Practical Reliability & Root Cause Analysis Essentials

PHILLIPS 66

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1

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INTRODUCTIONS

2

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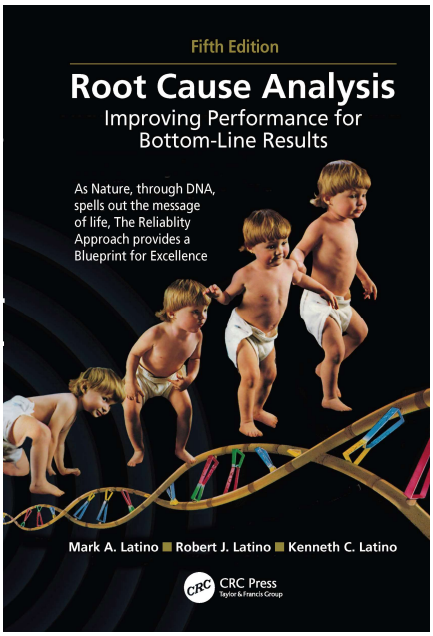
Who are Ken & Bob Latino?



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Charles J. Latino
1929 - 2007

Coined 'The Father of Manufacturing Reliability' in 1972

4

4

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Latino Family Career Path

Reliability is in our DNA ☺

1972 — Charles Latino founded the Allied Chemical Corp. R&D Reliability Center (called Honeywell today). Research focused on Equipment, Process and **HUMAN** Reliability

1985 — Charles retires and purchases Reliability Center, Inc (RCI) . Bob joins a now independent RCI as an NDT Tech

2007 — Charles passes and Bob becomes CEO of RCI (a family-owned business)

2019 — Latino Family enacts succession plans and sells RCI

2021 — Bob joins Ken's small firm at Prelical Solutions, LLC.

5

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Diversity of Industries We've Worked In

WestRock
DUPONT
UPS
PHILLIPS 66
PeaceHealth
Coors
bp
DP WORLD
sabic
Syncrude
RioTinto
International Paper
AES

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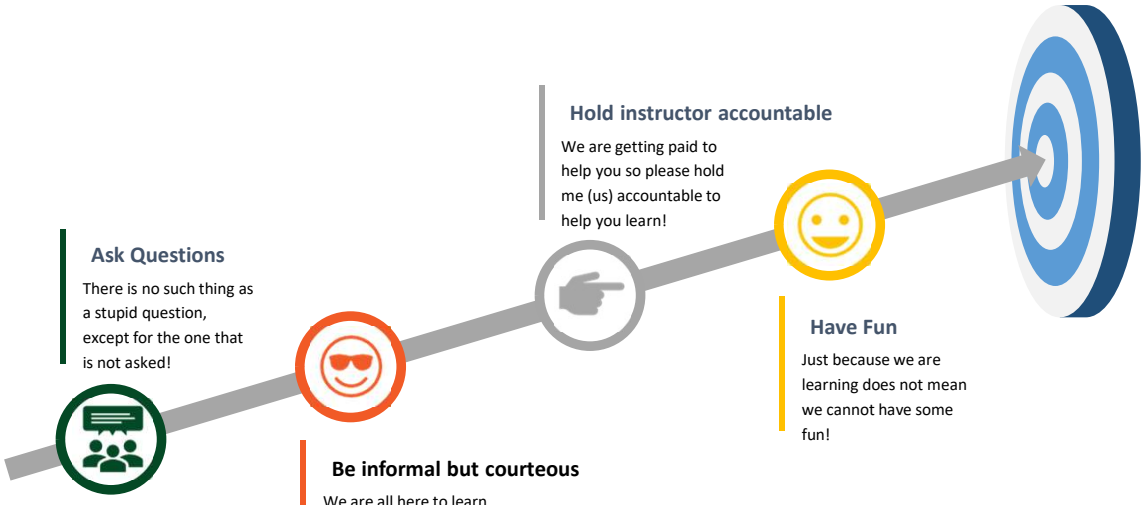
Workshop Rules

Criteria for a Successful Course



Ask Questions

There is no such thing as a stupid question, except for the one that is not asked!

Be informal but courteous

We are all here to learn so **be yourself** and sensitive to others.

Hold instructor accountable

We are getting paid to help you so please hold me (us) accountable to help you learn!

Have Fun

Just because we are learning does not mean we cannot have some fun!

7

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Your Intros!

What is the single greatest impediment to your ability to do the best Root Cause Analysis that you know you can do?

8

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WHERE ARE WE AT?

Exercise #1: Current State Assessment

9

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Exercise: Basic RCA Assessment

Root Cause Analysis (RCA) Self-Assessment Tool	Tot. Poss.	Likert Rating Scale	Total Rating By Category/ Rating	Category Score (%)
1. Fundamentals			30	
RCA Effectiveness is Measured Directly Against Defined, Bottom-Line Metrics.		1 2 3 4 5	0	
RCA is Clearly Defined		1 2 3 4 5	0	
An Effective RCA Procedure is in Place		1 2 3 4 5	0	
RCA Analysts are Formally Trained in the RCA Procedure		1 2 3 4 5	0	
RCA Objectives are Correlated to Corporate Dashboard Metrics		1 2 3 4 5	0	
RCA is Routinely Applied to Chronic Failures/Proactively		1 2 3 4 5	0	
Total Category Rating			0	0%
2. Failure Modes & Effects Analysis/Opportunity Analysis			10	
Proactive Tools Such as FMEA/OA are Used to Quantify and Qualify RCA Candidates		1 2 3 4 5	0	
Business Cases are Made to Justify Conducting RCA's		1 2 3 4 5	0	
Total Category Rating			0	0%
3. Preserving Event Data			5	
Disciplined Data Collection Prior to an RCA is a Requirement & a Priority		1 2 3 4 5	0	
Total Category Rating			0	0%

Average RCA Assessment Score: 57%

10

10

Tentative Agenda ☺

1. The Role of RCA in Reliability
2. What do We Analyze?
3. What are They Worth?
4. Who's on the Team?
5. How/What Data/Evidence Do I Gather?
6. Incorporating HOP Principles Into RCA
7. Reconstructing an Undesirable Outcome/Event Using a Logic Tree
8. Writing Effective Corrective Actions

11

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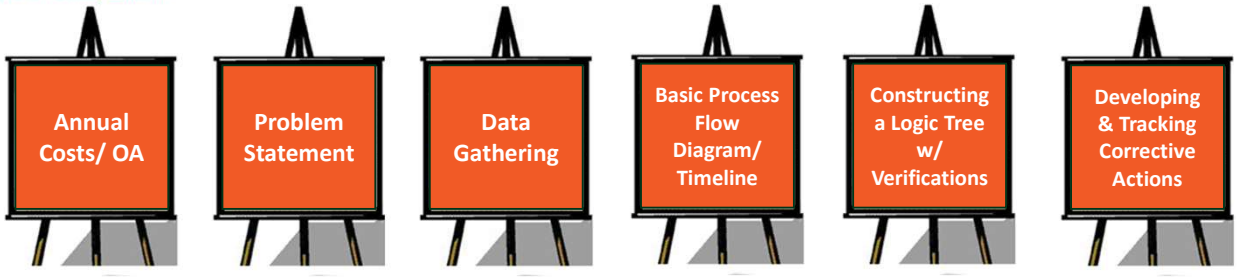
IF We Can Pull It Off…☺



12

12

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The Role of RCA in Reliability

13

13

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Acronym Soup

RCM
CMMS
PM
IIOT
EAM
FMEA
APM
KPI
ODR
PdM
RCA
HOP

14

14

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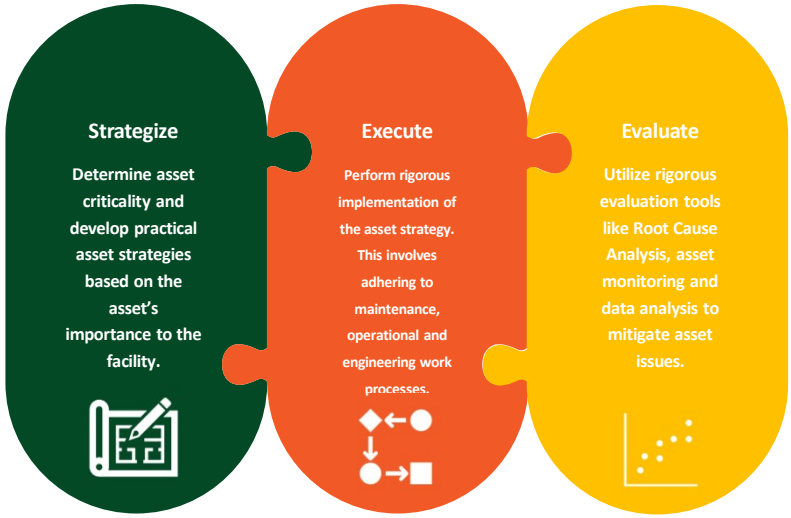
Reliability Performance Model

A Practical Approach to Proven Results



15

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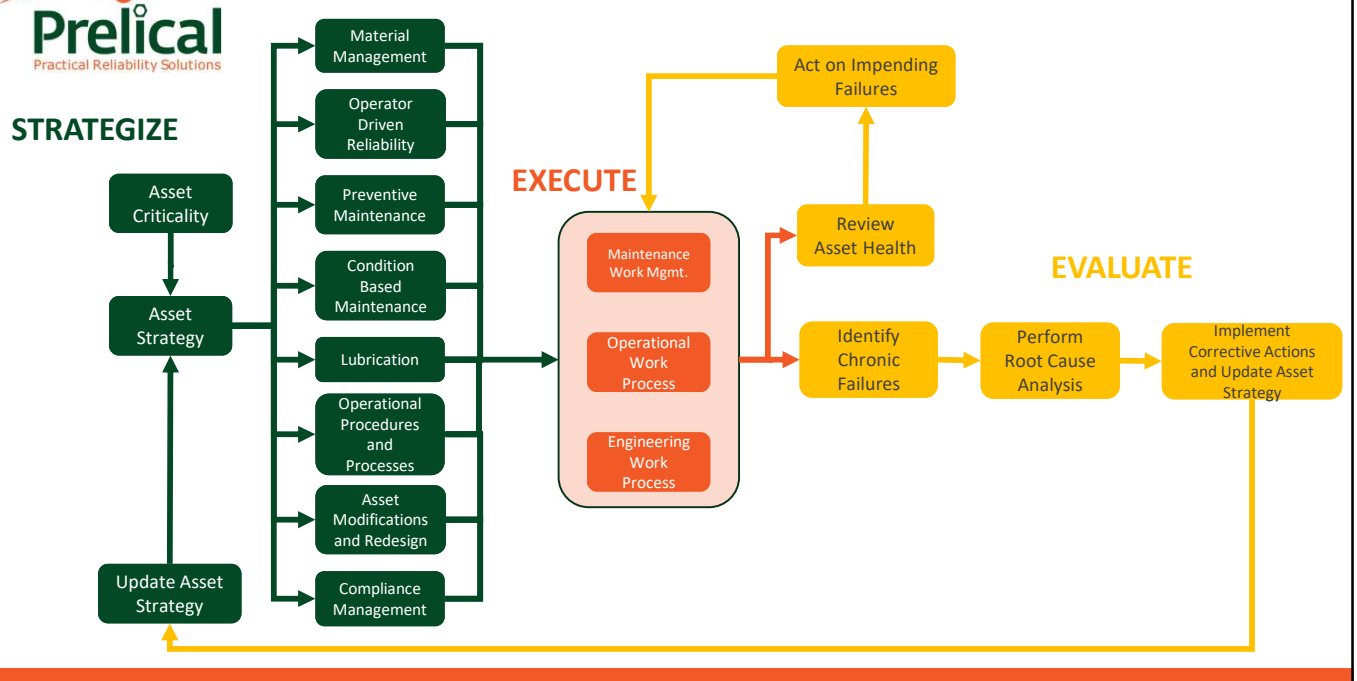

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16

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Process Enablers

Effective Communication
Communication is key through all levels of the organization

Management Support
Company leadership actively and publicly emphasizes the importance of asset reliability across the enterprise

Tools and Technologies
The latest tools and technologies to setup teams for success

Defined Roles and Responsibilities
Reliability roles and responsibilities built in to how the organization performs its business

Culture of Accountability
Team holds each other accountable to perform their roles and responsibilities

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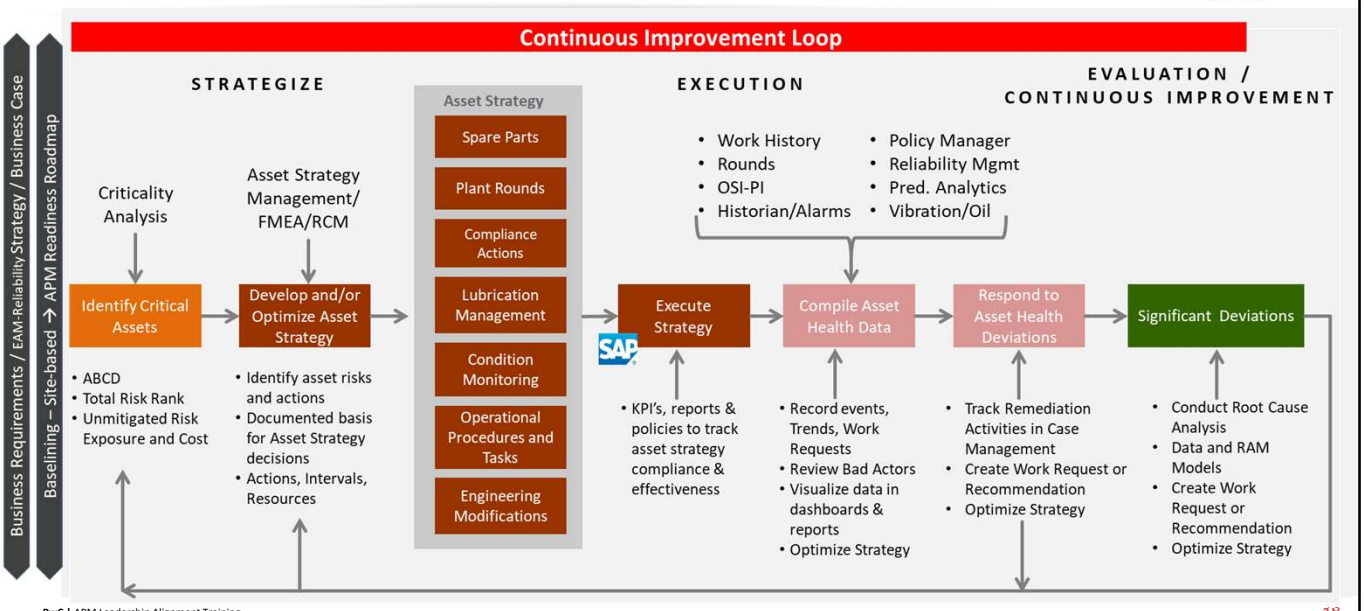
17

RELIABILITY PROCESS FLOW

DIGITAL 2.0 OPERATIONS & MAINTENANCE
Powered by ADVANTEDGE66



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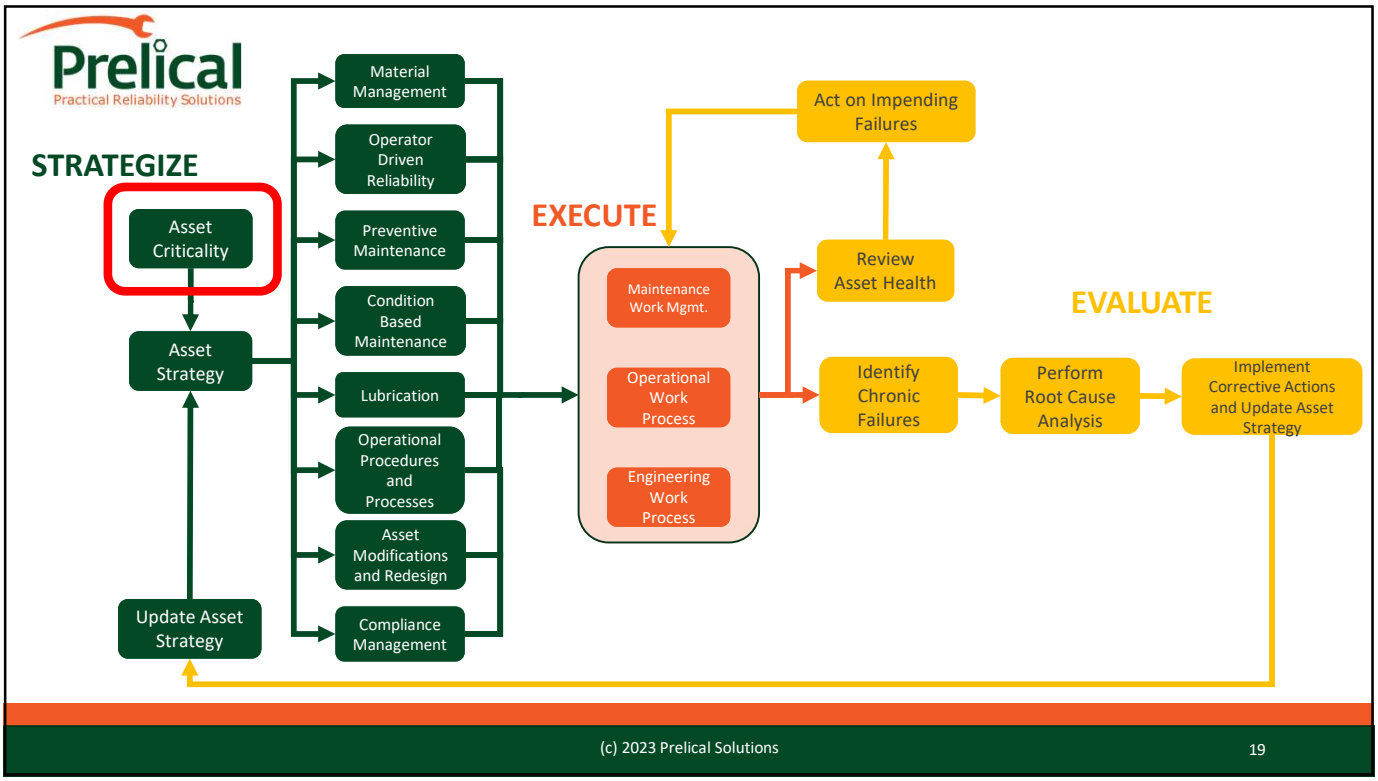
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STRATEGIZE
Asset Criticality
Asset Strategy
Update Asset Strategy
Material Management
Operator Driven Reliability
Preventive Maintenance
Condition Based Maintenance
Lubrication
Operational Procedures and Processes
Asset Modifications and Redesign
Compliance Management
EXECUTE
Maintenance Work Mgmt.
Operational Work Process
Engineering Work Process
Act on Impending Failures
Review Asset Health
EVALUATE
Identify Chronic Failures
Perform Root Cause Analysis
Implement Corrective Actions and Update Asset Strategy
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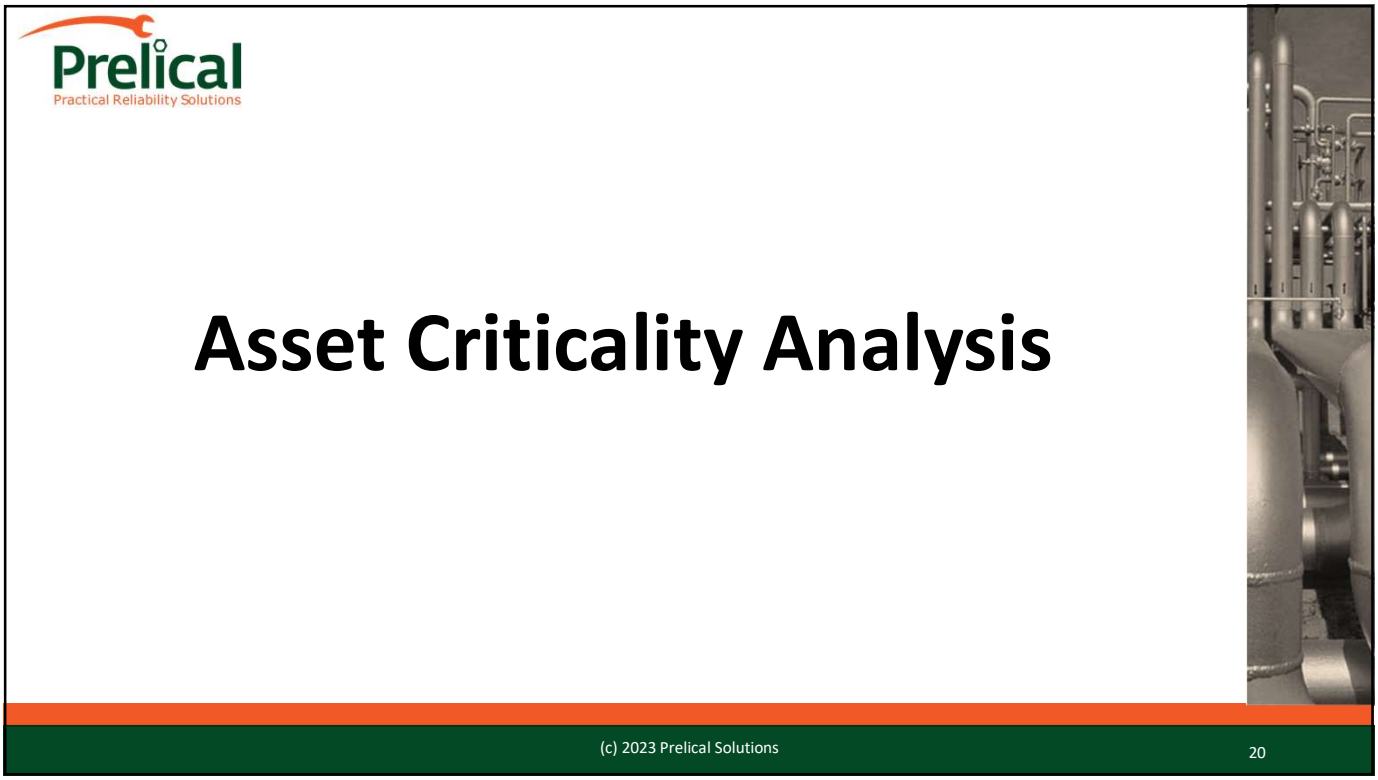
19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Asset Criticality Analysis
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20

Asset Criticality

- Asset Criticality
- Why is Criticality important?
- Elements of Criticality analysis (Safety, Environmental, Production and Cost)
- Typical criticality methodologies
- Typical distributions of Criticality
- Example of a risk matrix
- Demonstrate how to create one with a spreadsheet

21

What is Asset Criticality?

