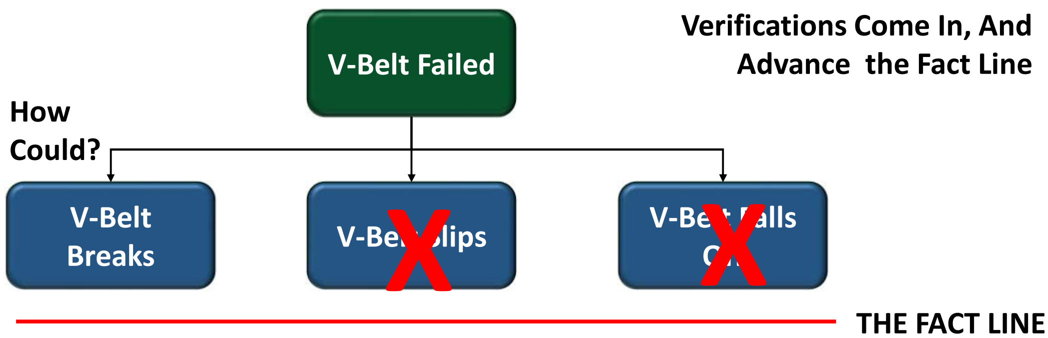
Data verification is key for a successful logic tree!

Logic Tree Facilitation – Tips and Tricks



Logic Tree Facilitation – Tips and Tricks

Managing the FACT Line



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Logic Tree Facilitation – Tips and Tricks

Maintaining the Verification Log (VL)

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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Logic Tree Facilitation – Tips and Tricks

Beware Conventional Wisdom/Confirmation Bias

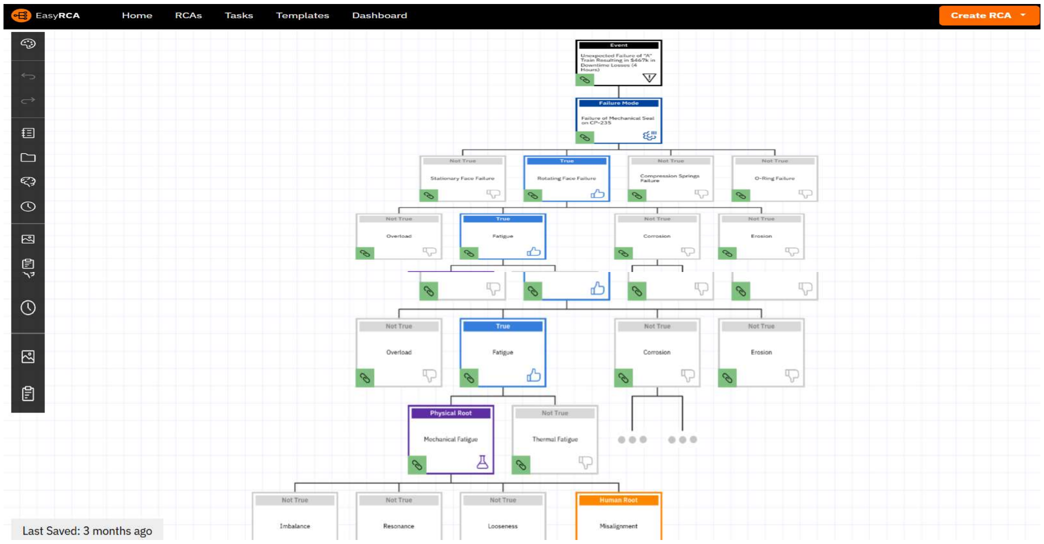
- We don't need this team; I know what the problem is because I've been here 22 years!!
- We've tried that before
- It's old equipment
- We don't have time to do an RCA on this failure

Conventional Wisdom: Beware of the above as they are most often 'Assumptions' and not facts. A successful RCA will NOT allow hearsay to fly as FACT!!

RCA Exercise Time

"I Really Get (Have) to be on an RCA Team?" ☺

EasyRCA Overview Tutorial



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Root Cause Analysis Exercise

Instructions: Break into teams of 3-5 members. Organize into work teams where each team has at least one member who is **NOT** familiar with the event being analyzed. Follow the steps below and be prepared to report your analysis and findings to the other teams. 60 minutes

Step 1: Identify Event to Analyze

Step 2: Calculate the Annual Losses Associated with Event

Step 3: Sketch Out the Event for Team (Basic)

Step 4: Construct a Basic Timeline

Step 5: Begin Logic Tree Construction

Step 6: Validate Hypotheses Using Data Previously Collected (Virtually)

Step 7: Continue Down Logic Tree Until Latent/System Roots are Identified. Properly Identify Physical, Human, and Latent Root Causes.

Step 8: Propose Corrective Actions for Actionable Root Causes

Step 9: Present Case Study to Leadership (Rest of Class)

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Paper Industry Case Study

Case #1 in RCA Book – Page 301

Thick Stock Pump Failures

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Case #1

Thick Stock Pump Analysis

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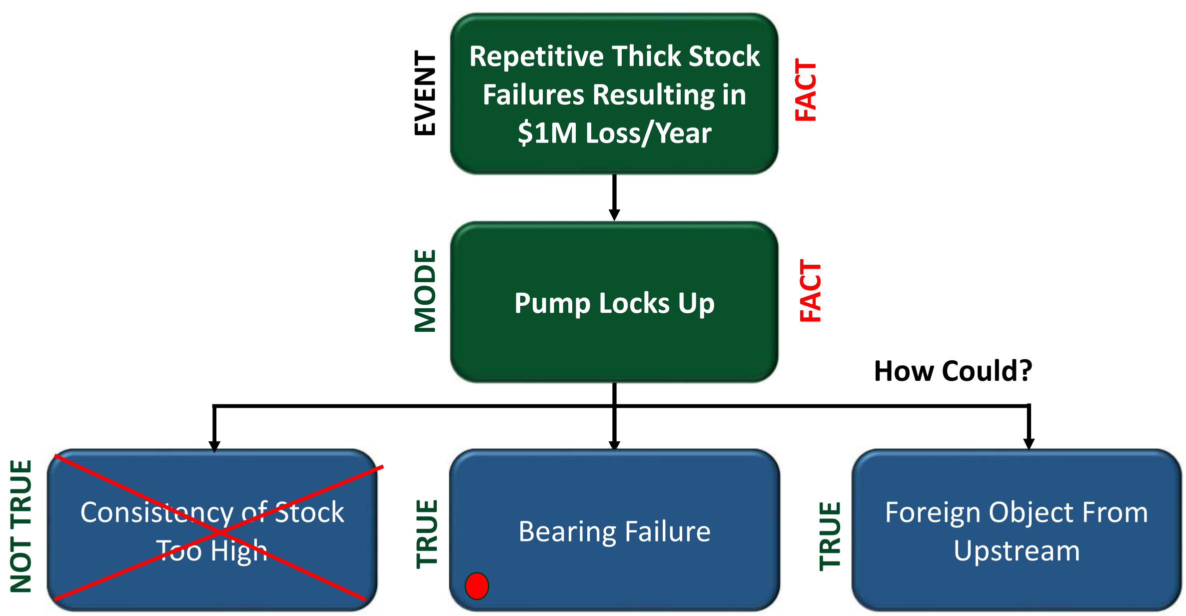
The RCA Business Case

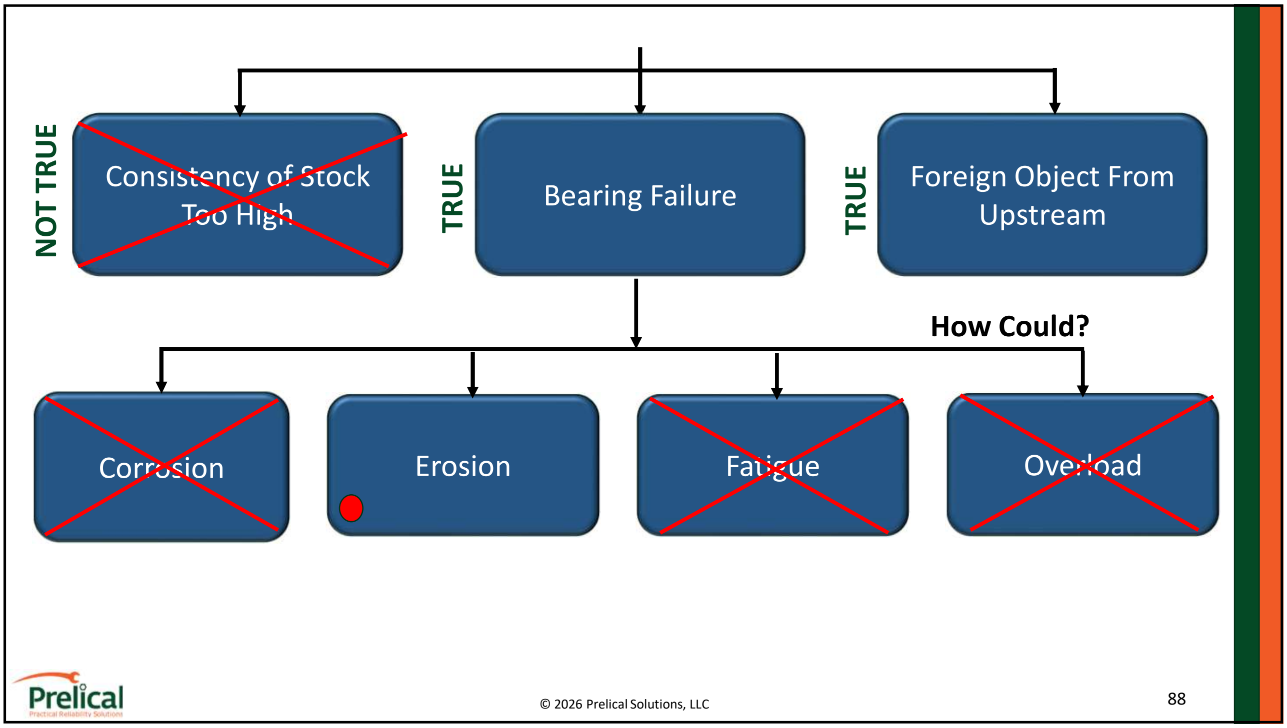
The Annual Impact of the Failure

Subsystem	Event	Mode	Frequency	Impact/ Occurrence	Total Annual Loss
Bleach Room	Thick Stock Pump Failure	Bearing Failures	10/year	$100,000	$1,000,000

The Bottom-Line Benefit

Duration of Analysis	3 Months (Part-Time Team)
Cost to Perform Analysis	$20,000
Approximate Savings/Year	$700,000
Estimated ROI	3,500%