By analyzing the criticality of assets, reliability professionals can prioritize maintenance activities and allocate resources more efficiently to ensure the most critical assets receive the appropriate level of attention and care. This approach can help reduce the likelihood of asset failure and improve overall plant reliability.

22

Why is Criticality Important?

Determines what level of asset strategy is required to mitigate failures

Helps to determine stocking levels of materials in the storeroom

Risk Variables

- Safety
- Environmental
- Operations
- Financial

Probability	Consequence: Very Low 1	Low 10	Medium 100	High 500	Very High 1000
Frequent 5	5	50	500	2500	5000
Probable 1	1	10	100	500	1000
Possible 0.3	0.3	3	30	150	300
Remote 0.1	0.1	1	10	50	100
Improbable 0.05	0.05	0.5	5	25	50

Mission Time

Mission time refers to the length of time during which an asset or system is expected to operate under normal operating conditions.

25

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Safety

Probability	Description
5	Likely to occur more often than mission time
1	Likely to occur the same as mission time
0.3	Likely to occur less frequent than the mission time
0.1	Likely to occur much less frequent than the mission time
0.05	Unlikely to occur

Safety Consequence	Description
1000	Fatality, litigation, business jeopardy
500	Permanent disability and potential litigation
100	Hospitilization and/or temporary disability
10	Lost Time Injury
1	None to minor first-aid

Probability \ Consequence	Very Low 1	Low 10	Medium 100	High 500	Very High 1000
Frequent 5	5	50	500	2500	5000
Probable 1	1	10	100	500	1000
Possible 0.3	0.3	3	30	150	300
Remote 0.1	0.1	1	10	50	100
Improbable 0.05	0.05	0.5	5	25	50

26

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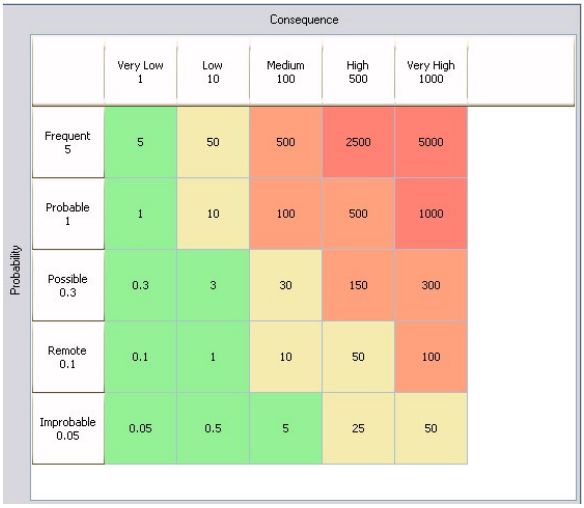
Environmental

Probability	Description
5	Likely to occur more often than mission time
1	Likely to occur the same as mission time
0.3	Likely to occur less frequent than the mission time
0.1	Likely to occur much less frequent than the mission time
0.05	Unlikely to occur

Environmental Consequence	Description
1000	World Issue, litigation and business jeopardy
500	National regulatory issue, fine or litigation
100	Local regulatory Issue, Fine, reputation damage
10	DEQ Recordable Issue
1	None to minor cleanup required



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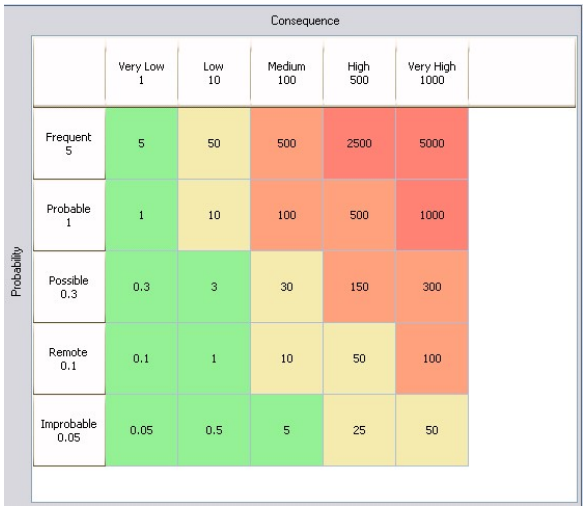
Operational

Probability	Description
5	Likely to occur more often than mission time
1	Likely to occur the same as mission time
0.3	Likely to occur less frequent than the mission time
0.1	Likely to occur much less frequent than the mission time
0.05	Unlikely to occur

Operational Consequence	
1000	Plant outage and $MM Loss
500	Area outage and $M loss
100	Subarea outage and $k loss
10	Asset outage with moderate repair cost
1	Minor repair or adjustment required



28

Financial

Probability	Description
5	Likely to occur more often than mission time
1	Likely to occur the same as mission time
0.3	Likely to occur less frequent than the mission time
0.1	Likely to occur much less frequent than the mission time
0.05	Unlikely to occur

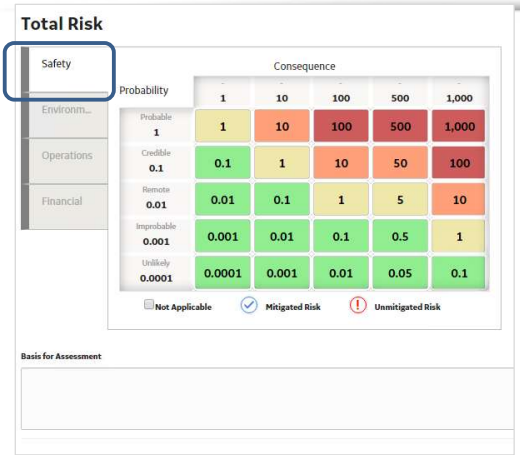
Production Loss $

X **+** **=** **Consequence $**

Maintenance Cost $

29

SAFETY RISK DIMENSIONS



Safety Risk = Safety Probability * Safety Consequence

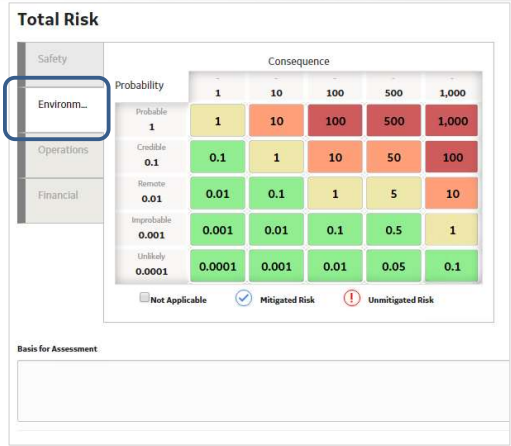
Remember to capture the Basis for Assessment!

Probability	
1	Chance of causing a safety event in 1 year
0.1	Chance of causing a safety event in 10 year
0.01	Chance of causing a safety event in 100 year
0.001	10% chance of causing a safety event in 100 years
0.0001	1% chance of causing a safety event in 100 years

Consequence	
1	Medical Treatment, Minor Health Effects, First Aid Case, or Less, or Loss of Containment below the Tier 2 PSE threshold
10	Medical Treatment with Restricted Duty or Medium Health Effects or Tier 2 PSE without fire or explosion
100	One or More Lost Time Workday Cases or Significant Health Effects or Tier 1 PSE remaining within containment (C5 or heavier material), or Tier 2 toxic release, or Tier 2 PSE with a fire or explosion
500	Permanent Disability, Multiple Hospitalizations, or Major Health Effects or Tier 1 PSE with no fire or explosion (C4 or lighter material), or onsite toxic release
1000	Fatality, Public Hospitalization, or Severe Health Effects or Tier 1 Process Safety Event (PSE) with fire or explosion, or offsite toxic release

30

ENVIRONMENT RISK DIMENSIONS



Environmental Risk = Environmental Probability * Environmental Consequence

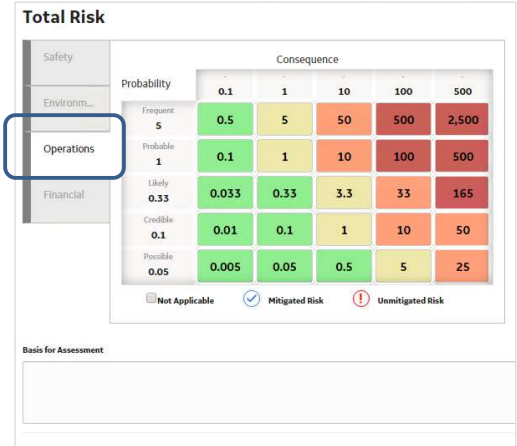
Remember to capture the Basis for Assessment!

Probability	
1	Chance of causing a environmental event in 1 year
0.1	Chance of causing a environmental event in 10 year
0.01	Chance of causing a environmental event in 100 year
0.001	10% chance of causing a environmental event in 100 years
0.0001	1% chance of causing a environmental event in 100 years

Consequence	
1	No environmental event can occur
10	Environmental event resulting in < RQ; or an event that lasts < one hour; or occurs up to 3 times per year
100	Environmental event resulting in > 1 times RQ but < 10 times RQ; or an event that lasts up to 24 hours; or occurs 3-5 times per year
500	Environmental event resulting in >10 times Reportable Quantity (RQ); or an event that lasts > 24 hours; or occurs > 5 times per year
1000	Community injury or shelter-in-place; or release on roadways or sensitive waterways impacting communities or commerce

31

OPERATIONS RISK DIMENSIONS



Operations Risk = Operations Probability * Operations Consequence

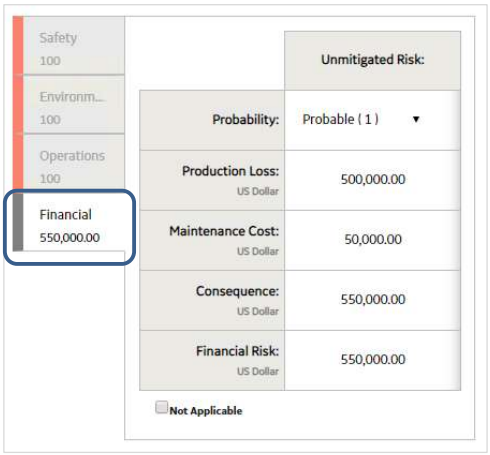
Remember to capture the Basis for Assessment!

Probability	
5	Chance of failing multiple times per year
1	Chance of failing 1 time per year
0.33	Chance of failing 1 time per 3 years
0.1	Chance of failing 1 time per 10 years
0.05	Chance of failing 1 time per 20 years

Consequence	
0.1	Business Interruption <$10M
1	Business Interruption $10M to $100M
10	Business Interruption $100M to $1MM
100	Business Interruption $1MM to $10MM
500	Business Interruption > $10MM

32

FINANCIAL RISK CRITERIA



Financial Risk

- The estimated monetary value attributed to the Unmitigated Risk
- Financial Probability is the same as Operations Probability
- Financial Consequence is:

  Production Loss + Maintenance Cost

- Financial Risk = Probability X Financial Consequence ($)

33

Overall Rating

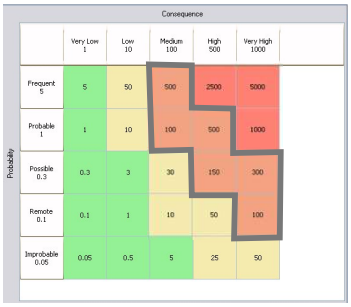
Safety Probability X Safety Consequence + **Environmental Probability X Environmental Consequence** + **Operational Probability X Operational Consequence**

34

Overall Rating

Safety		Environmental		Operational		
1 x 10 = 10	+	1 x 100 = 100	+	1 x 100 = 10	=	120 (B)

Rating	Range
A	>= 1000
B	>=100 and <1000
C	>5 and <100
D	<=5



35

Asset Criticality Distribution

High Criticality (A)

- 5-10% of Assets
- Consider robust asset strategies development

Medium Criticality (B)

- 20-30% of Assets
- Manufacturer Recommendations
- Asset Specific Templates

Low Criticality (C/D)

- 60-75% of Assets
- Basic Care
- Run to Failure

36

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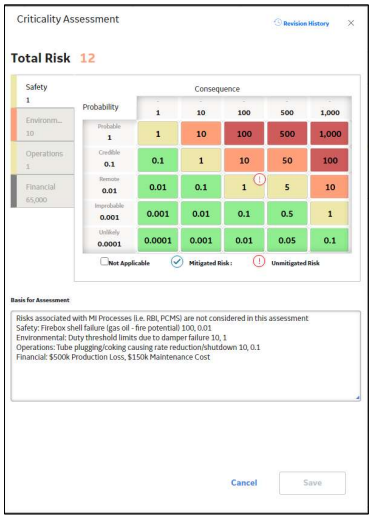
R201-FCC0135-36-H6 ~ H6, FCC CHARGE C 12 B



37

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STRATEGIZE

Asset Criticality

Asset Strategy

Material Management

Operator Driven Reliability

Preventive Maintenance

Condition Based Maintenance

Lubrication

Operational Procedures and Processes

Asset Modifications and Redesign

Compliance Management

Update Asset Strategy

EXECUTE

Maintenance Work Mgmt.

Operational Work Process

Engineering Work Process

Act on Impending Failures

Review Asset Health

EVALUATE

Identify Chronic Failures

Perform Root Cause Analysis

Implement Corrective Actions and Update Asset Strategy

38

Asset Strategy Development

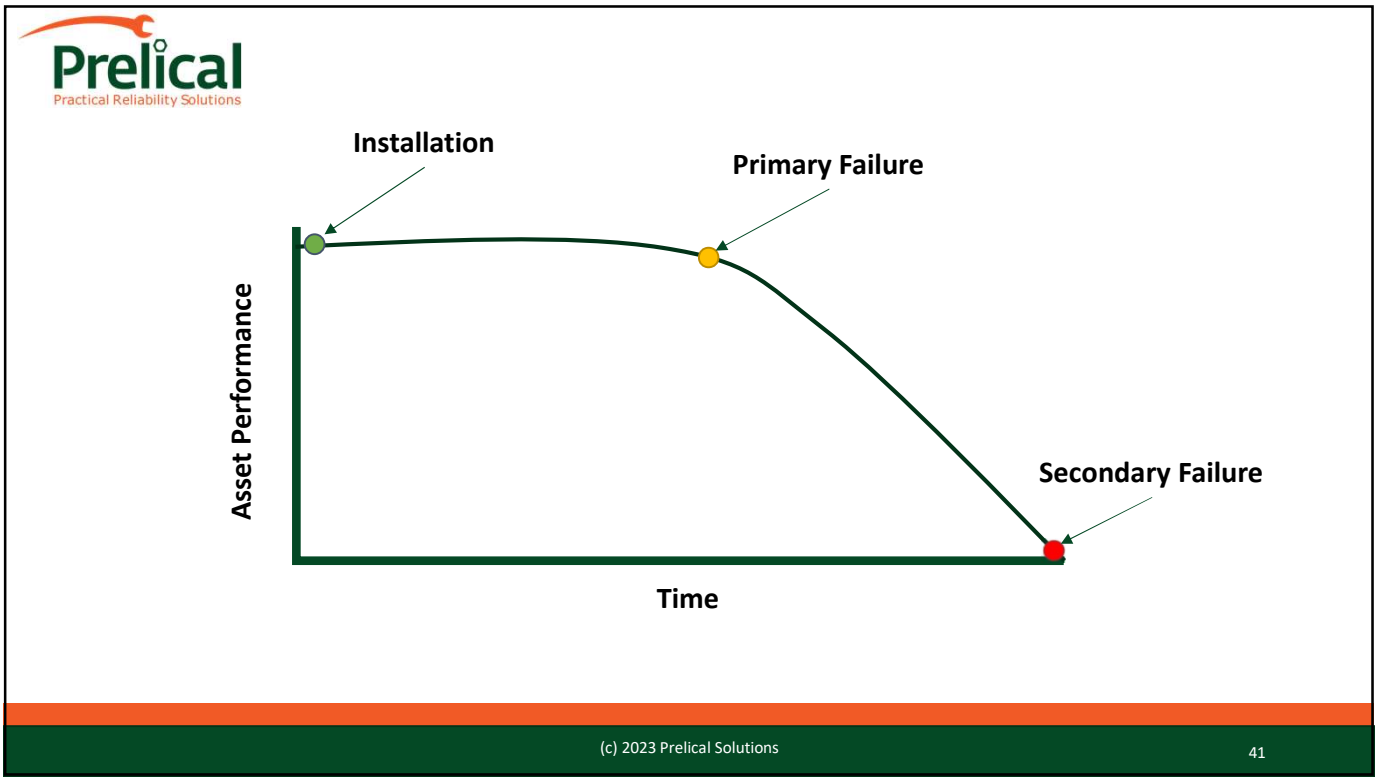
39

Failure Phases

Phase of Failure	Effect	Mitigating Action
Primary Failure	Initial indication of an impending failure	Condition Monitoring
Secondary Failure	Inability to perform intended function	Root Cause Analysis (RCA)

Primary	Secondary
Process temperature too hot →	Off-spec product
High vibration of bearing →	Pump fails
Pipe thinning →	Steam leak

40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Installation
Primary Failure
Secondary Failure
Asset Performance
Time
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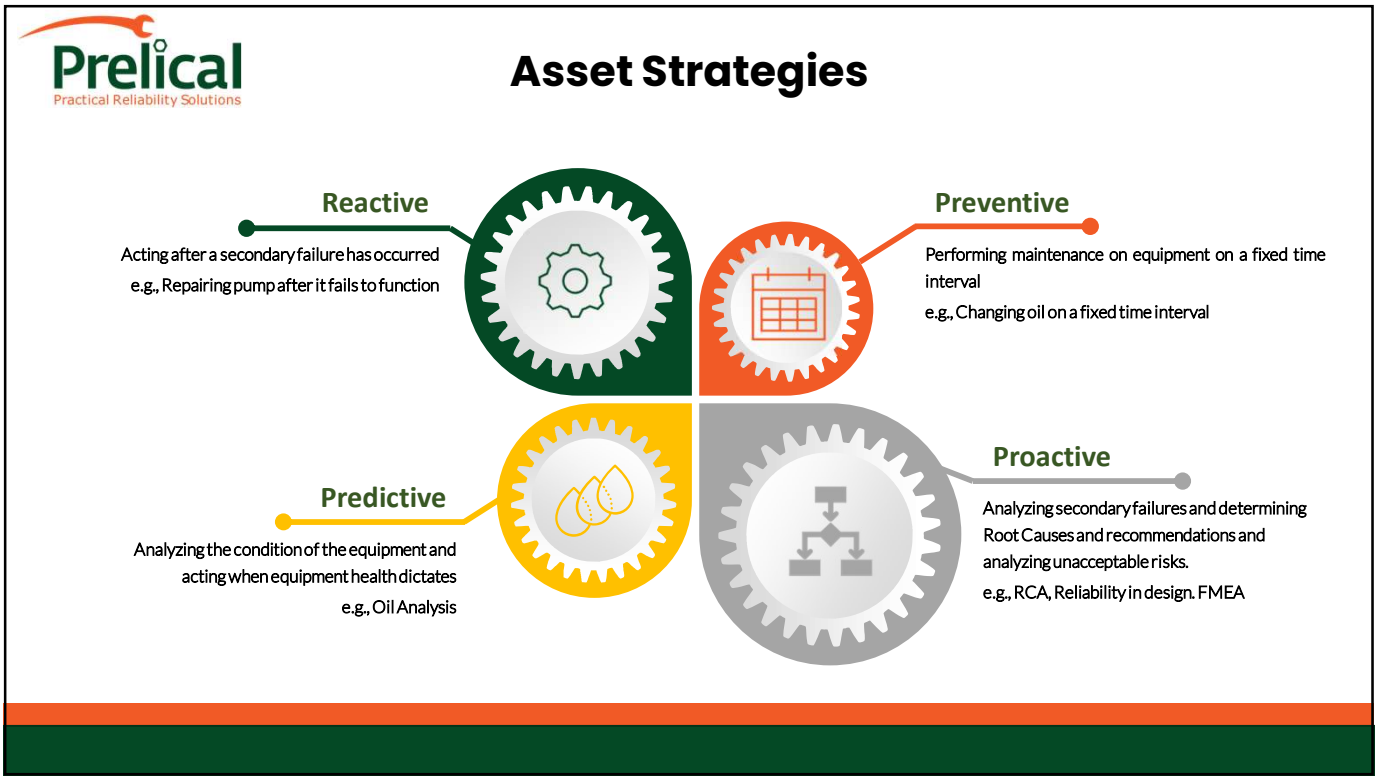
41

41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Asset Strategies
Reactive
Acting after a secondary failure has occurred
e.g., Repairing pump after it fails to function
Preventive
Performing maintenance on equipment on a fixed time interval
e.g., Changing oil on a fixed time interval
Predictive
Analyzing the condition of the equipment and acting when equipment health dictates
e.g., Oil Analysis
Proactive
Analyzing secondary failures and determining Root Causes and recommendations and analyzing unacceptable risks.
e.g., RCA, Reliability in design. FMEA

42

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Industrial Maintenance Strategy Evolution

1960

Prior to the 1960's, run to failure was the predominate maintenance strategy

1970

In the 1970's, plants started implementing time-based maintenance

1980

In the 1980's, technologies provided better tools to understand the condition of equipment and gave rise to predictive maintenance

2000

Since the turn of the century, we now are more proactive in trying to eliminate failures and the need for unplanned repairs

43

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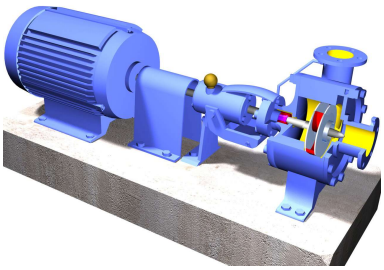
Risks (Failure Modes)

- Bearing Failures
- Seal / Packing Failure
- Coupling Failures
- Performance Issue



Mitigating Actions

- Vibration Analysis
- Visual Coupling Inspection
- Maintenance Rounds
- Operator Rounds
- Alignment Check
- Routine Oil Sampling
- Evaluate pump performance curve and system curve
- Stock materials in storeroom

44

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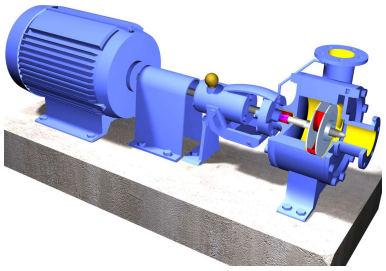
Risks (Failure Modes)

- Bearing Failures



Mitigating Actions

- Vibration Analysis
- Visual Coupling Inspection
- Maintenance Rounds
- Operator Rounds
- Alignment Check
- Routine Oil Sampling
- Evaluate pump performance curve and system curve
- Stock materials in the storeroom

45

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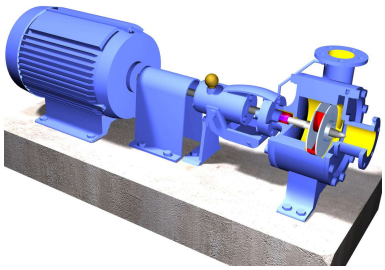
Risks (Failure Modes)

- Bearing Failures



Mitigating Actions

- Vibration Analysis

Task Properties

Interval:
1/month
Cost:
$25/check
Recommended Resources:
Vibration Analysis

46

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Exercise

What is your maintenance strategy ratio?

47

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Reactive	_____%
Preventive	_____%
Predictive	_____%
Proactive	_____%

48

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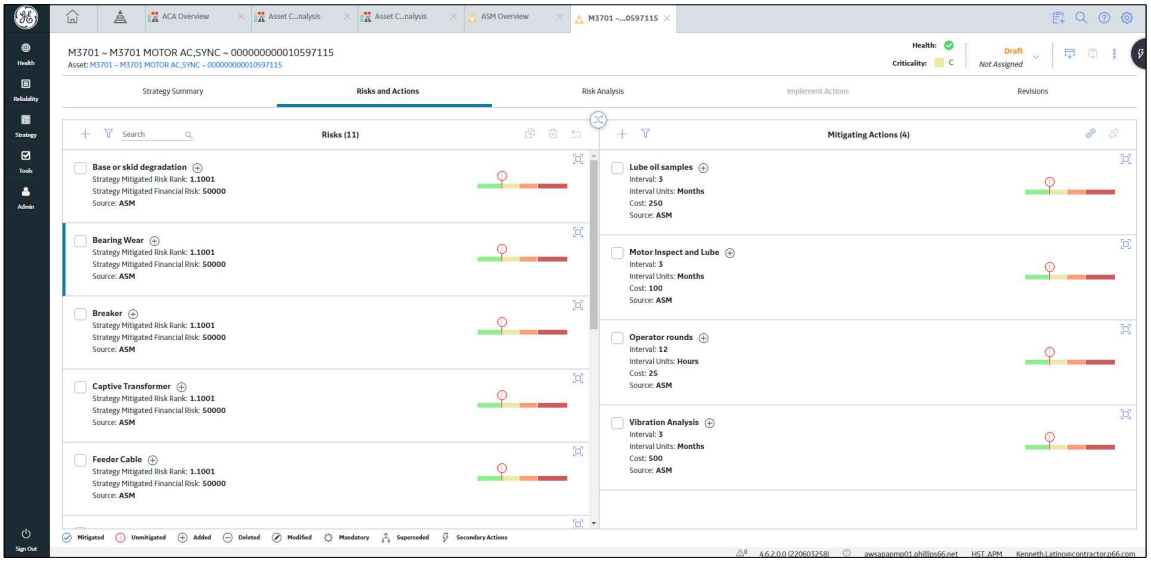

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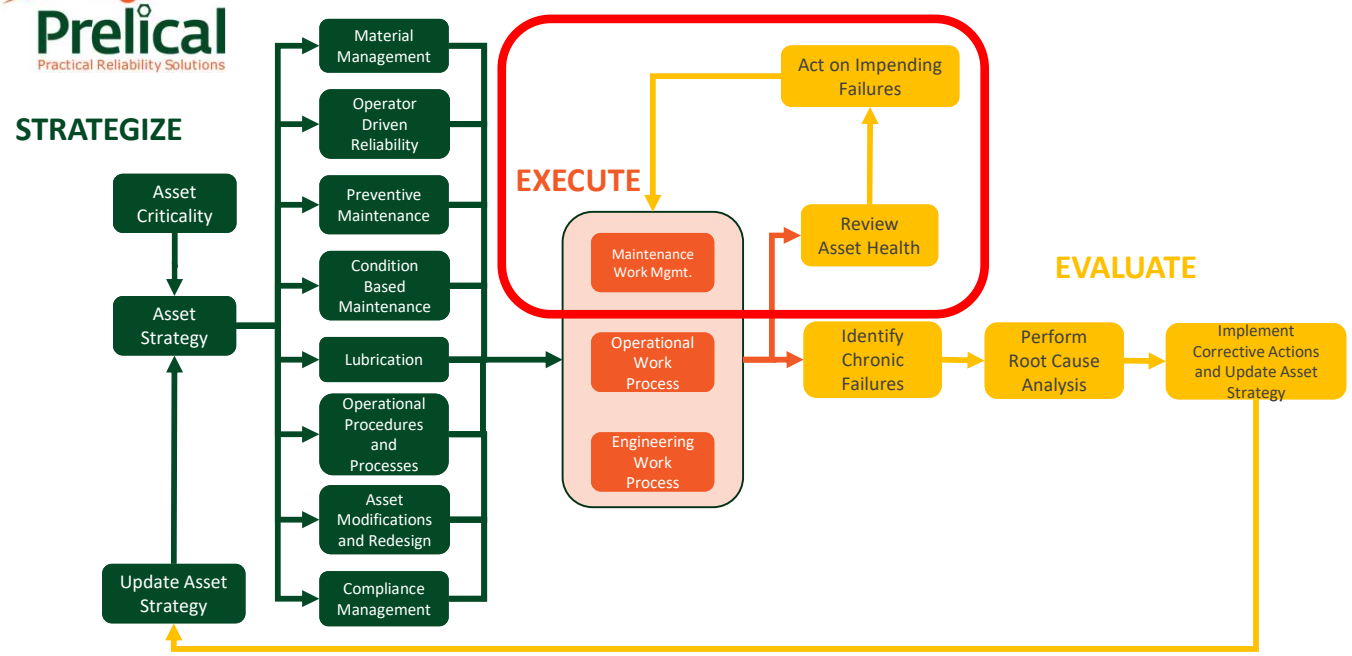

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Maintenance Work Execution

51

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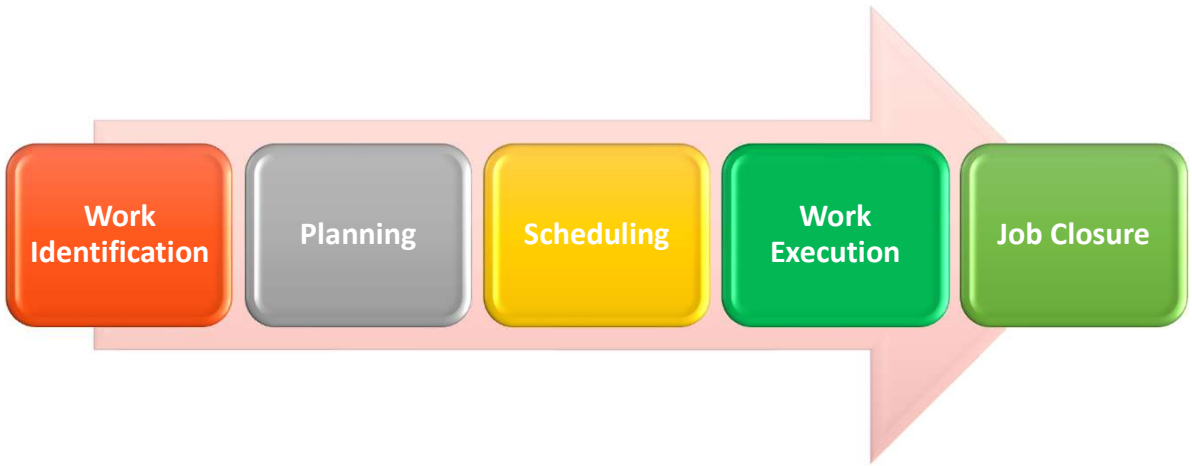
Typical Maintenance Work Management System



52

Work Identification

How is work identified in the facility?

53

Work Identification

- Operator/Maintenance Routes
- Preventive and Predictive (PM/PdM) Maintenance Routes
- Root Cause Analysis (RCA) action Items
- Tank Integrity
- Safety and Environmental Audits
- Employee Ownership and Awareness
- Engineering and/or Capital Initiatives

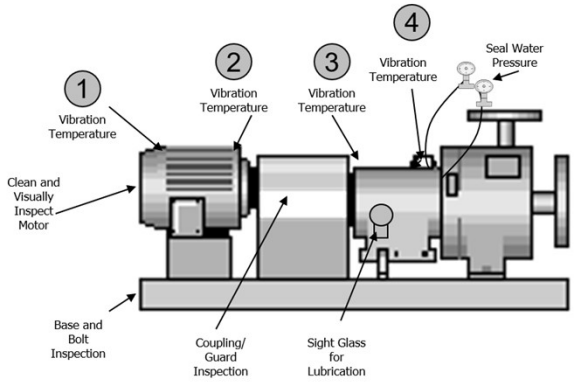
54

Rounds (Operator/Maintenance)

- Early detection of equipment defects
- Use of operator/craftsman senses and basic diagnostic tools
- Supplements more advance inspections performed by Predictive Maintenance Group (e.g. vibration, infrared)
- Allows identified defects to be planned and scheduled
  - Will reduce unplanned equipment downtime and related maintenance repair cost
  - Reduces the probability of safety and environmental issues
- Creates a feeling of ownership of the equipment

55

Pump / Motor Data Collection Points



Centrifugal Pump

- Check Bearing Temperatures (inboard/outboard)
- Check Bearing Overall Vibration (ips) (inboard/outboard)
- Check Seal Water Pressure
- Inspect Coupling RPM (if safe to do so)
- Inspect for loose, short or missing bolts on base and flanges
- Check oil level
- Check oil quality (visual inspection)

Electric Motor

- Check Bearing Temperatures (inboard/outboard)
- Check Bearing Overall Vibration (ips) (inboard/outboard)
- Ensure airflow on fins and back, and clean debris from back of motor
- Inspect for loose, short or missing bolts on base
- Ensure all cables are in working order

56

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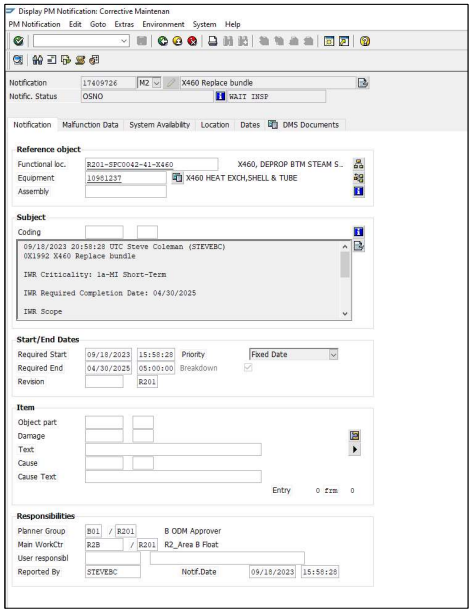

Quality work history starts with accurate SAP notifications

57

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Practical Reliability Solutions

Backlog Management

- Work is coming in faster than we can process it
- Prioritization is critical to managing the backlog of work
- Priority should be based on the level of risk
- Backlog review and prioritization should be an ongoing activity
- Every work order should have an accurate priority code

58

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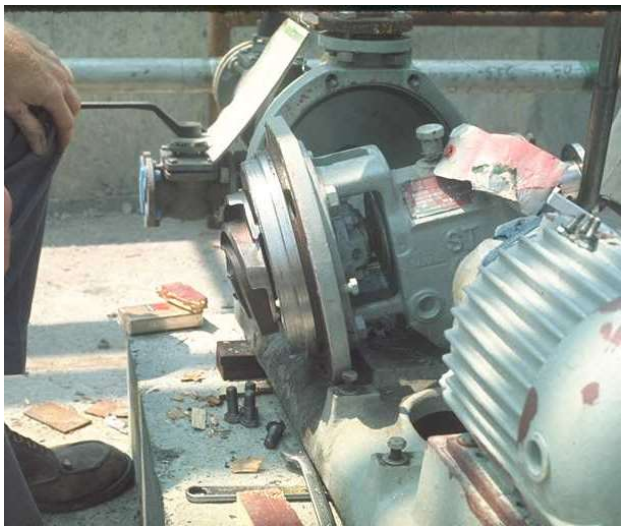
Practical Reliability Solutions

Planning

- Detailed work instructions
- Supplemental documentation (e.g. procedures, drawings, etc.)
- Proper time allocation from internal resources
- Contract work if required:
  - Permits
  - Mill Entry Requirements
  - Pre-Job Requirements
- Spare parts procured (internal or external)
- Proper work order coding in CMMS



59

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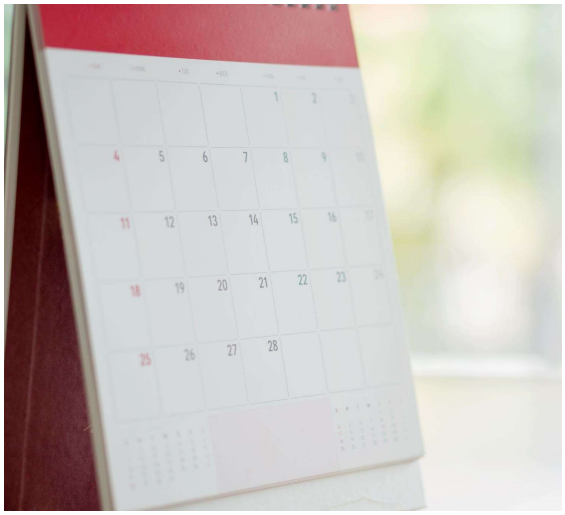
Practical Reliability Solutions



Scheduling

- Maintenance Resource Optimization cannot be obtained without effective scheduling
- Operations and Maintenance are both responsible for work scheduling and coordination of work (Core Teams)
- Planned and ready to be scheduled (R2BS) work is essential for effective scheduling
- The backlog is used to prioritize, select and Schedule work
- Manpower availability must be established for effective scheduling
- Final manpower availability is established weekly by Operations/maintenance coordinator
- Weekly, daily & shutdown schedules are developed, distributed and posted

60

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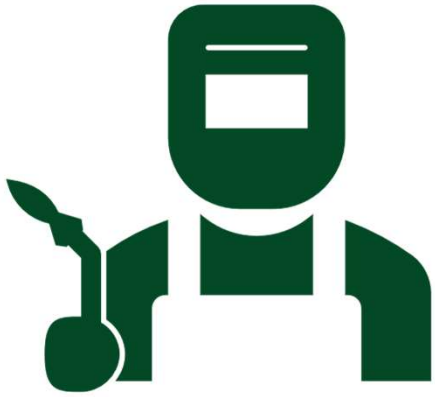
Practical Reliability Solutions