NOT TRUE
Consistency of Stock Too High
TRUE
Bearing Failure
TRUE
Foreign Object From Upstream
How Could?
Corrosion
Erosion
Fatigue
Overload
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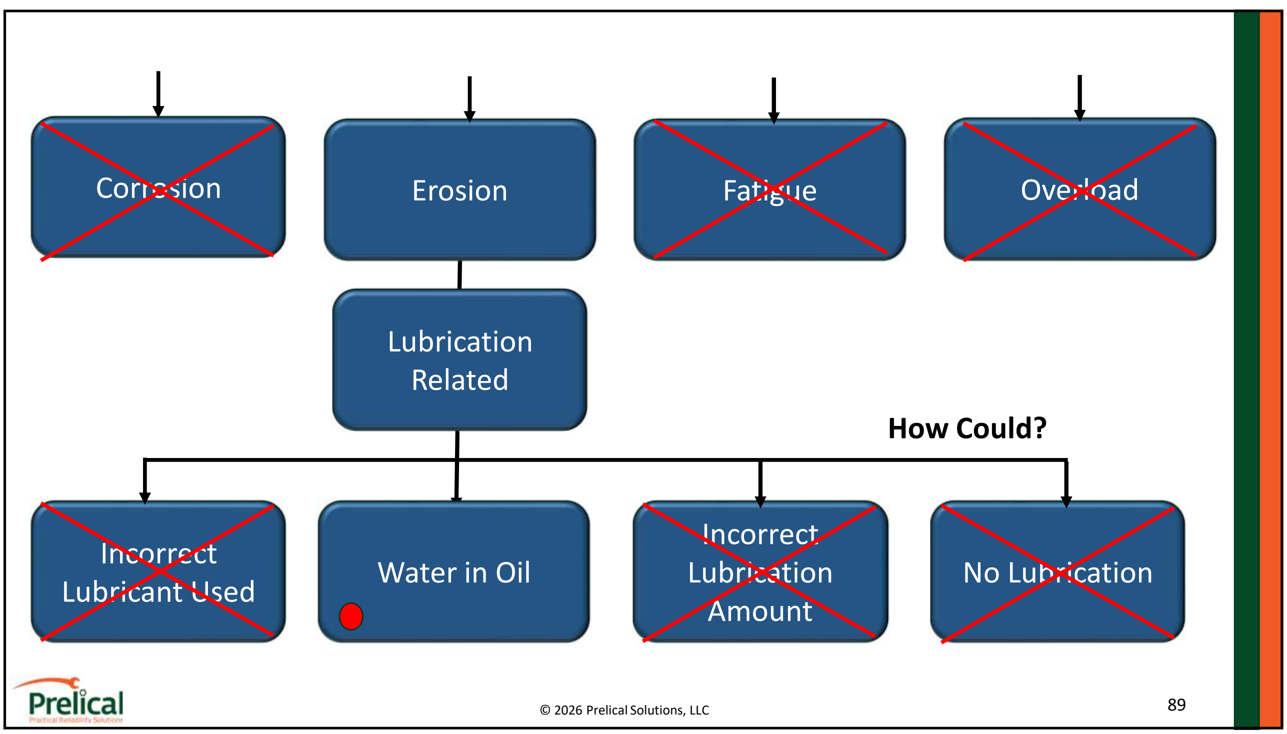
Corrosion
Erosion
Fatigue
Overload
Lubrication Related
How Could?
Incorrect Lubricant Used
Water in Oil
Incorrect Lubrication Amount
No Lubrication
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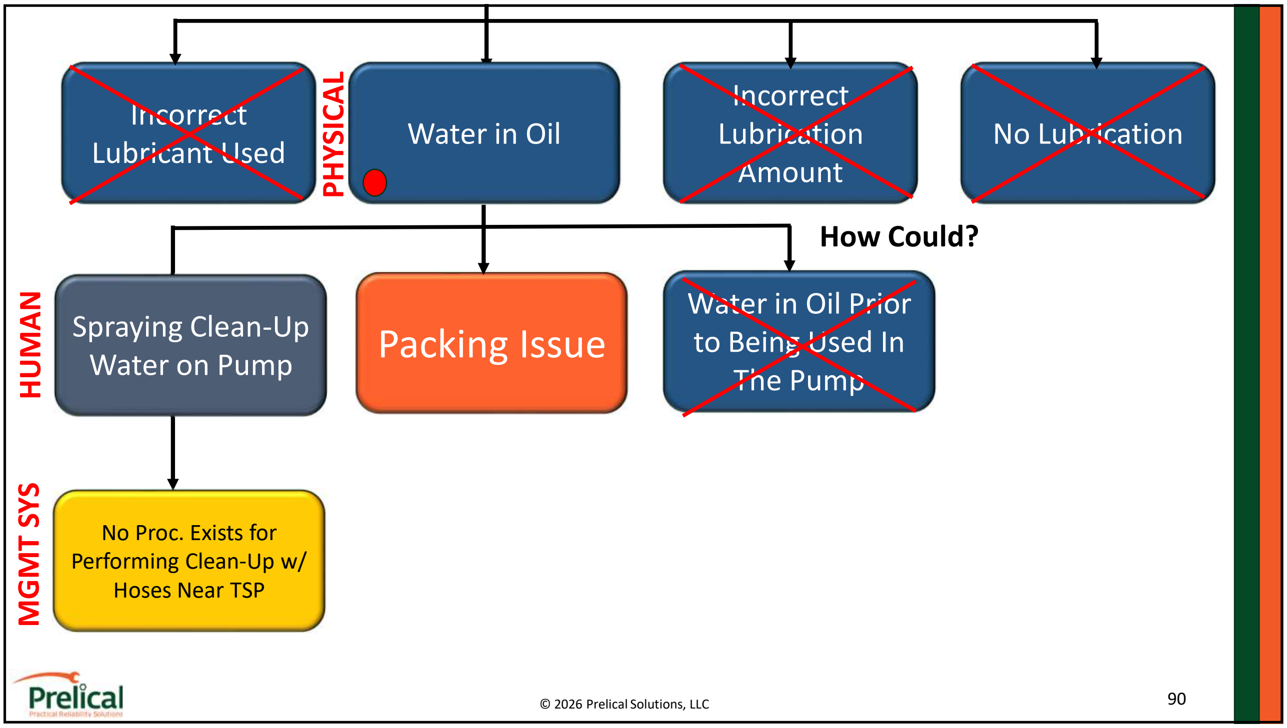
Incorrect Lubricant Used
PHYSICAL
Water in Oil
Incorrect Lubrication Amount
No Lubrication
How Could?
HUMAN
Spraying Clean-Up Water on Pump
Packing Issue
Water in Oil Prior to Being Used In The Pump
MGMT SYS
No Proc. Exists for Performing Clean-Up w/ Hoses Near TSP
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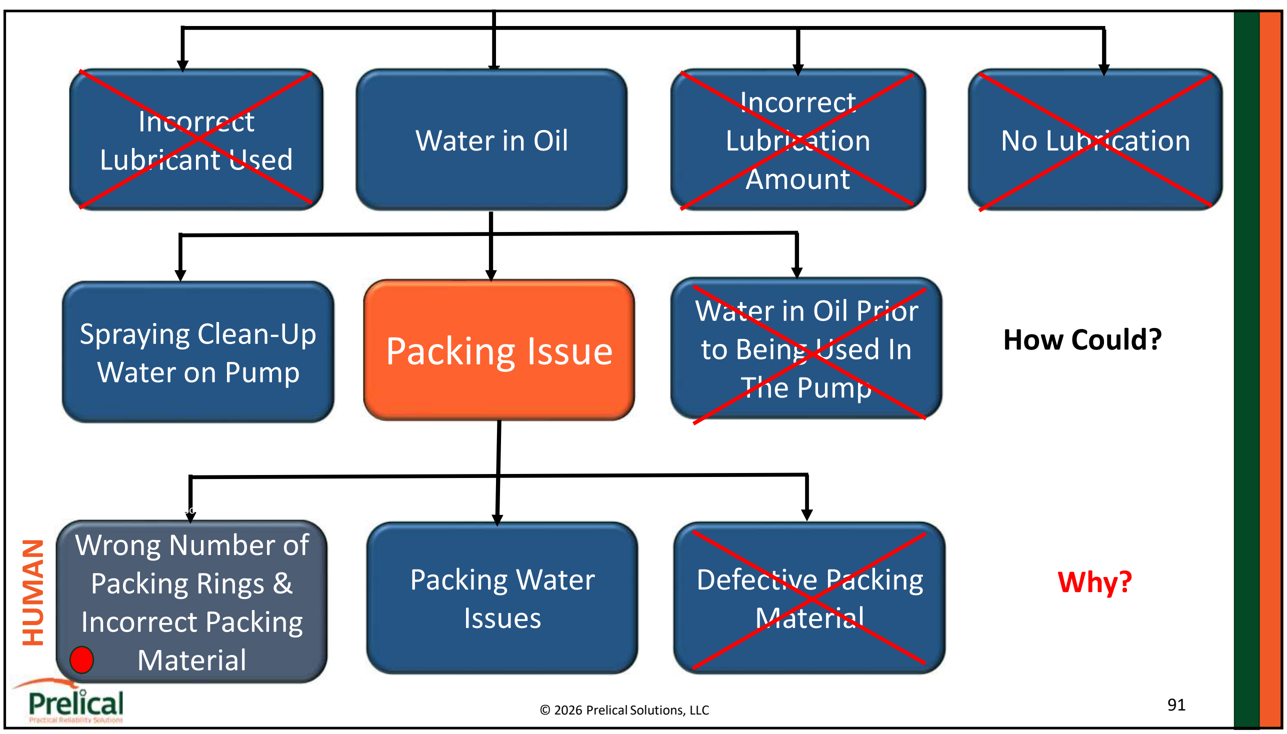
Incorrect Lubricant Used
Water in Oil
Incorrect Lubrication Amount
No Lubrication
Spraying Clean-Up Water on Pump
Packing Issue
Water in Oil Prior to Being Used In The Pump
How Could?
HUMAN
Wrong Number of Packing Rings & Incorrect Packing Material