Work Execution

- All safety precautions will be in place and reviewed prior to performing the work.
- Ensure that all tools, parts and service equipment (e.g. cranes) are available for the schedule start of work
- Ensure that the equipment is locked out ahead of work execution and the area is ready for maintenance to perform the required work
- Utilizing precision maintenance techniques and principles will be the expectation on every job effort.
- Good housekeeping practices
  - Identifies issues and assigns work to promote good housekeeping to extend equipment life and asset health.
  - Personally, assure that each job site is left in a neat and clean condition promoting equipment reliability and life, and that his/her area is kept in safe and clean condition for all employees

61

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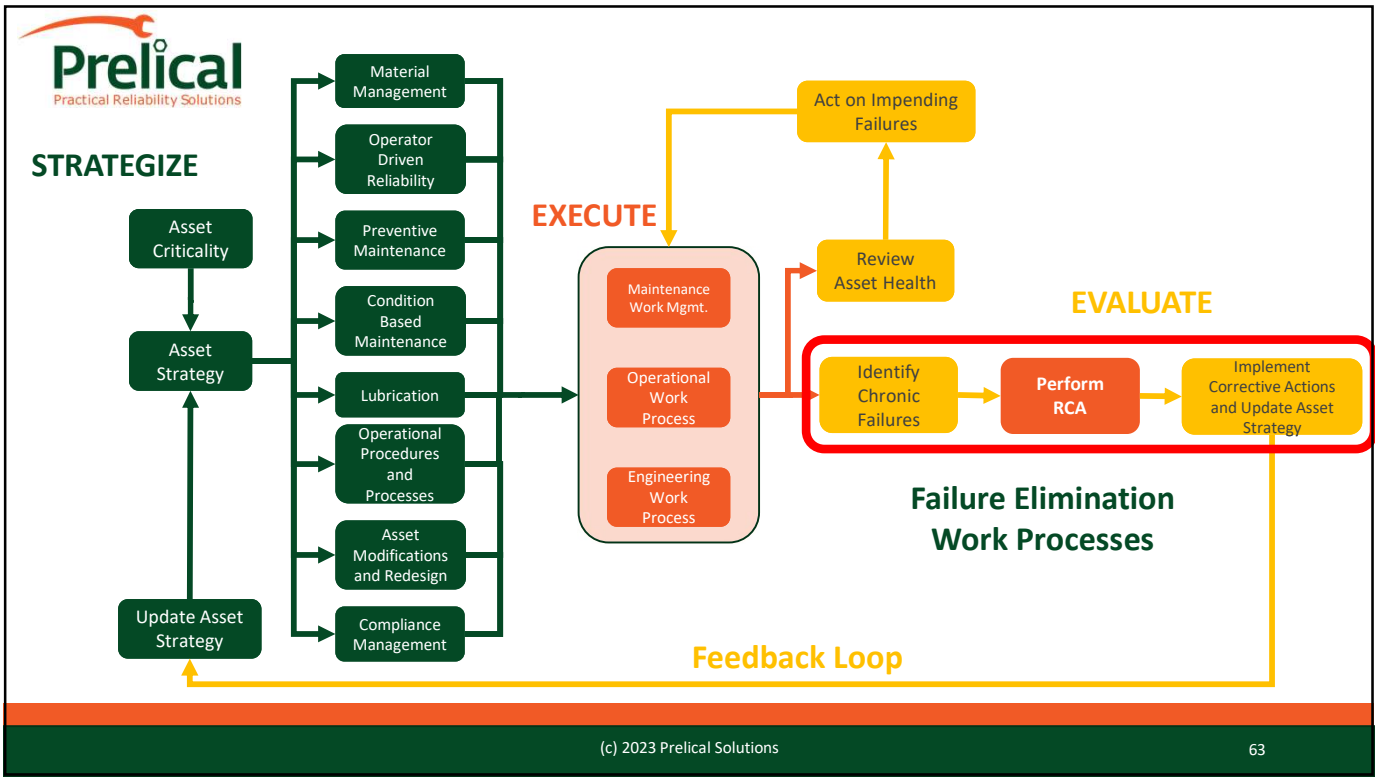
Job Closure

- The crew should communicate with the Supervisor, Operation/Maintenance Coordinator or an appointed operations contact to properly return the equipment to service and the desired performance is obtained
- Maintenance works with operations to startup or “try” equipment, when possible, to insure it operates properly when work is complete
- Document the details of the job in CMMS
- Craft time confirmations are accurately entered CMMS
- Precision Maintenance forms are completed and returned to Supervisor as required by the job
- Spare parts / cores are properly tagged and returned to the storeroom
- Feedback provided to the planner for any corrections needed (e.g. wrong parts, time estimates incorrect, etc.)
- Work order is properly closed

62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STRATEGIZE
Asset Criticality
Asset Strategy
Update Asset Strategy
Material Management
Operator Driven Reliability
Preventive Maintenance
Condition Based Maintenance
Lubrication
Operational Procedures and Processes
Asset Modifications and Redesign
Compliance Management
EXECUTE
Maintenance Work Mgmt.
Operational Work Process
Engineering Work Process
Act on Impending Failures
Review Asset Health
EVALUATE
Identify Chronic Failures
Perform RCA
Implement Corrective Actions and Update Asset Strategy
Failure Elimination Work Processes
Feedback Loop
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63

63


2
What do We Analyze?
Identifying Bad Actors for Analysis
64

64

Root Cause Analysis Steps

01 — Data Collection
Critical data about the event needs to be collected before analysis can begin

02 — Assemble the Team
A cross functional team needs to be assembled

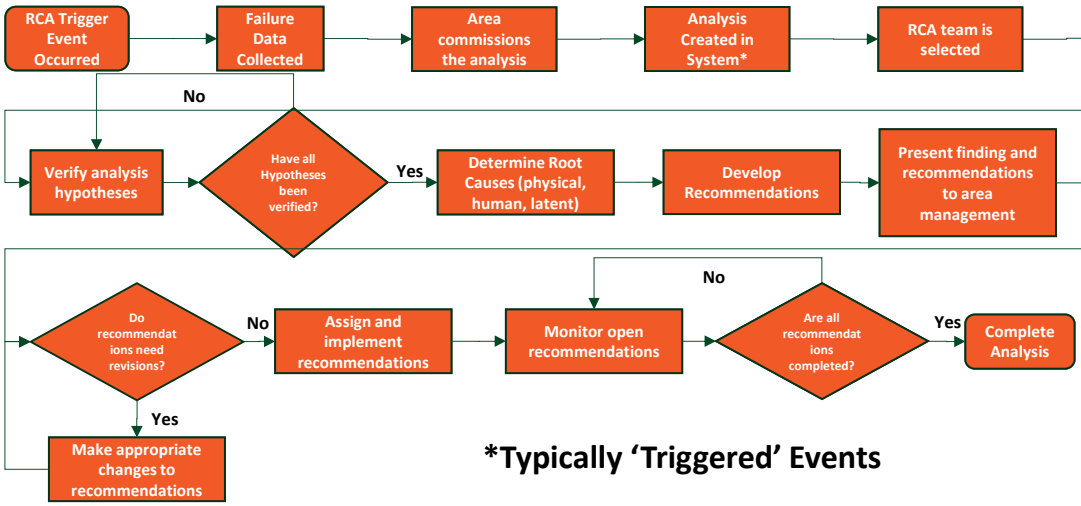
03 — Analyze the Event
The team will begin the analysis process utilizing a cause-and-effect diagram.

04 — Develop Corrective Actions and Report
Once causes are known, corrective actions can be developed and reported to decision makers

05 — Review Trends to Verify Success
Track work history, process trends and other data to ensure the event has been mitigated or eliminated

65

Simplified Failure Elimination Workflow (Sporadic)



*Typically 'Triggered' Events

* System denotes the software solution where the RCA will be created.

66

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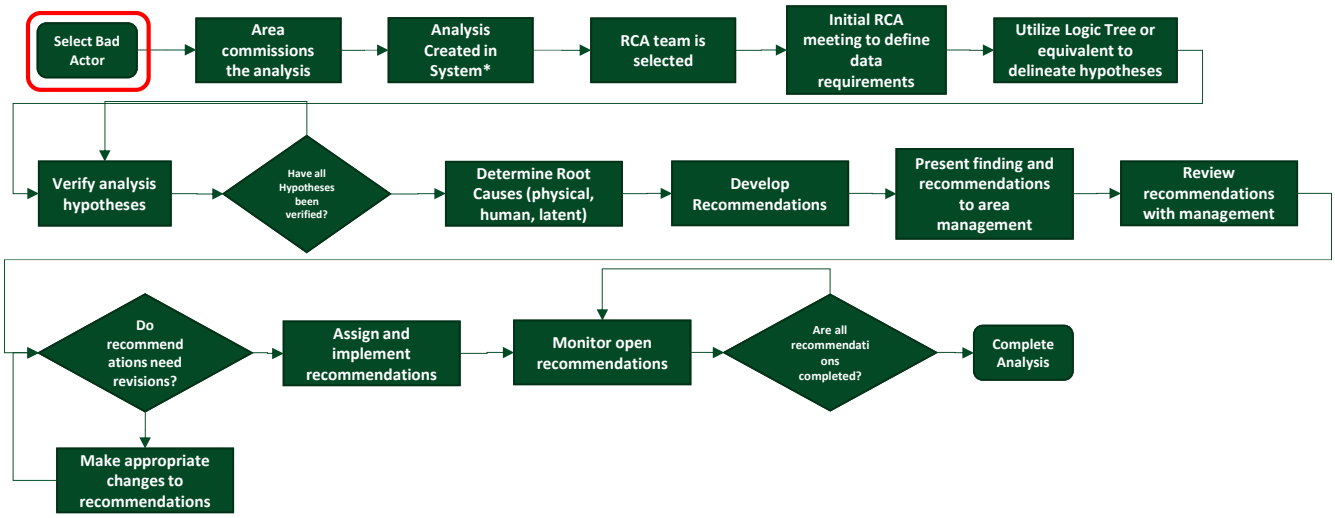
Simplified Failure Elimination Workflow (Chronic)

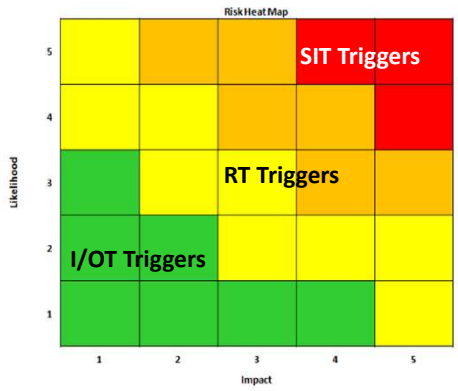


* System denotes the software solution where the RCA will be created.

67

Sample RCA Trigger Thresholds

- **Improvement/Opportunity Triggers (I/OT)**
  - Management Discretion
- **Reportable Triggers (RT)**
  - > $20k for Single Incident
  - > 4 Hours Unexpected Cumulative Downtime Over a 24-Hour Period
- **Serious Incident Triggers (SIT)***
  - > $100k for Single Incident
  - > 12 Hours Unexpected Cumulative Downtime Over a 24-Hour Period



STKY = 'Stuff That Kills You'
https://www.quantaservices.com/safety/the-capacity-model

What are Your RCA Triggers?

68

Generic Incident Management System (GIMS)

Perform RCA

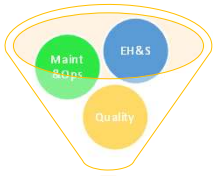
Aggregate Candidates for Analysis Into GIMS

KPI Rev

CMMS/ CA Work Orders

Execute Corrective Actions

Tree & CA Rev



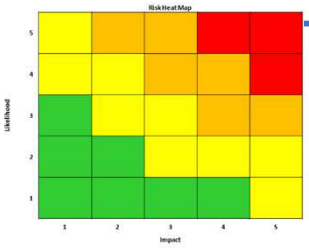
Root Cause Failure Analysis (RCA)

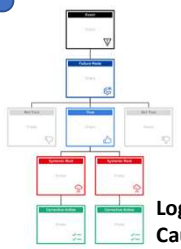
Significant Few (20%)

Follow In-Depth RCA Procedure

Incident Mgmt System

Prioritize & Assign Candidates





Logic Tree/ Cause & Effect Diagram

Develop Corrective Actions

Defect Elimination (DE)

Vital Many (80%)

Follow DE Procedure

5 - Whys

O R

Fishbone Diagram

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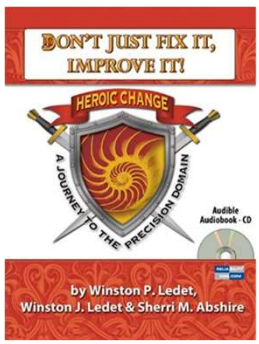
69

Defect Definition

"Anything that erodes value, reduces production, compromises health, safety or environmental performance or creates waste"



- Dr. Winston Ledet

Developer of 'The Manufacturing Game'

70

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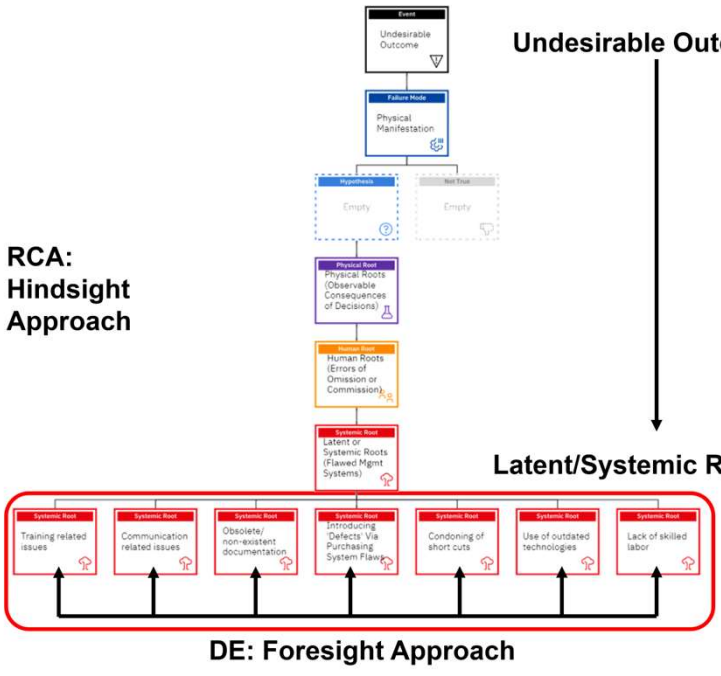
70



RCA: Hindsight Approach

Undesirable Outcome

Latent/Systemic Roots

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/healthcare-organizations-still-struggle-to-ensure-patient-safety

71

Graphic Source for All Logic Tree Expressions: Reliability Center, Inc.

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71

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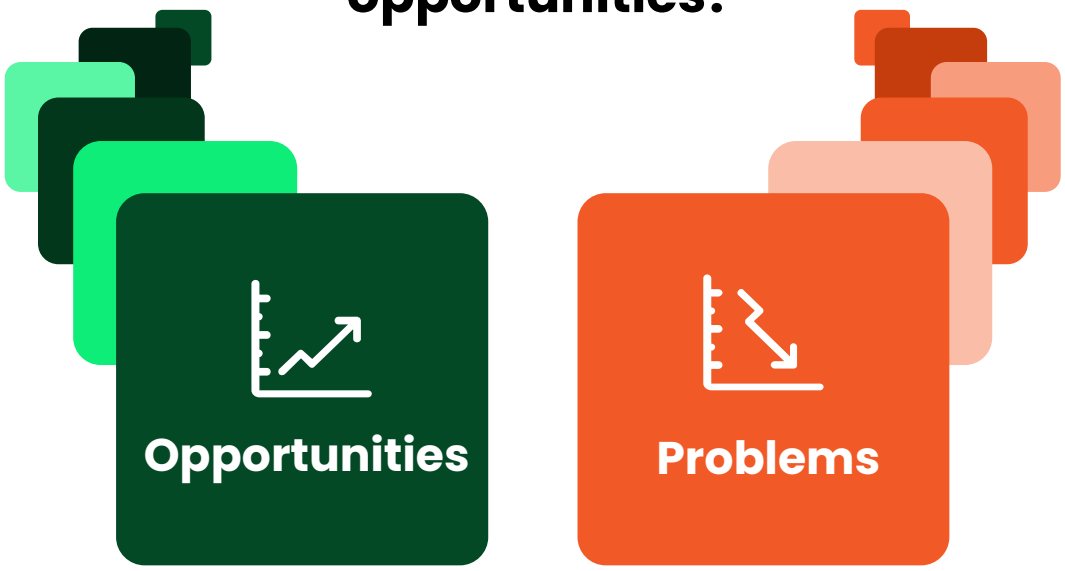
Are problems really opportunities?



72

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Are problems really opportunities?

Opportunities

An occasion or situation that makes it possible to do something to improve the current situation (status quo)

Problems

A matter or situation regarded as unwelcome or harmful and needing to be dealt with and overcome to get back to status quo.

73

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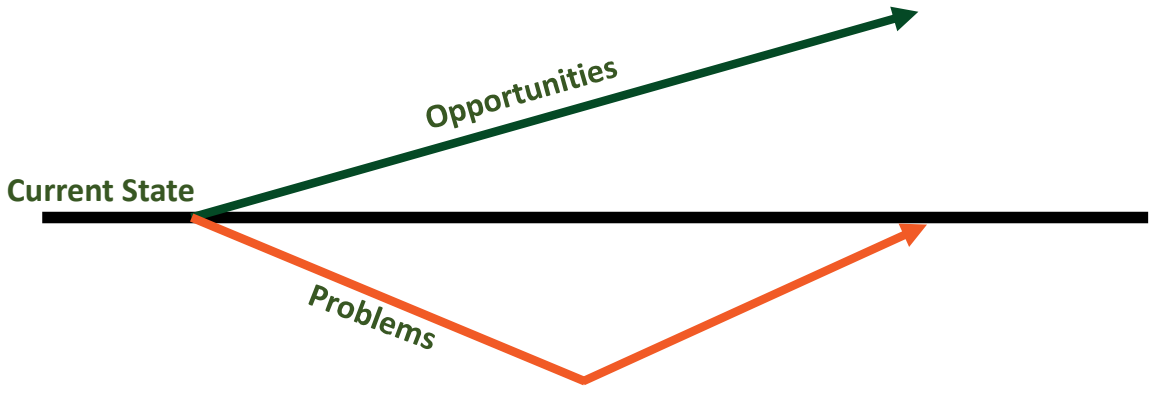

74

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If opportunities drive improvements, why do we focus so much on fixing problems?

75

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It is human nature for us to work on the 'urgent' versus the 'important'!!

76

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Sporadic Failure Characteristics

Urgent

These events are typically dramatic event that require immediate attention from the site

Infrequent

These events, by definition, do not occur very often

Time Consuming

These events take considerable time and attention away from the site to deal with the consequences of the event

Costly

These events require considerable financial resources to get back to steady state operations

77

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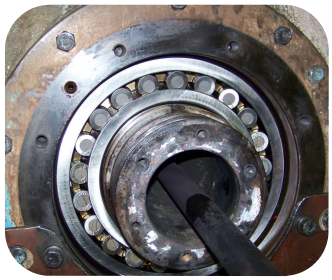
Sporadic Effect

Conveyor Fracture



Dryer Bearing Failure

Gloss Calender Roll Failure

78

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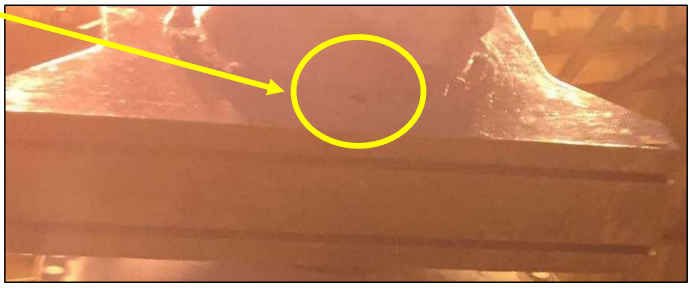

2nd Plug not easily visible inside the role (6" deeper than 1st plug).