Packing Water Issues
Defective Packing Material
Why?
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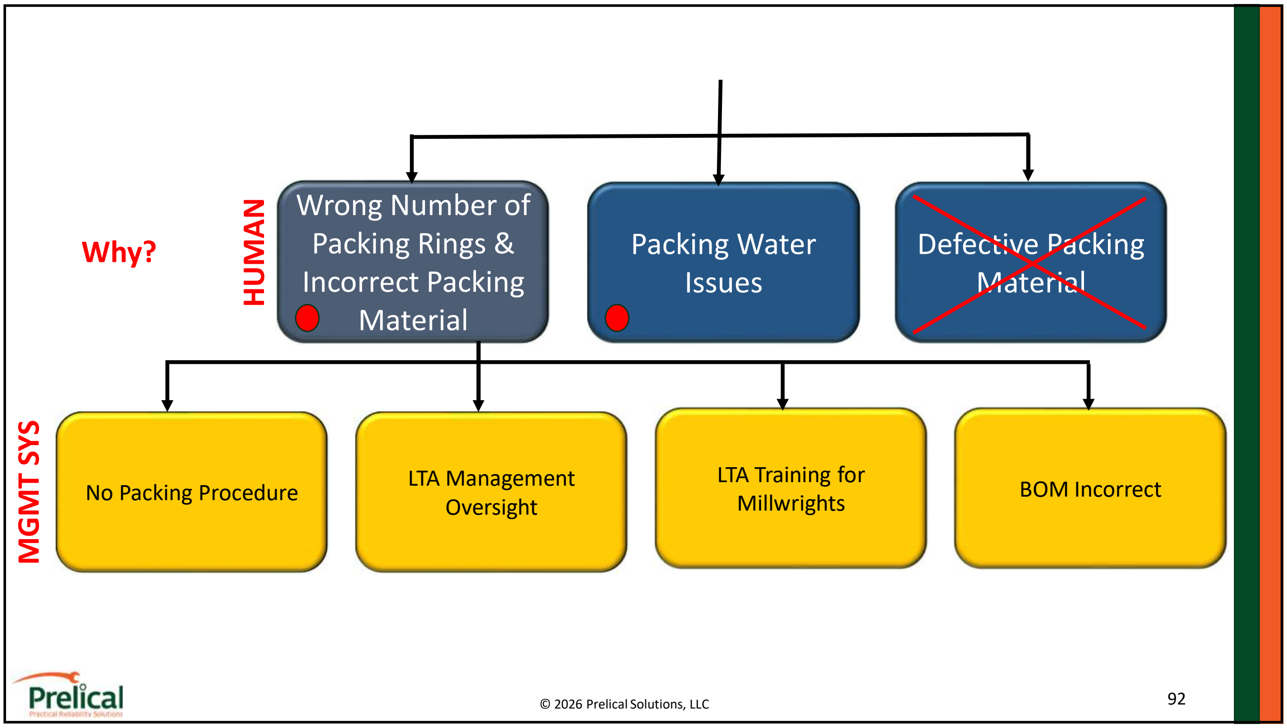
Why?
HUMAN
Wrong Number of Packing Rings & Incorrect Packing Material
Packing Water Issues
Defective Packing Material
MGMT SYS
No Packing Procedure
LTA Management Oversight
LTA Training for Millwrights
BOM Incorrect
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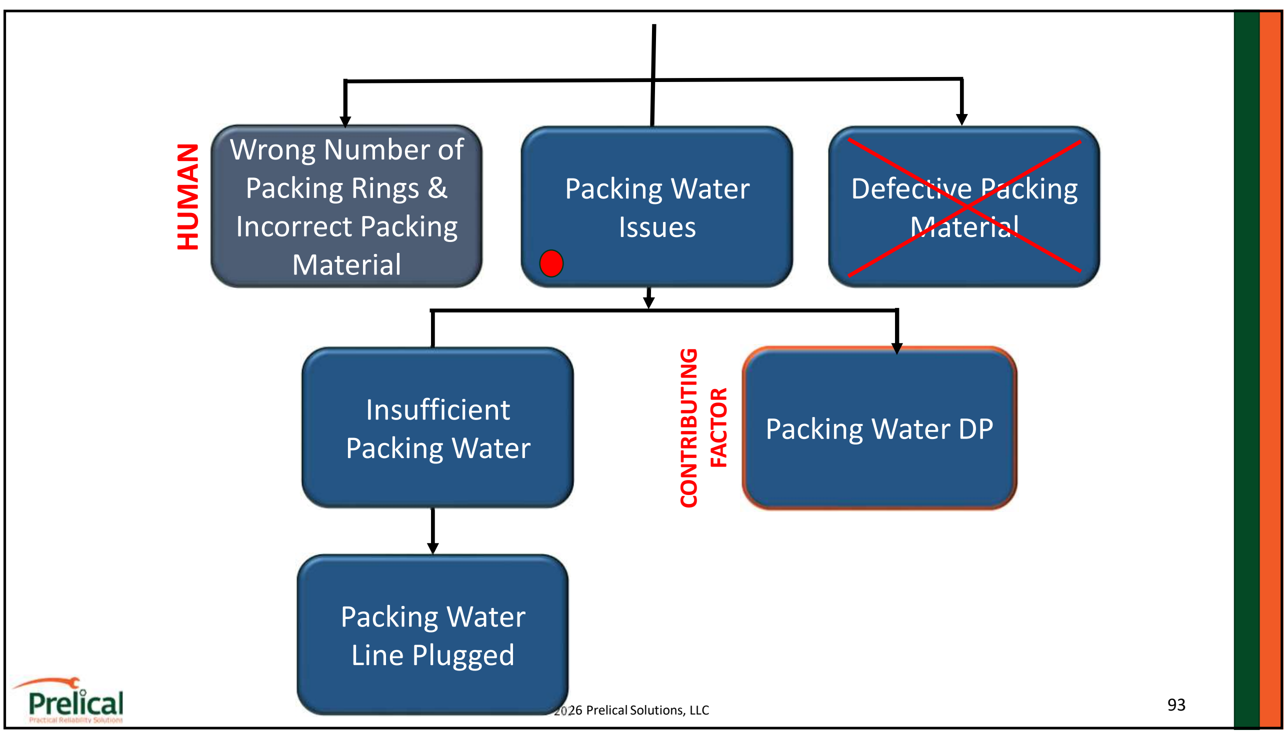
HUMAN
Wrong Number of Packing Rings & Incorrect Packing Material
Packing Water Issues
Defective Packing Material
Insufficient Packing Water
CONTRIBUTING FACTOR
Packing Water DP
Packing Water Line Plugged
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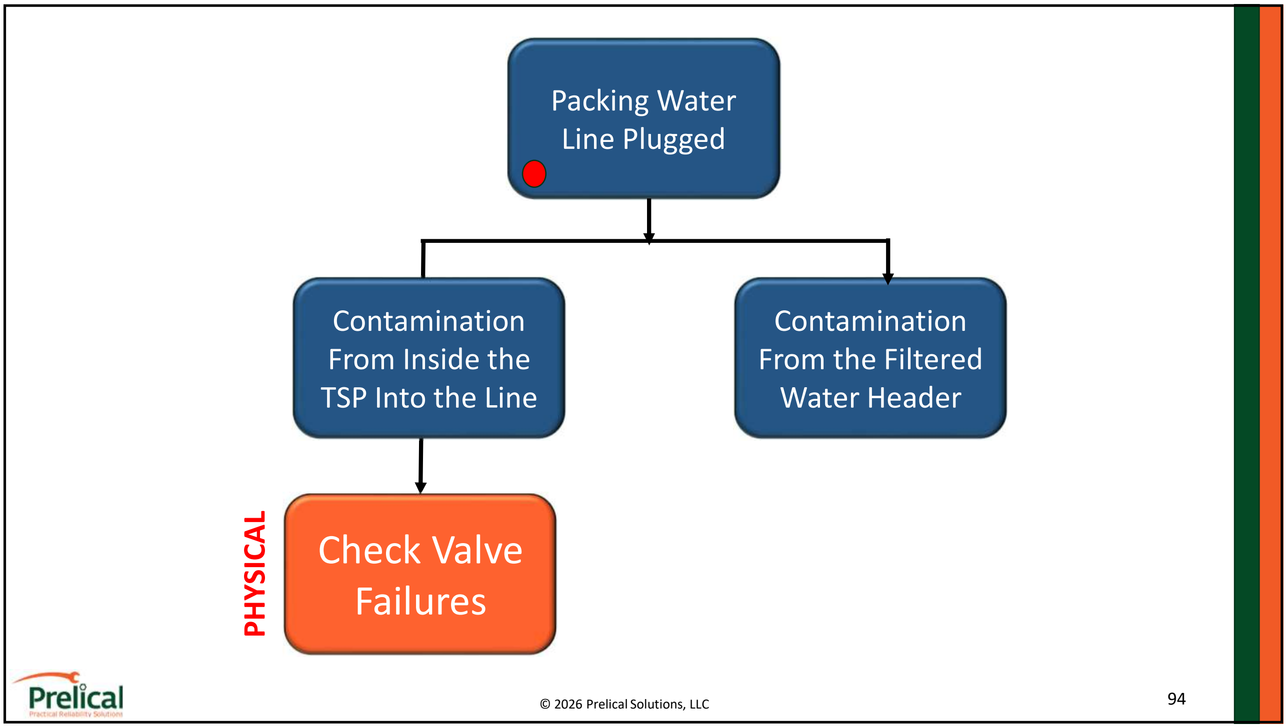
Packing Water Line Plugged
Contamination From Inside the TSP Into the Line
Contamination From the Filtered Water Header
PHYSICAL
Check Valve Failures
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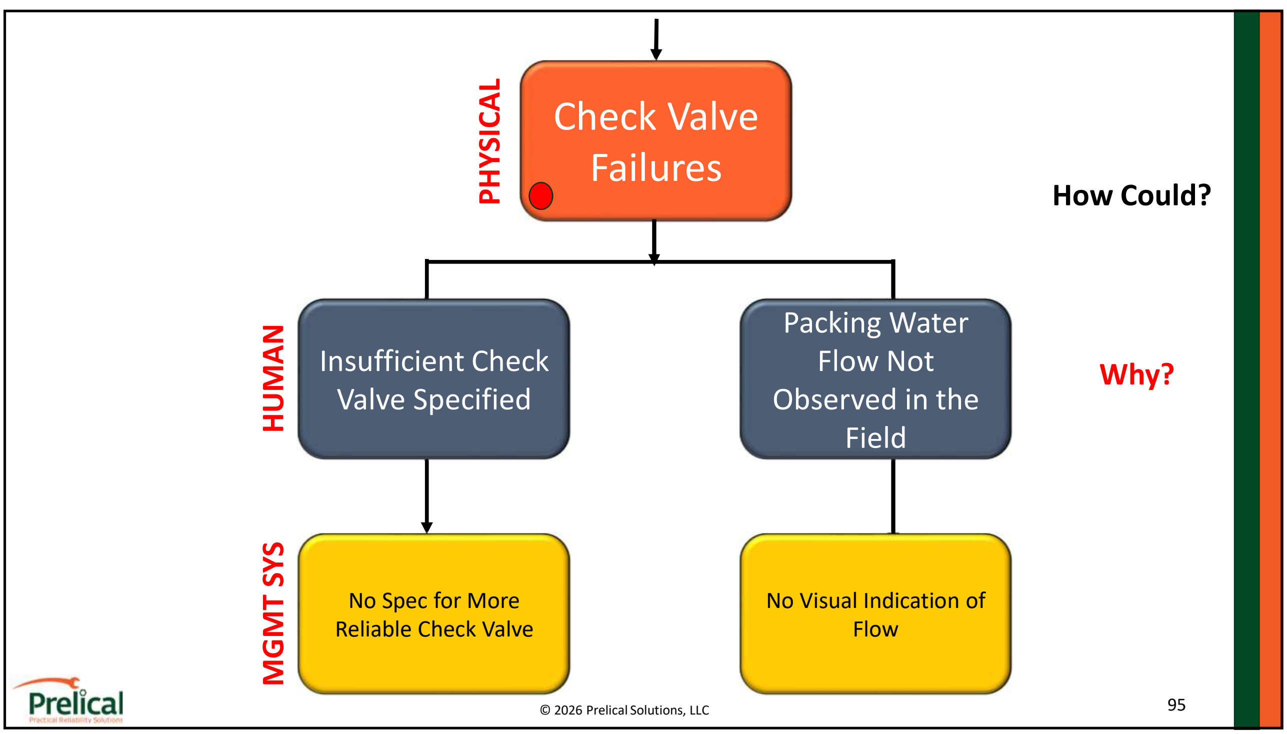
PHYSICAL
Check Valve Failures
How Could?
HUMAN
Insufficient Check Valve Specified