79

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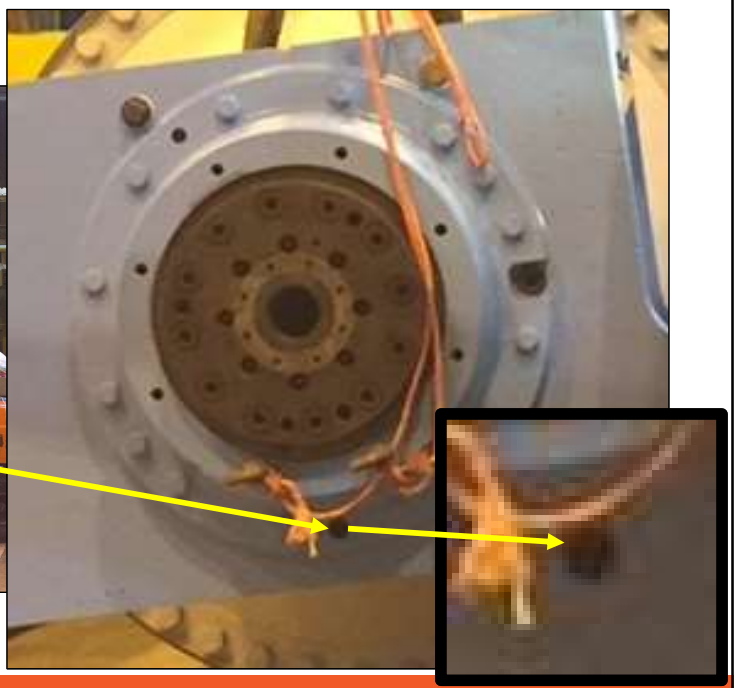
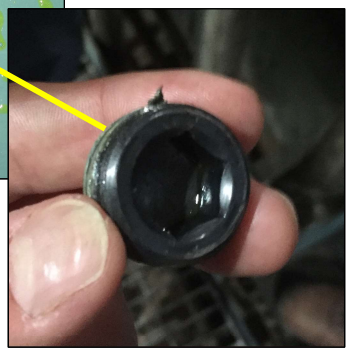
2nd Plug not easily visible inside the roll



80

Front Side



Back Side

Note: Practice was to hold roll being replaced before sending out for repairs, in case new roll had issues.

81

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Team Exercise: Sporadic Failure Listing

82

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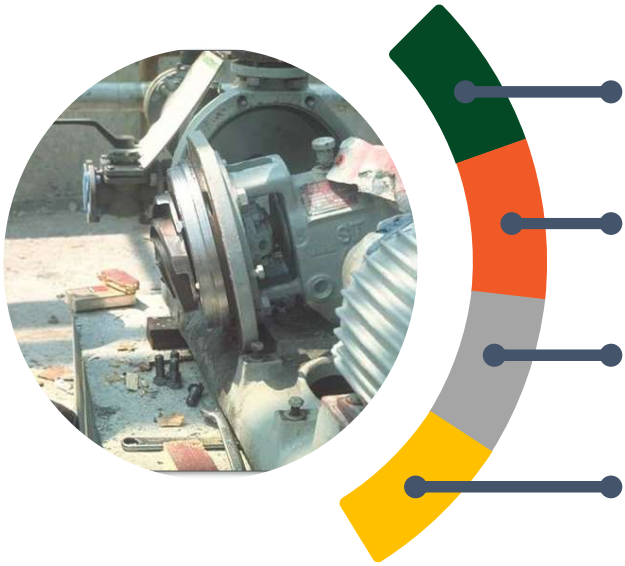
Chronic Failure Characteristics



Routine

These are events that happen so often, they are considered part of the status quo

Frequent Occurrence

These events, by definition, happen very frequently

Quick Fix

These events generally get resolved quickly. Mainly due to how often they occur

Not Individually Costly

Individual events do not cost very much when compared to sporadic failures. However, they are very costly if you multiple their impact by their frequency of occurrence.

83

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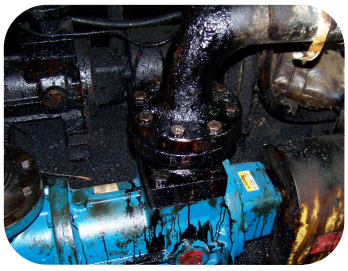
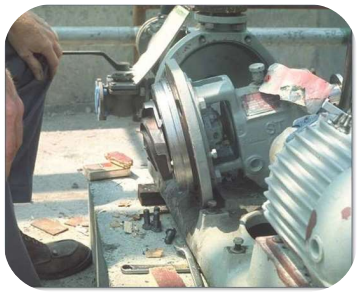
Chronic Effect



Fuel Oil Pumps

Conveyor Failures



Centrifugal Pump Failures

Heat Exchanger Leaks

84

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Team Exercise: Chronic Failure Listing

85

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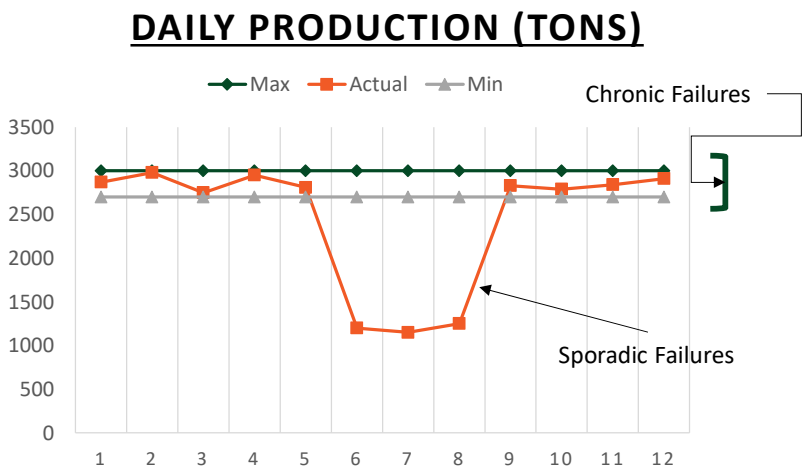
Chronic Failures are Built Into the Current State

Max Goal Production
Maximum Sustainable Production

Min Goal Production
Minimum Sustainable Production

Actual Production
Actual Daily Production



86

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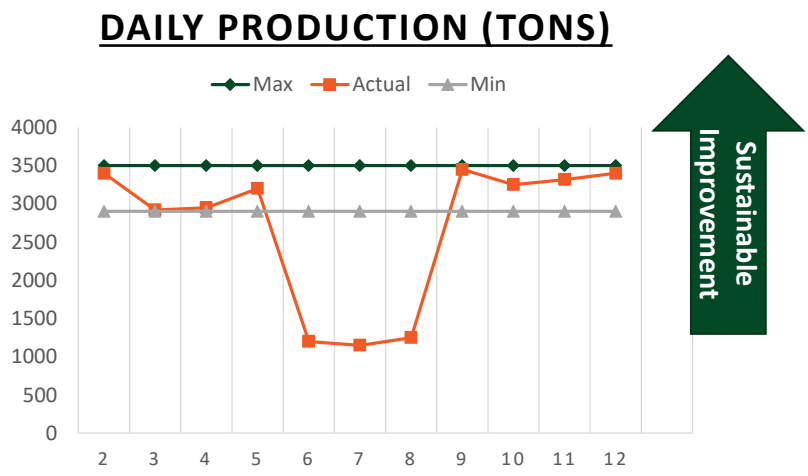
Focusing on Reducing Chronic Failures Increases the Status Quo

Max Goal Production
Maximum Sustainable Production

Min Goal Production
Minimum Sustainable Production

Actual Production
Actual Daily Production



87

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'No Blame' Zone

We are here to learn how failures and high risks occur, **NOT** how to pin the incident on someone or some group of individuals.

"To address this mistake we need to utilise our thorough system of root cause analysis. I will begin, if I may, by pointing out that it's not my fault"

88

88

3

What Are They Worth?

Quantifying Bad Actors for Analysis

89

89

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People?

Plant Data?

90

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System	Event Descriptiuon	Event Mode	Frequency Per Year	Impact Per Event (Maintenance + Production)	Total impact
Pulp Mill	Digester Failures	Cap failures	52	$25,000	$1,300,000
Bleach Plant	TSP1 Failures	Locks Up	6	$150,000	$900,000
Paper Machine 1	Trim Squirt Pump Failures	Impellar Wear	12	$65,000	$780,000
Woodyard	Chipper Failures	Blade Failures	26	$20,000	$520,000
Paper Machine 1	Felt Roll Failures	Bearings	5	$90,000	$450,000
Paper Machine 1	Pulper Failures	Pulper Gearbox Failures	3	$95,000	$285,000
Woodyard	Truck Dump	Hydraulic Failures	6	$45,000	$270,000
Recausticizing	Kiln Failure	Insulation Failures	2	$125,000	$250,000
Paper Machine 2	Fan Pump Motor Failures	Winding Failures	2	$100,000	$200,000
Pulp Mill	Primary Screen Failures	Screen Fails	2	$75,000	$150,000
Waste Treatment	Primary Clarifier	Bull Gear Bearing Failures	2	$75,000	$150,000
Bleach Plant	MC Pump 4 Failures	Bearing Failures	2	$75,000	$150,000
Power	Power Boiler Failures	Trips	6	$20,000	$120,000
Pulp Mill	MC Pump 1 Failures	Bearing Failures	2	$55,000	$110,000
Pulp Mill	MC Pump 1 Failures	Seal Leaks	4	$25,000	$100,000
Recausticizing	Kiln Failure	Gearbox Failures	1	$90,000	$90,000
Paper Machine 2	Press Section	Press Roll Failures	1	$90,000	$90,000
Pulp Mill	A Washer Failures	Doctor Failures	3	$27,000	$81,000
Power	FD Fan Failures	Coupling Failures	2	$30,000	$60,000
Woodyard	Debarking Drum Failure	Gearbox Failures	2	$25,000	$50,000
Paper Machine 2	Kady Mill Failures	Bearing Failures	2	$25,000	$50,000
Power	Power Boiler Failures	Igniter Failures	4	$5,000	$20,000
Waste Treatment	Sump Pump Motor Failures	Will not start	3	$5,000	$15,000
Total					$6,191,000

91

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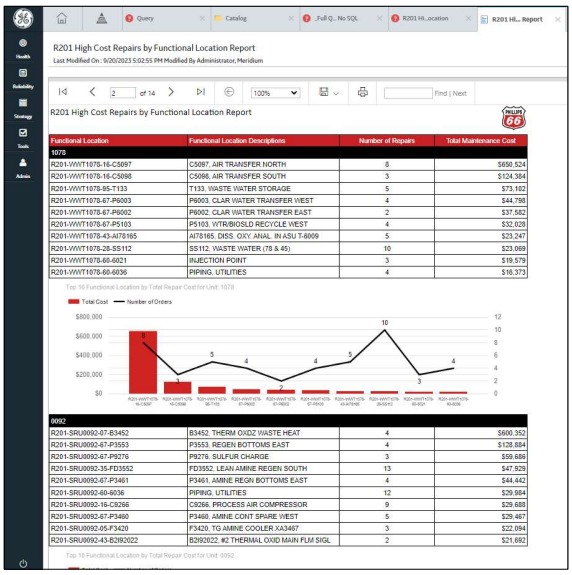

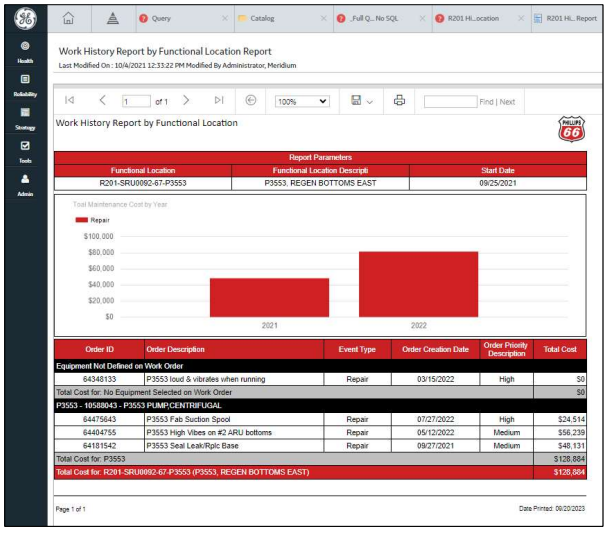

92

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Exercise #3: Quantifying Chronic Failures

Opportunity Analysis of a Car

93

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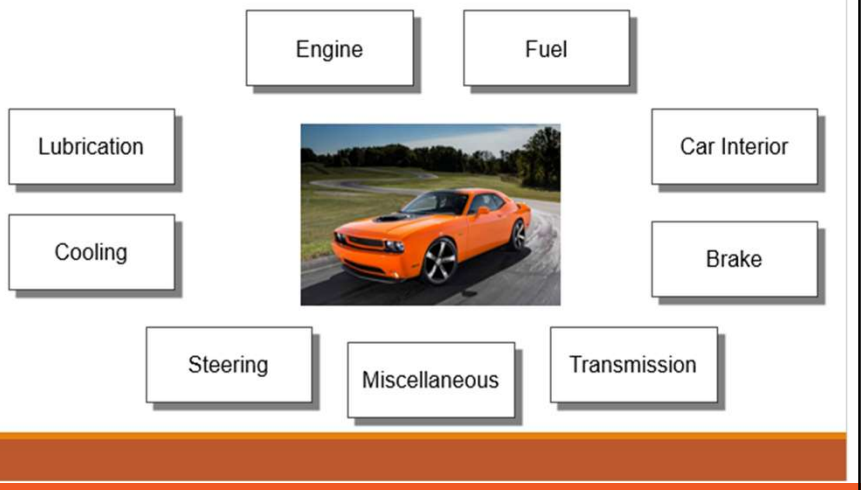
Failure Definition: Any event or condition that requires out-of-pocket expenditures to operate and/or maintain the vehicle.

Sub-System Diagram



94

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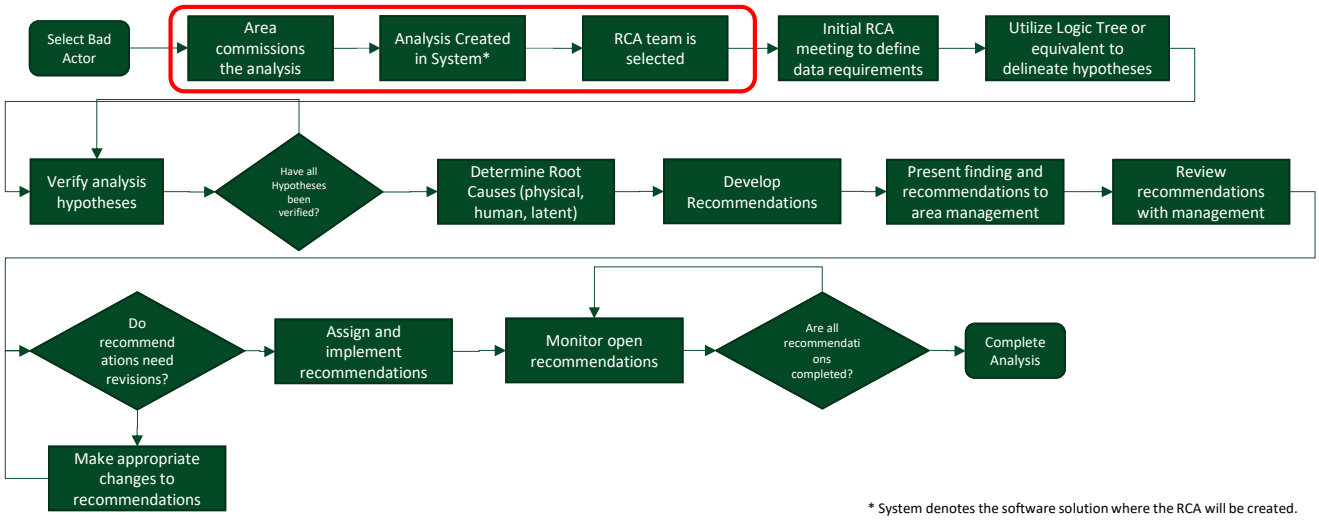
Simplified Failure Elimination Workflow (Chronic)



* System denotes the software solution where the RCA will be created.

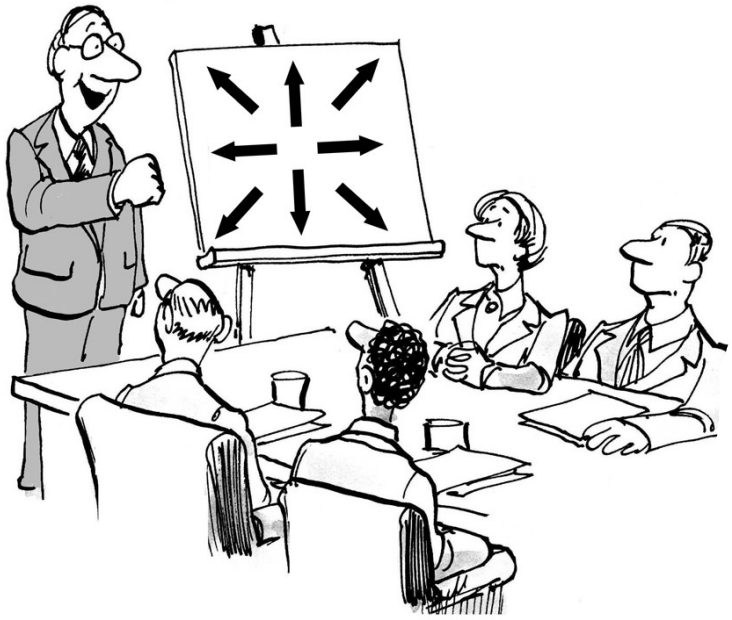
95

4

Who's On the Team?

Putting Together an Analysis Team

96



"Today we are going to decide who to blame.[3]

Contrary to Popular Belief…

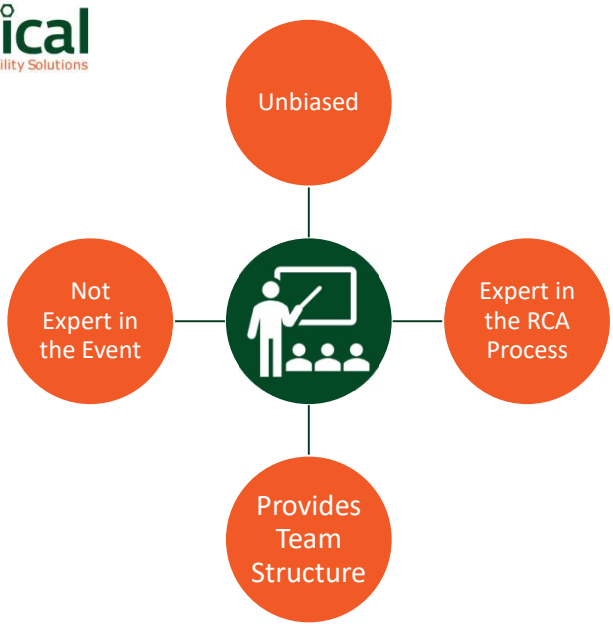
97

Source: ChatGPT.5.2.23

Characteristics for an Effective Team

- **Multidisciplinary:** A good RCA team should consist of members with diverse expertise and perspectives. The team should include individuals from various departments who have relevant knowledge and skills to contribute to the analysis.
- **Analytical skills:** The team members should have strong analytical skills to be able to identify the underlying causes of the problem. They should be able to analyze data, identify patterns, and use logical reasoning to make informed decisions.
- **Communication skills:** The RCA team should have excellent communication skills to effectively communicate the findings to other stakeholders. This includes both written and verbal communication skills.
- **Objectivity:** The RCA team should be able to approach the analysis objectively and avoid any biases. They should be able to consider all relevant factors and perspectives without being influenced by personal opinions or agendas.
- **Accountability:** The RCA team should take ownership of the analysis and the recommendations made. They should be committed to following through on the recommendations and ensuring that the underlying issues are resolved.