Packing Water Flow Not Observed in the Field
Why?
MGMT SYS
No Spec for More Reliable Check Valve
No Visual Indication of Flow
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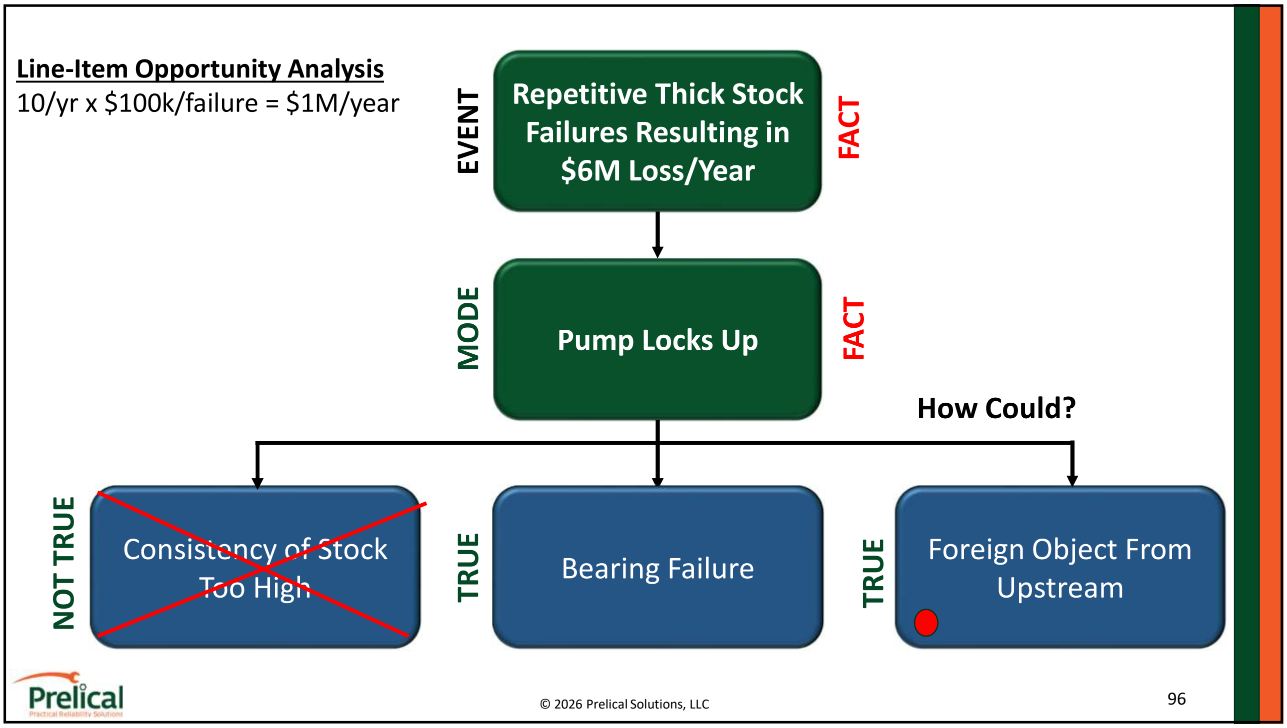
Line-Item Opportunity Analysis
10/yr x $100k/failure = $1M/year
EVENT
Repetitive Thick Stock Failures Resulting in $6M Loss/Year
FACT
MODE
Pump Locks Up
FACT
How Could?
NOT TRUE
~~Consistency of Stock Too High~~
TRUE
Bearing Failure
TRUE
Foreign Object From Upstream
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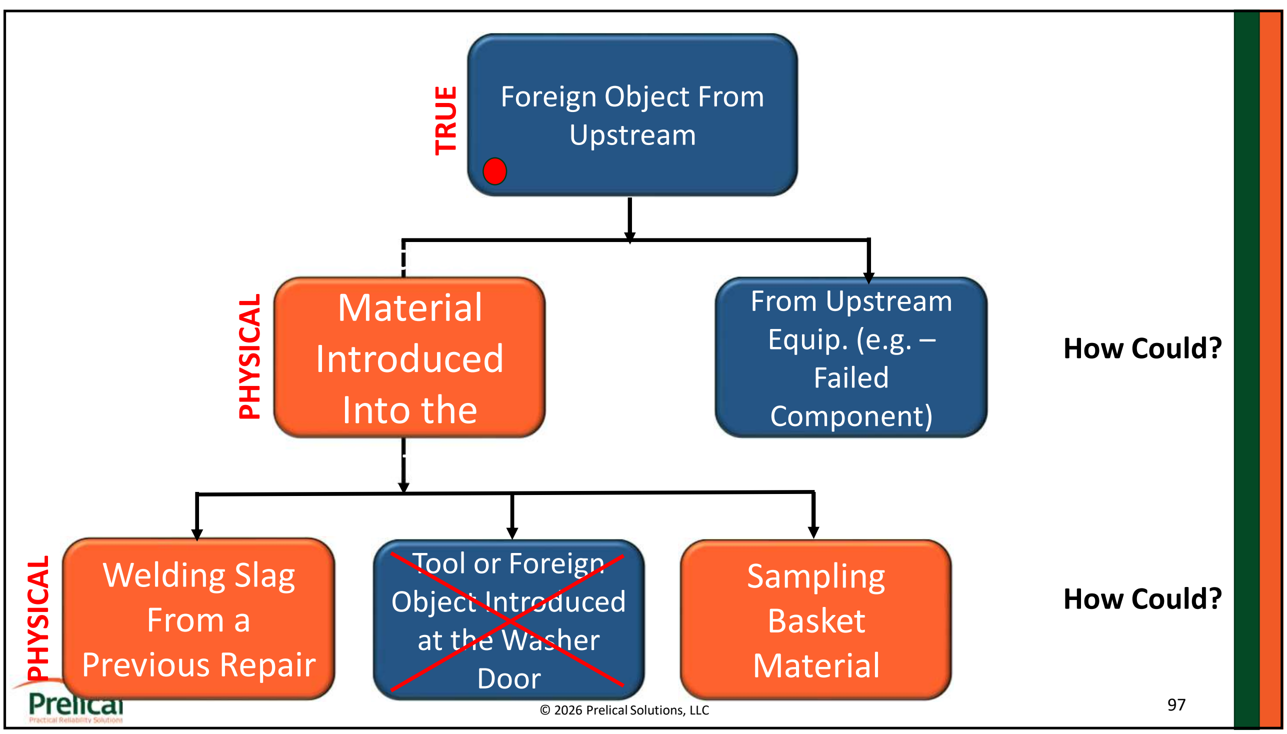
TRUE
Foreign Object From Upstream
PHYSICAL
Material Introduced Into the
From Upstream Equip. (e.g. – Failed Component)
How Could?
PHYSICAL
Welding Slag From a Previous Repair
~~Tool or Foreign Object Introduced at the Washer Door~~
Sampling Basket Material
How Could?
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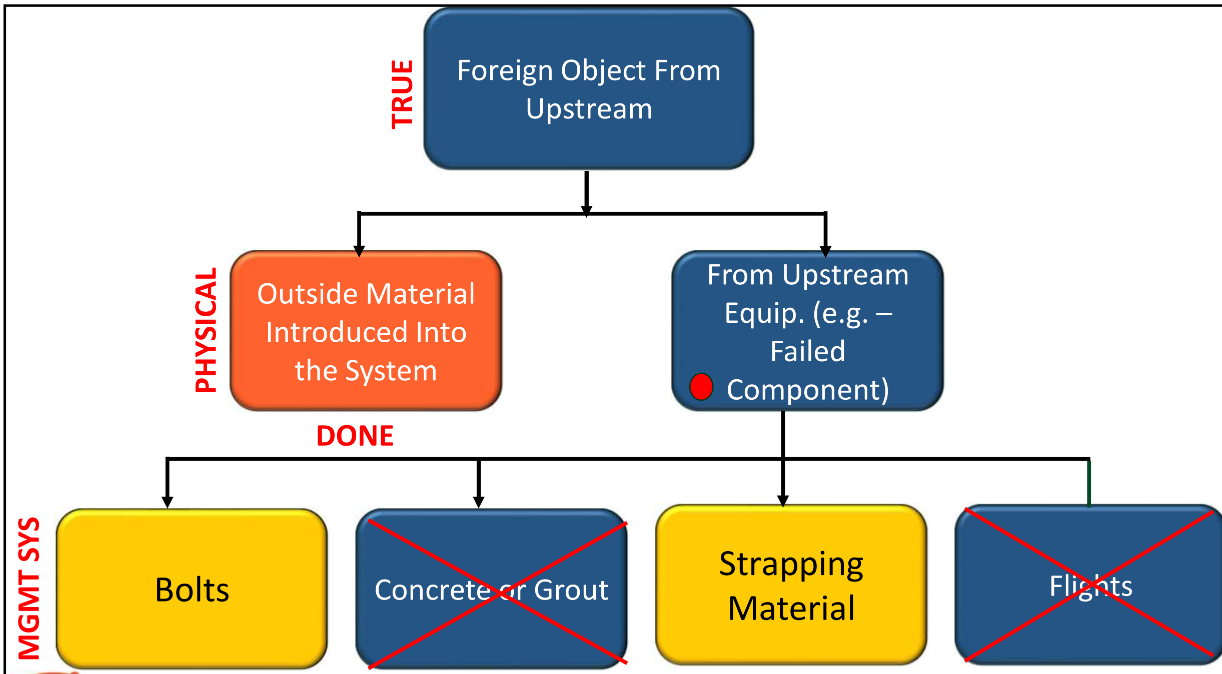

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Human Error is <u>NOT</u> a Root Cause!!

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