98



Role and Characteristics of an RCA Facilitator

99

Properly Defining the Problem is Half the Game

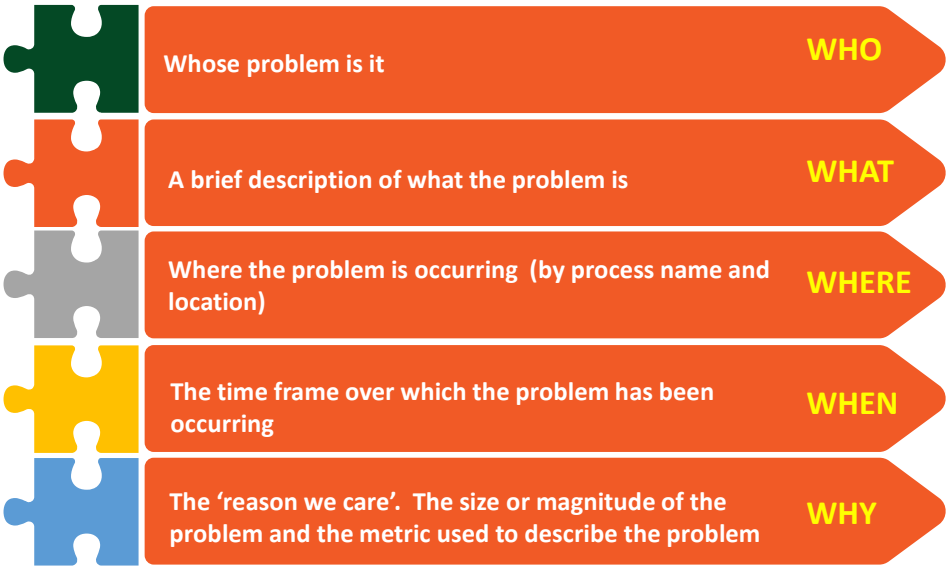
100

Problem Statement Tip

- Write the Problem Statement **knowing beforehand who your audience is**, and what their expectations may be.
- Be aware you must likely **convince** both :
  - 1) **management** to provide resources to help you solve the problem as well as
  - 2) enlist **team members** to assist you;
- You don't want to spend your scarce time **explaining repeatedly** what you're trying to accomplish.
- **The Problem Statement is not to be confused with the Team Objective**. The Team Objective is a description of the scope of the analysis team.

101

Elements of an Effective Problem Statement – Job Aid



102

Problem Statement: Warnings

- **DON'T UNDERSTATE** - Be careful to avoid under-stating a problem statement. A natural tendency is to write a problem statement too simplistically because we don't have time to do the due diligence to define all the elements described.
- **DON'T TAKE SHORT CUTS** - If you're going to recruit support and resources to help solve your problem, others must understand the context and the significance in order to support you.
- **ONLY STATE FACTS** - The problem statement must not include any indication or speculation about the cause of the problem or what actions will be taken to solve the problem. Never attempt to solve the problem or steer the solution at this stage. This will allow the influence of biases to draw unproven conclusions as facts.

103

Problem Statement Example

- **Poor Problem Statement:** Crude charge pumps keep failing
- **Better Problem Statement:** Repetitive crude charge pump failures causing unplanned downtime and excessive maintenance repair cost. This is causing the refinery $2,000,000 in LPO cost and $150,000 in maintenance repair cost that was not budgeted.

104

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Practical Reliability Solutions

<u>Ideal</u> Initial Team Meeting
…But We Have to be Practical, NOT PERFECT!
<u>(FOR TRIGGERED EVENTS)</u>

105

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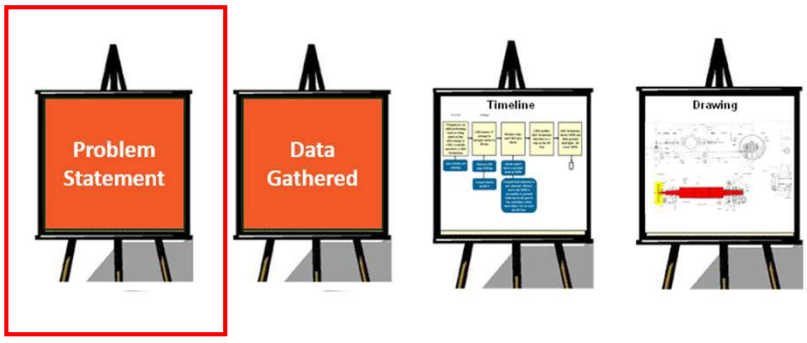
Practical Reliability Solutions

Exercise #5: Team Prep/Develop Problem Statement



106

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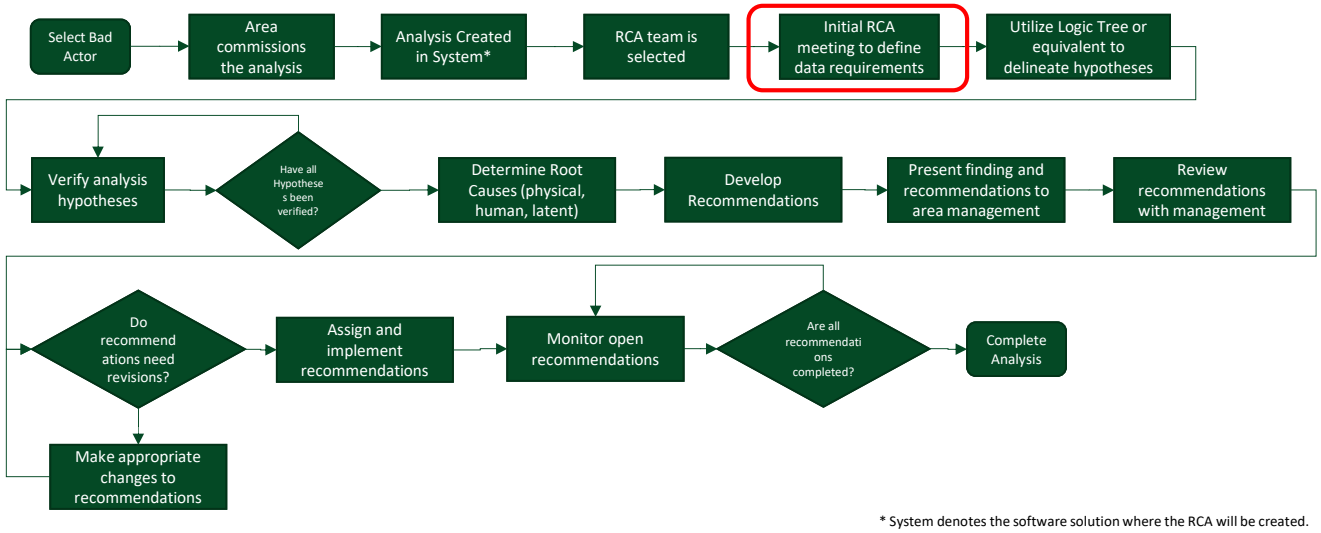
Practical Reliability Solutions

Simplified Failure Elimination Workflow (Chronic)



* System denotes the software solution where the RCA will be created.

107

5

What Data/Evidence Do I Gather?

Developing a Data Gathering Strategy

108

Types of Failure Data

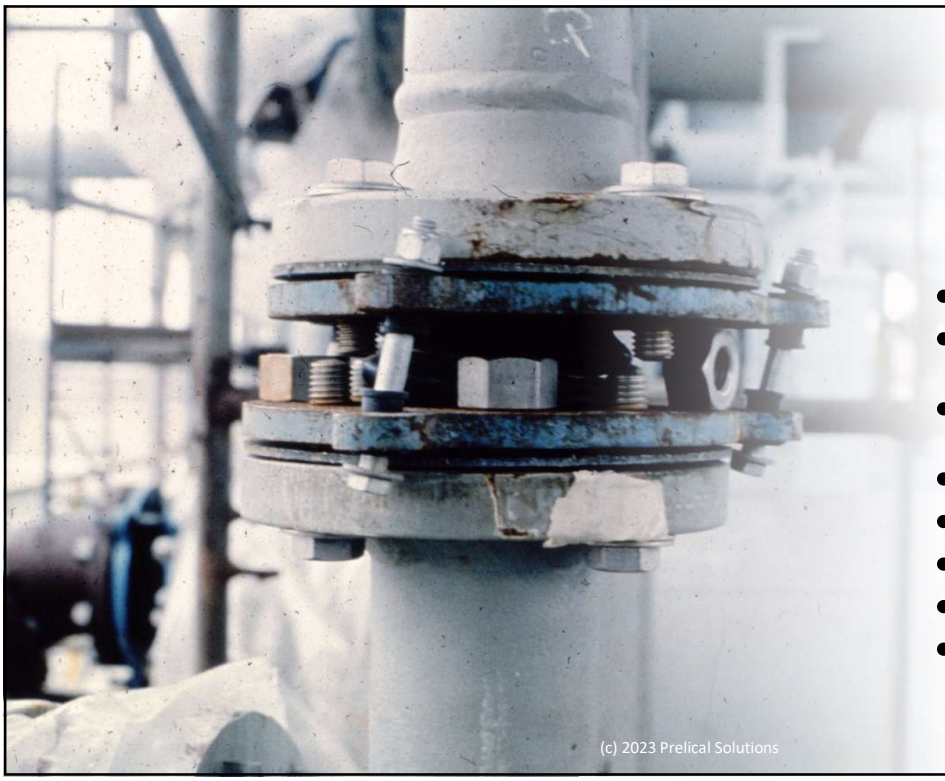
- **Physical data:** Failed components and other physical data from the scene of the failure.
- **Equipment data**: Collecting data about the equipment itself, such as its make, model, age, and maintenance history, can help identify any issues with the equipment that may have contributed to the failure.
- **Operational data**: Data related to the operation of the equipment, such as the operating parameters, performance data, and any deviations from normal operating conditions, can provide insight into what may have caused the failure.
- **Maintenance data**: Collecting data about the maintenance history of the equipment, such as the maintenance schedules, repair records, and any modifications made to the equipment, can help identify any potential maintenance-related issues that may have contributed to the failure.
- **Environmental data**: Data related to the environment in which the equipment operates, such as temperature, humidity, and other environmental factors, can help identify any external factors that may have contributed to the failure.
- **Human factor data**: Data related to the operators and maintenance personnel, such as their training, experience, and any actions taken before or during the failure, can help identify any human factors that may have contributed to the failure.
- **Process data**: Data related to the process in which the equipment is used, such as the process parameters, controls, and procedures, can help identify any process-related issues that may have contributed to the failure.

109

Component Examples (Tangibles)

- **Material Samples**
- **Review of Old vs New Parts**
- **Residue Samples**
- **Lubricant Samples**
- **Failed Parts (i.e. - Bearings, Gears)**
- **Calibration of Instruments/Gauges**
- **Leaking Fluids**
- **Water Samples**
- **Air Samples**
- **Raw Materials**

110



Failure Location & Timing Information

- Functional Location of Failure
- Time of Failure (Day, Shift & Time of Year)
- Weather/Environmental Conditions
- Location of Fractured Parts
- Gauge Readings
- Where Were Relevant Personnel
- Failure Histories (Timing)
- Work Order Histories (Timing)

111

Document Data

- Procedures & Their Histories
- Training Records
- Procurement Documentation
- Shift Logs
- JD Edwards/DCS/PI Info
- Inspection Results (Visual, PM)
- Chem & Metallurgical Lab Test Results
- P&IDs
- Work Order Histories
- HR Records

112

Potential People To Talk With

- Witnesses
- Maintenance Personnel
- Operations Personnel
- Quality Personnel
- Reliability Technicians
- E & I Personnel
- Mechanics
- Storeroom/Warehouse Personnel
- EH&S Personnel
- Purchasing/Accounting Personnel
- Chem/Metallurgical Lab Personnel
- Leadership/Sponsors/Mgmt
- Vendors/Suppliers

113

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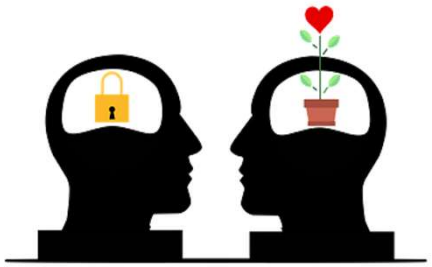
Mindsets/What People Believe

- We Were Short-Staffed
- We Lack Quality, Skilled Labor
- Turnover is Too High
- They Were Inexperienced
- Procedures are Not Updated/Not Followed
- We Were Never Trained on New Systems/ Technologies
- We've Always Done it this Way
- It's Maintenance's Fault (Can't Keep Equipment Running)!
- It's Operation's Fault! (Running to Fast)



114

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Optional Exercise #6: Data Gathering Strategy

CSB Failure – ExxonMobil Torrance, CA

Break into Teams

115

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What Data Would You Need to Collect?

ExxonMobil Torrance Refinery Explosion

116

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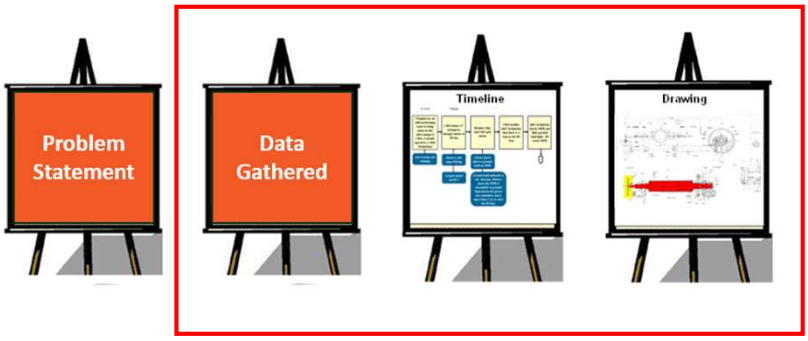
Exercise #7: Identify Initial Data to Gather for RCA Team Meeting



117

6A

Incorporating HOP (Human & Organizational Performance) Principles Into RCA

118

118

5 Core Principles of Human & Organizational Performance (HOP)

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

Source: Conklin, Pre-Accident Investigations, 2014

119

Understanding Human Reasoning Via Effective Interviewing

www.pixabay.com

120

How Therapy Works…

- Therapy is, in part, an ongoing interview…**NOT AN INTERROGATION**
- An interview is essentially a structured conversation where one participant asks questions and the other provides answers.
- Indeed, therapists regularly use interview techniques to gather useful information that will, in turn, help them better understand the client's difficulties, implement proper interventions, assess progress, and overcome obstacles in therapy

Source for the following slides: Spencer Ph.D., Noam. How Therapy Works: The Role of Basic Interview Techniques. Psychology Today Online. Accessed on 7.6.22.

121

#	Interviewing Technique	Description
1	Reflection	'Verbal mirroring' of the client's communications, by which the therapist restates what the client has said (usually in a summarized, paraphrased form)
2	Pinpointing	Clarify or 'pin down' the client's specific meaning regarding some event or interaction
3	Open-Ended Questions	An open-ended question is one that cannot be answered with a simple yes or no or another short reply
4	Confrontation	Used to point out discrepancies between what the client states and what is being observed
5	Self-Disclosure	Disclosing an aspect and show empathy of the therapist's experience is another technique that may be used to establish rapport, support the client emotionally,
6	Silence	Pauses in conversation may create a space for self-reflection, in which thoughts and emotions may become clearer and reach awareness
7	Reframing	Seeing old problems or events with new eyes
8	Focusing	Ensure that the therapeutic encounter remains just that—focused on the work of therapy

Source for the following slides: Spencer Ph.D., Noam. How Therapy Works: The Role of Basic Interview Techniques. Psychology Today Online. Accessed on 7.6.22.

122

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#	Interviewing Technique	Therapeutic Examples
1	Reflection	**Client says,** "I can't seem to get anywhere in life". **Reflective Response:** "So, you feel like you're not achieving your life goals?"
2	Pinpointing	**Client says**, "I was abused as a child". **Pinpoint Response:** "What do you mean by abused?"
3	Open-Ended Questions	**Therapist says,** "Did you enjoy dinner with your mother?" vs. **Open-Ended question**: "Tell me how dinner was with your mother?"
4	Confrontation	**Client says,** "I drink socially". **Confrontation Response:** "You've had 3 DUIs in the recent past and you said you drink in the morning to steady your nerves. Tell me what social drinking means to you."

Source for the following slides: Spencer Ph.D., Noam. How Therapy Works: The Role of Basic Interview Techniques. Psychology Today Online. Accessed on 7.6.22.

123

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#	Interviewing Technique	Therapeutic Examples
5	Self-Disclosure	**Client says,** 'People think I'm a troublemaker because I get bored quickly in school and then get in trouble." **Self-Disclosure Response:** "I can relate, as I had ADHD in school and did the same thing."
6	Silence	**Client says,** "I get so mad at my spouse I feel like hitting them". **Silence then Client Responds:** "Then I immediately feel guilty for being a lousy spouse myself".
7	Reframing	**Client says,** "I'm nervous about my job interview". **Reframing Response:** "That's a good thing, it means you care".
8	Focusing	**Client** goes off on tangent about child's accomplishments. **Focusing Response:** "Your child sounds amazing, and you should be proud. Now let's pick up where we left off talking about your mother-in-law"

Source for the following slides: Spencer Ph.D., Noam. How Therapy Works: The Role of Basic Interview Techniques. Psychology Today Online. Accessed on 7.6.22.

124

Application to RCA Interviewing…

#	Interviewing Technique	RCA Facilitation Examples
1	Reflection	**Interviewee says,** "I took a shortcut to ensure there was no production loss". **Reflective Response:** "As you know, this is very common. When one feels time pressured, they often take short-cuts in order to maximize production"
2	Pinpointing	**Interviewee says**, "We always take that short cut". **Pinpoint Response:** "Tell me more details about how often 'always' is, and specifically this short cut"
3	Open-Ended Questions	**RCA Facilitator says,** "Did you follow the procedure?" vs. **Open-Ended question**: "What led you to believe that was the correct choice (Sense-making), at that time?"
4	Confrontation	**Interviewee says,** "All those bolts were tightened when I did the inspection yesterday". **Confrontation Response:** "2 of the 8 coupling bolts were missing and the remaining ones had oxidation about ¼" from the head, indicating they were loose for some time. How do we reconcile these two accounts?"

125

Application to RCA Interviewing…

#	Interviewing Technique	RCA Facilitation Examples
5	Self-Disclosure	**Interviewee says,** 'People think I'm a troublemaker because I'm opinionated." **Self-Disclosure Response:** "I can relate, as I was just like that. Then I got into the investigation business and learned I needed evidence to support my claims…it really works"
6	Silence	**Interviewee says,** "I get so mad when my boss doesn't listen to me". **Silence then Client Responds:** "Then I just give up and stop telling him about the safety hazards I see".
7	Reframing	**Interviewee says,** "They say Safety is #1, but their actions say differently". **Reframing Response:** "Why do you feel Safety is just a slogan?".
8	Focusing	**Interviewee** goes off on tangent about being reprimanded in the past. **Focusing Response:** "I'm sorry you had this impactful event, when did this happen [usually it's been years and they still carry the burden]"

126

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Interviewing Preparation Guide

Psychological Safety
Interviewing Guide
Amy Edmondson

127

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Time to Get Salty ☺!

128

129

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RCA Interviews - Getting 'Salty' in the Mill ☺

130

6B

Incorporating Human Factors Engineering Principles Into RCA

131

131

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Human Error Defined

"Error will be taken as a generic term to encompass all those occasions in which a planned sequence of mental and physical activities fails to achieve its intended outcome, and when these failures cannot be attributed to some chance agency."

- J.T. Reasons

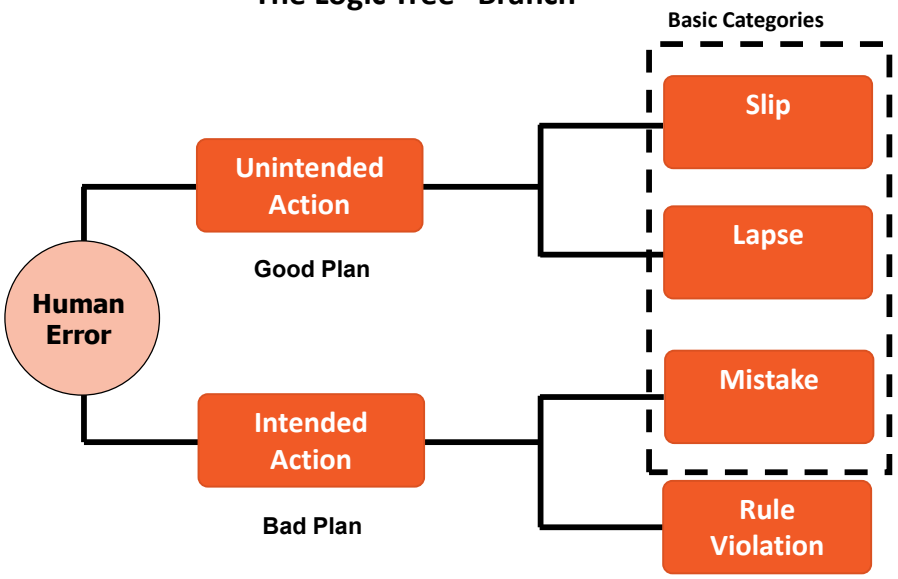
University of Manchester

132

132

Human Error

The Logic Tree "Branch"



133

Term	Definition
Unintended Actions	Actions that deviate from intended action fall into two classes; those that nevertheless achieve the goal, and those that do not.
Slips	Are potentially observable as externalized actions-not-as-planned (i.e. – slips of the tongue).
Lapses	Are generally more covert errors and involve failures of memory.
Intended Actions	Even when the intended actions proceed as planned, they can still be judged as erroneous if they fail to achieve their intended outcome. In this case, the problem resides in the adequacy of the plan rather than conformity of its actions to some prior intention. If the intention is not appropriate, it is a mistake.
Mistakes	Are defined as deficiencies or failures in the judgmental and/or inferential processes involved in the selection of an objective or in the specification of the means to achieve it, irrespective of whether or not the actions directed by this decision-scheme run according to the plan.

Source: Managing the Risks of Organizational Accidents (Reason)

134

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

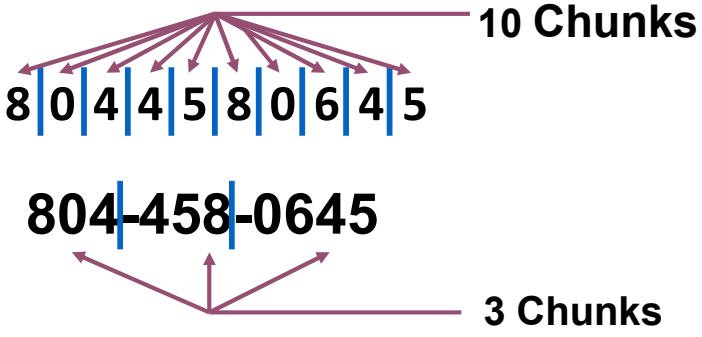
Procedure Writing – All Upper Case:
THE ATTENDING SURGEON SHALL RECORD IN THE MEDICAL RECORD THE CORRECT SIDE FOR AND NAME OF THE SURGICAL PROCEDURE

Medication — Unique Pattern

MEDICATION — Generic Pattern

135

Human Factors in Design – Brain Processing Capability



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)

136

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.

137

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?

138

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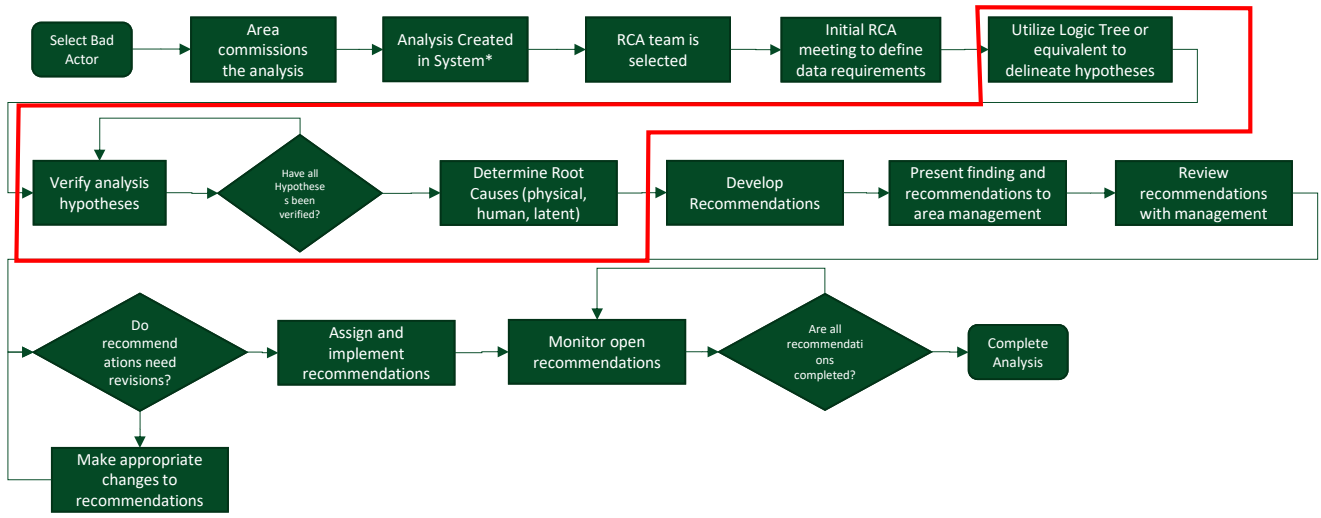
Simplified Failure Elimination Workflow (Chronic)



* System denotes the software solution where the RCA will be created.

139

7

Reconstructing an Undesirable Outcome/ Event

140

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Practical Reliability Solutions

What is your preferred RCA Approach?

- 5 Whys
- Fishbone Diagram
- Logic Tree/Causal Factor Type Tree
- Other

141

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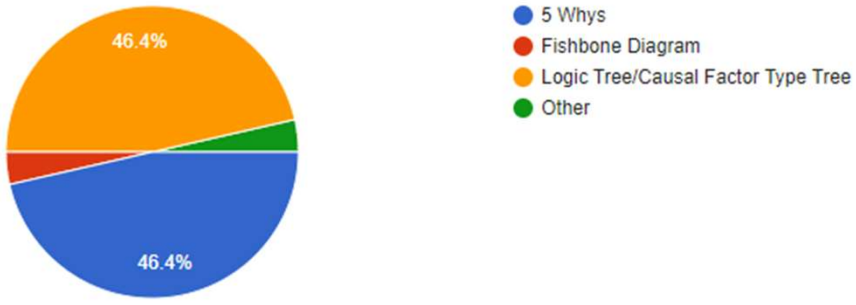
Previous Running Averages

What is your preferred RCA Approach?



142

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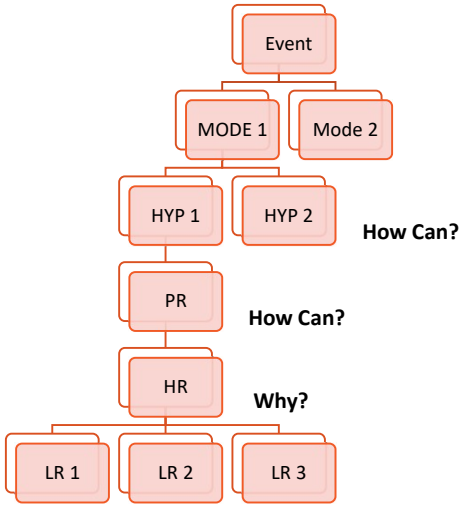
5-WHYS



Causal Factor Tree

143

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If an Analysis Concludes with 1 Root Cause (RC), It's NOT an RCA

5-WHY

1. Loss of Peripheral Vision – latch on to something obvious, we do not look for other things going on simultaneously
2. Does not consider multiple root causes and contributing factors
3. This '1 cause' belief provides fuel to the critics of the term 'RCA'

144

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If an Analysis Concludes With Blame, It's NOT an RCA

5-WHY

- Problem
- Why?
- Why?
- Why?
- Why?
- Why?
- BOB

1. Ran out of 'Whys'…
2. Does not seek reasoning for inappropriate decision
3. Cannot identify multiple flawed organizational systems, influencing the decision-maker

145

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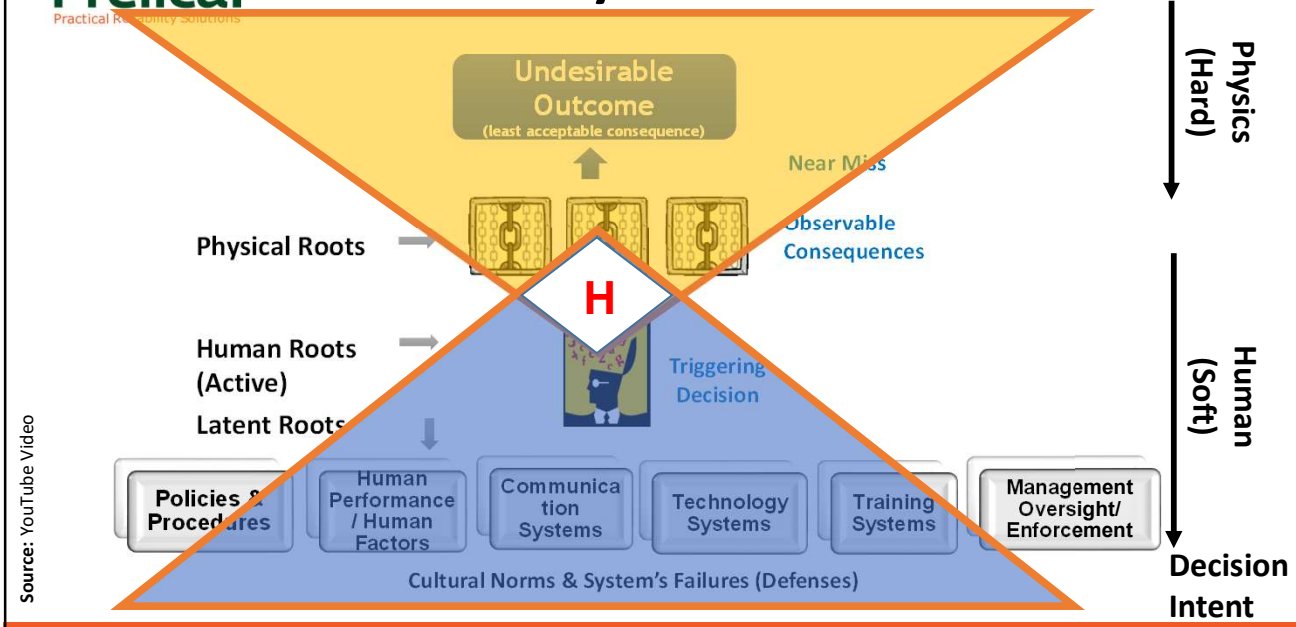
Anatomy of a 'Failure'



Source: YouTube Video

146

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The 'Root' System

HOW's { Consequences

Component Causes (Physical)

WHY's { Actions

Intent

Decision Roots – WHY? (Human)

HOP

Where Current RCA Efforts Often Lack Depth!

Deficiencies in Organizational Systems (Latent)

HOP = Human & Organizational Performance

147

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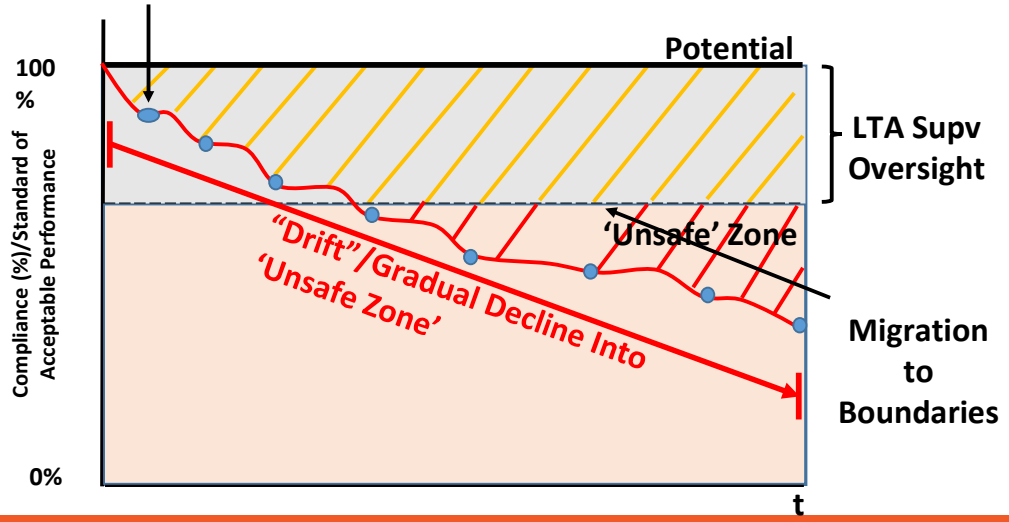
Forgetting to be Afraid*…

Normalization of Deviance
(short-cuts turn into practice)

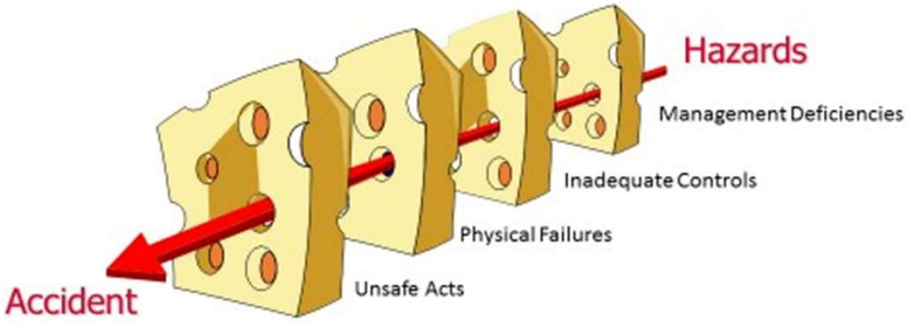


*Excerpted from the Texas City Investigation - Baker Report.

148

148

James Reason's "Swiss Cheese" Model of Accident Causation (1990)



149

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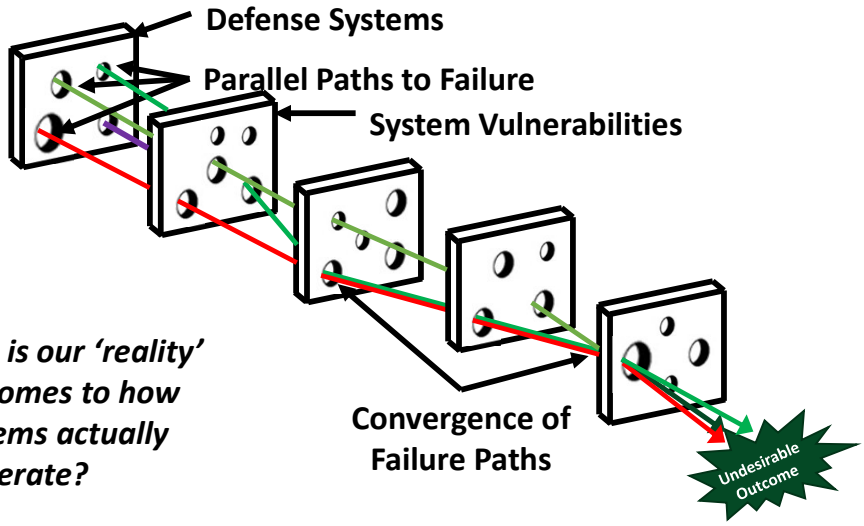
The Bob Latino Interpretation of Reason's SCM



…but what is our 'reality' when it comes to how our systems actually operate?

150

Constructing a Logic Treee

Properly State the '**EVENT**'

- ❑ The **Undesirable Outcome**
- ❑ Business Performance **Consequence**
- ❑ The '**Trigger**' requiring further analysis
- ❑ **The 'Reason We Care'**
- ❑ An indisputal FACT

The 'Event' is the Direct LINK to Leadership for Analysis Support

151

151

Constructing a Logic Tree

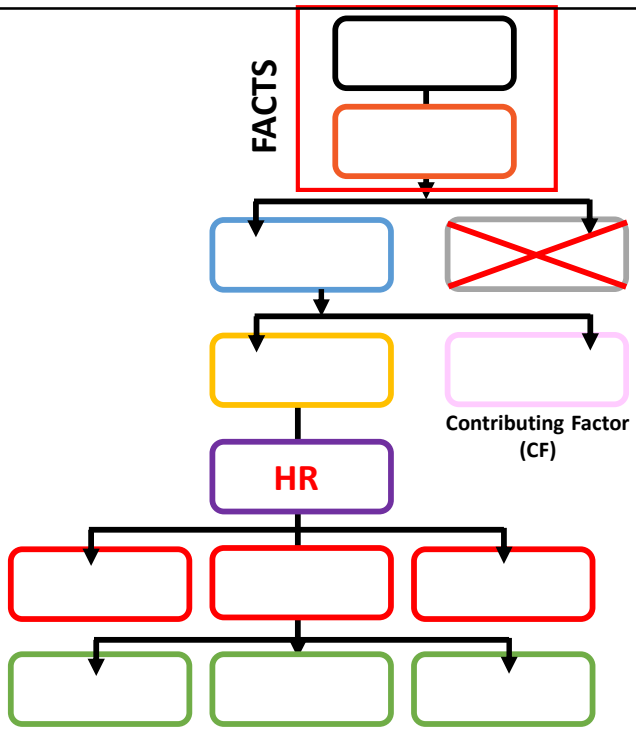
Properly Identify the **Failure Mode(s)**

- ❑ **Failure Mechanisms** leading to the Event
- ❑ Observed **Anomalies**
- ❑ **FACTS! FACTS! FACTS!**

152

152

The Basics of Constructing a Logic Tree Job Aid



Component/ Physical Root (PR)

Decision/ Human Root (HR)

Mgmt System/ Latent Root (LR)

Recommendations/ Corrective Actions (CA)

153

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Verification Log

Hypothesis	Verification Method	Verification Outcome	Resp	Due Date	Completion Date

154

154

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Corrective Action Log

Identified Root Cause	P, H or L	Suggested Corrective Actions	Resp	Due Date	Completion Date	Metrics Date

155

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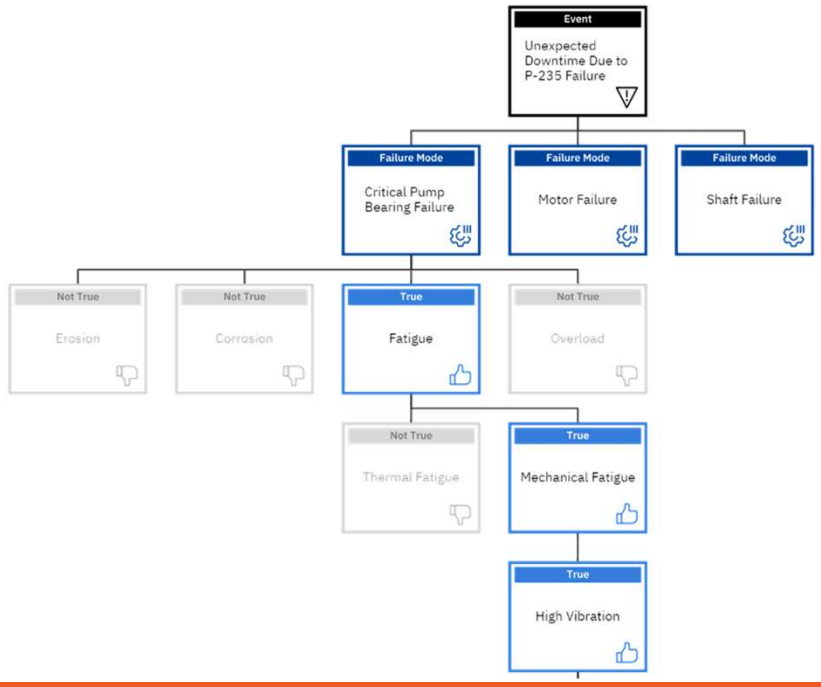

156

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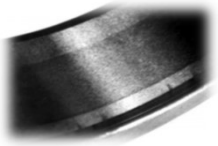
Metallurgy 101

How Material Failure Occurs

Material Loss	Material is Overpowered
➢Erosion (Wear)	➢Fatigue
➢Corrosion	➢Overload

And many combinations of these four mechanisms!

Erosion



Uniform Loss of Metal

Corrosion

Pitting (Electrical Phenomena)

Fatigue

Cyclic Failure

Overload

Instantaneous Fracture

The Physical Sciences Stuff

157

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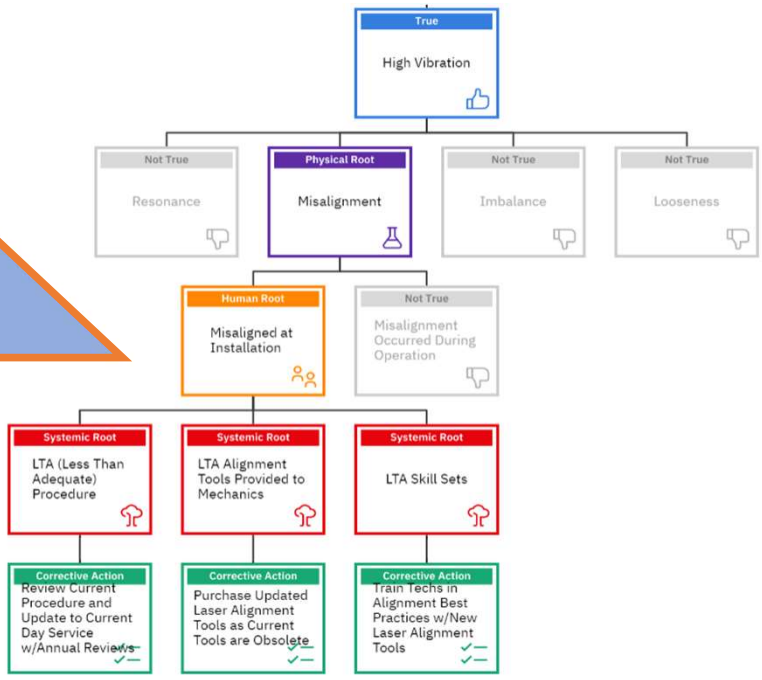
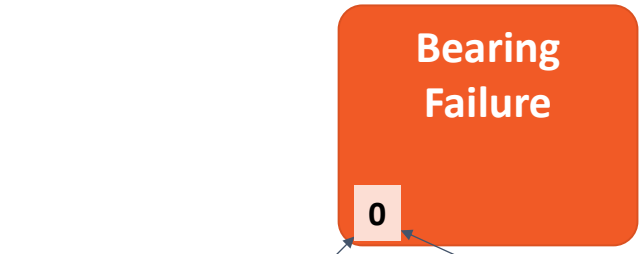
Practical Reliability Solutions

The Social Sciences Stuff



158

Event Reconstruction Using a Logic Tree Tips & Tricks



Utilizing Confidence Factors

Probability vs. Facts

Confidence Factor

Strength of Evidence (Data Collected from Failure Scene)

0 = Not True

5 = True

159

Event Reconstruction Using a Logic Tree Tips & Tricks

- To see if the logic is sound, read it backwards as well as forwards.
  - For instance, in the last example, if I read it this way: "Are all the ways in which a bearing can fail, contained somewhere within the Erosion, Corrosion, Fatigue, and/or Overload hypotheses?"
- During reconstruction, consider it being in a 'draft' mode. When completed, we must re-read and re-word to ensure the logic reads like a story.
- Each hypothesis must represent a 'Statement of Deficiency'.
  - For instance, 'Vibration' does not describe a deficiency. It must be more descriptive like, 'Vibration levels exceeded set alarm limits.

160

Event Reconstruction Using a Logic Tree Tips & Tricks

- The natural tendency of a team will be to jump to conclusions, usually way down the tree. As the team leader, your job is to pull the reigns in and stick to the discipline of the logic tree questioning.
  - For instance, when we find that a bearing fails, the natural tendency is to jump to installed wrong, lubrication wrong, wrong bearing, etc. However, move back in shorter increments of time and visualize 'HOW' the bearing actually failed (erosion, corrosion, fatigue, and/or overload)'.
- When the tree is complete, start to label roots. The easiest way to do that is to find where humans made a decision/choice (or a Human Root). Typically, just above that node is a Physical Root (consequence) and just below that node will be the Latent Roots (reasoning/systems roots).

161

Event Reconstruction Using a Logic Tree Tips & Tricks

- Another natural tendency of a team will be to jump to a predetermined conclusion. This is common when revisiting a prior failure where a conclusion had been determined. Under such conditions, there will be a tendency to make the logic match your prior conclusions, and it will often prevent you from exploring new, additional options. Ensure that new options are explored by using 'How Can' questioning versus only 'Why'. Remember, parallel paths to failure are most common.

162

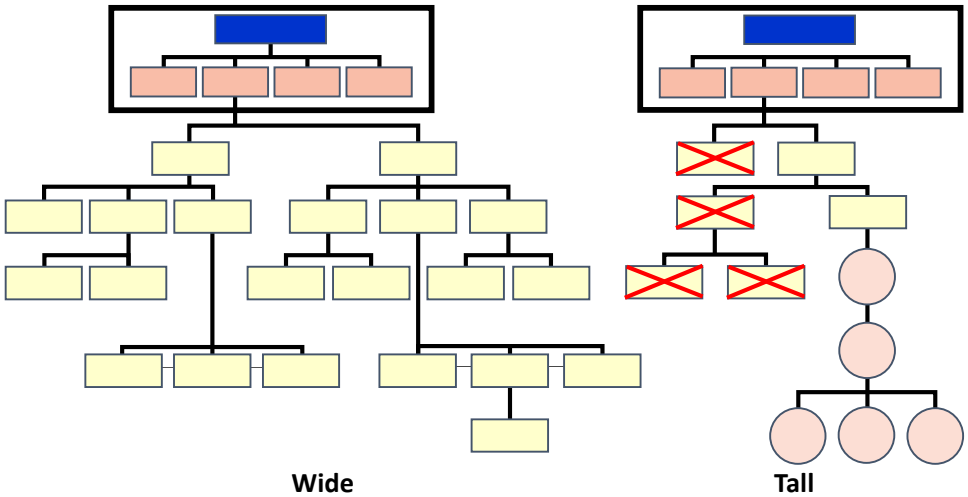
Event Reconstruction Using a Logic Tree Tips & Tricks

"Wide" Logic Trees (Bushes)

"Tall" Logic Trees (Redwoods)

Which Tree Structure is Desired?

Event Reconstruction Using a Logic Tree Tips & Tricks



Wide

Tall

Online Case Studies

Thermo-Compressor Cone Failures

(~ 18 minutes)

Turbine Driven Boiler Feed Pump Failure

(~16 minutes)

165

What is ChatGPT & How Can it Help an RCA?

166

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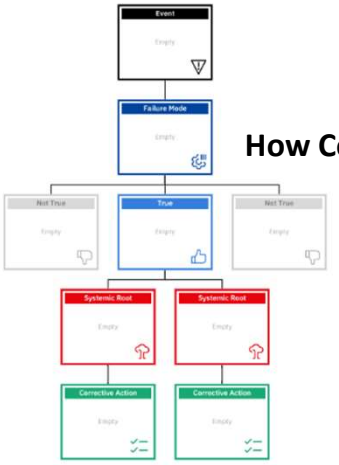
5-Whys vs Logic Tree: What's the Difference?

5-WHY

Logic Tree/ Causal Factor Tree



How Could?

167

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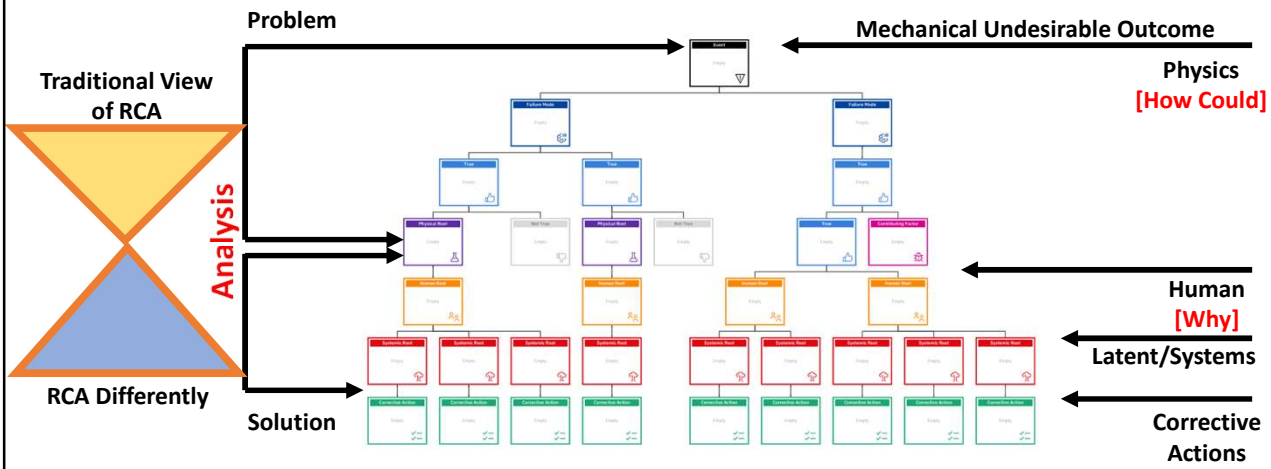
In Holistic RCA, The Nature of Undesirable Outcome is Irrelevant



Example: Reportable Injury of Employee While on the Job

168

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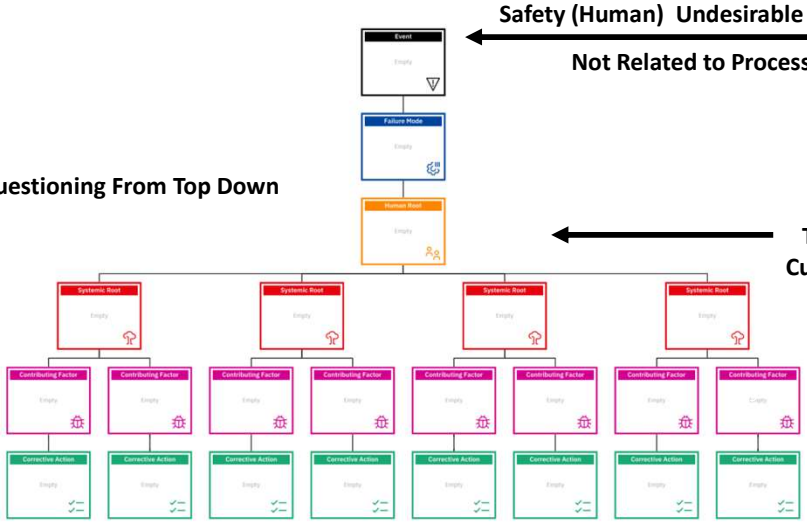
HOP Principles Applied to RCA

Safety (Human) Undesirable Outcome/Risk

Not Related to Process Failure

From Human to Desired Depth (Systems, Socio-Technical Factors, Cultural Norms, Etc.)

RCA Typical Questioning From Top Down



LT Questioning Typically from Bottom-Up (LT = Learning Teams)

169

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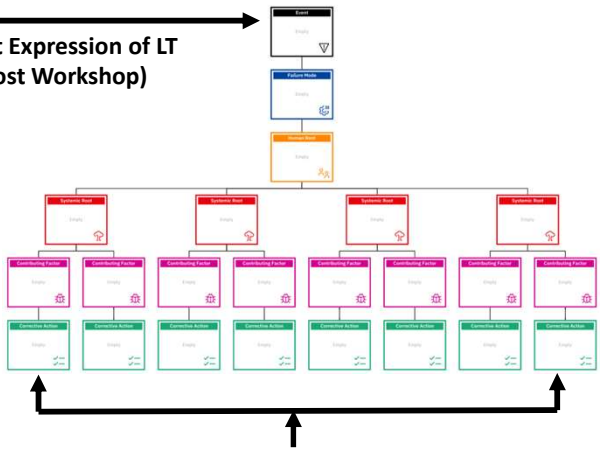
RCA Differently vs Learning Teams (LT): Cause-And-Effect Expressions

Cause-and-Effect Expression of LT Discussion (Post Workshop)



Corrective Actions Have to be Compensating for Some Sort of 'Cause'

170

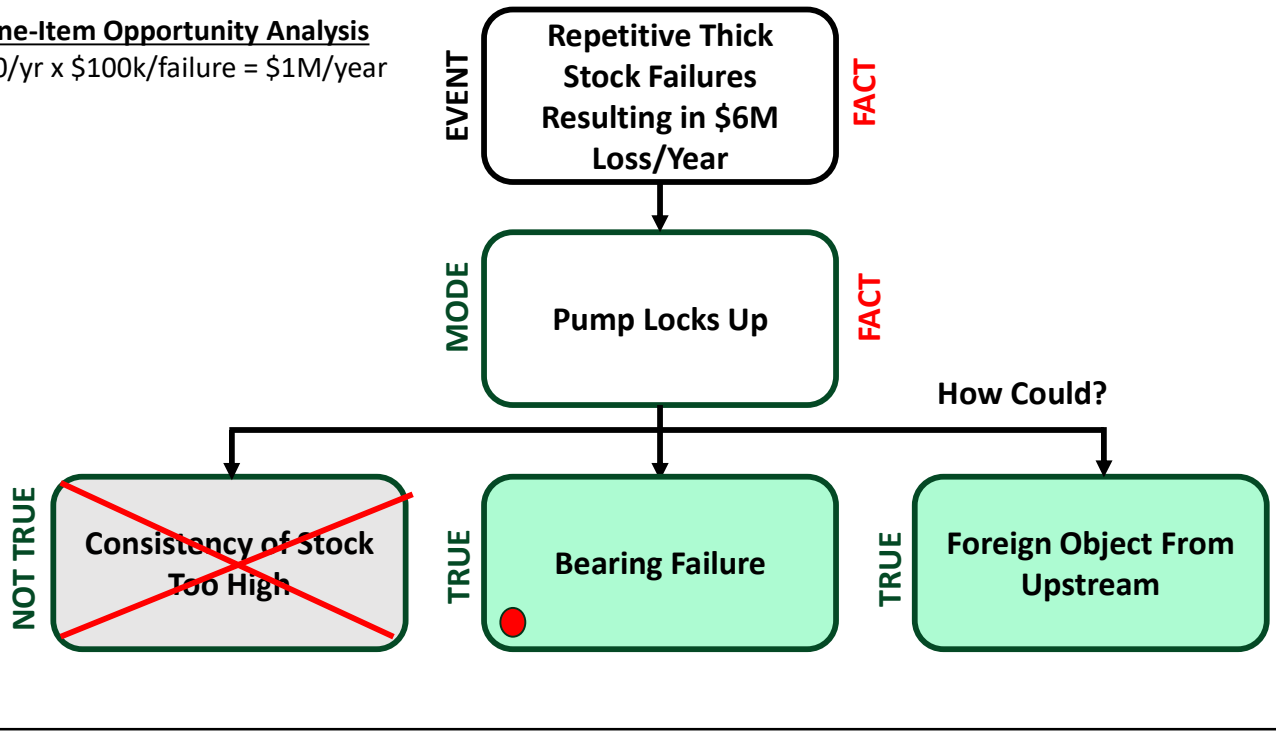
Case #1

Thick Stock Pump Analysis

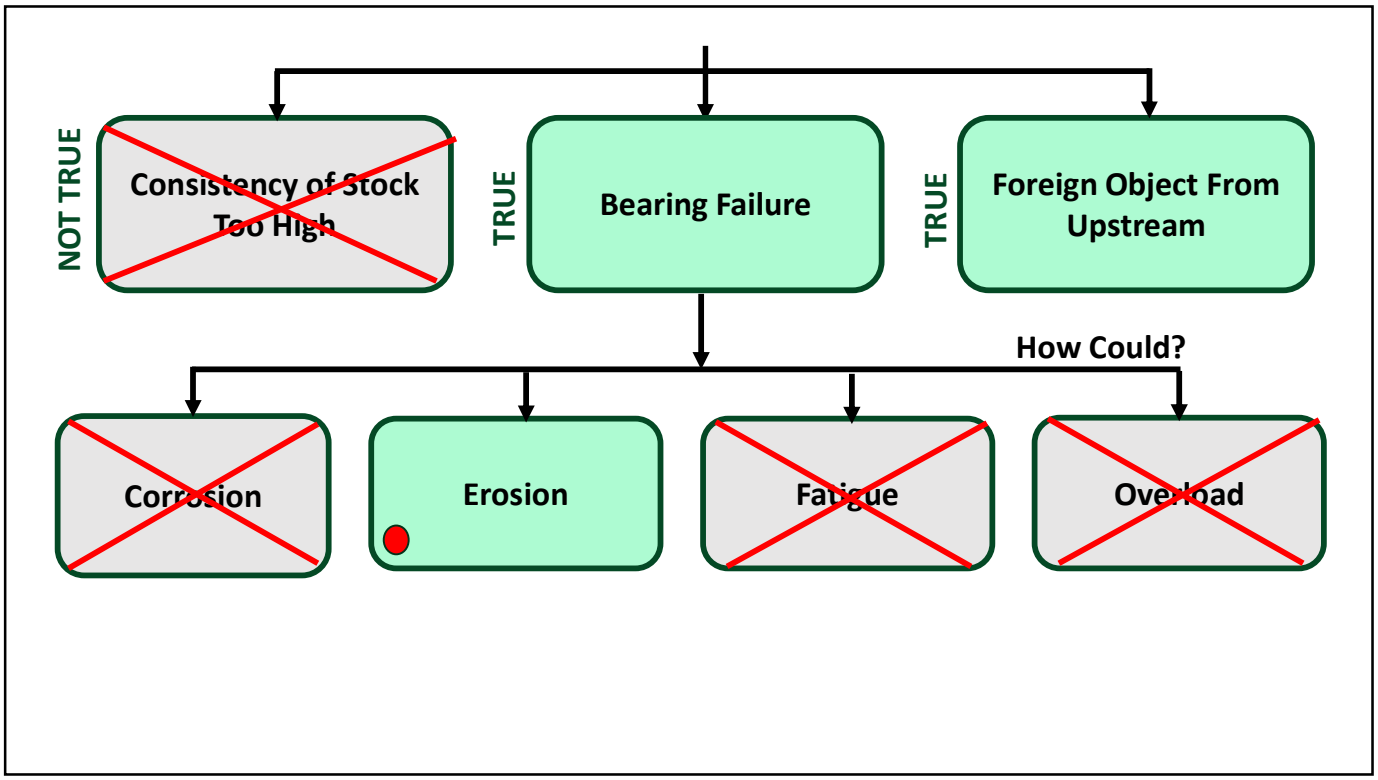
171

171

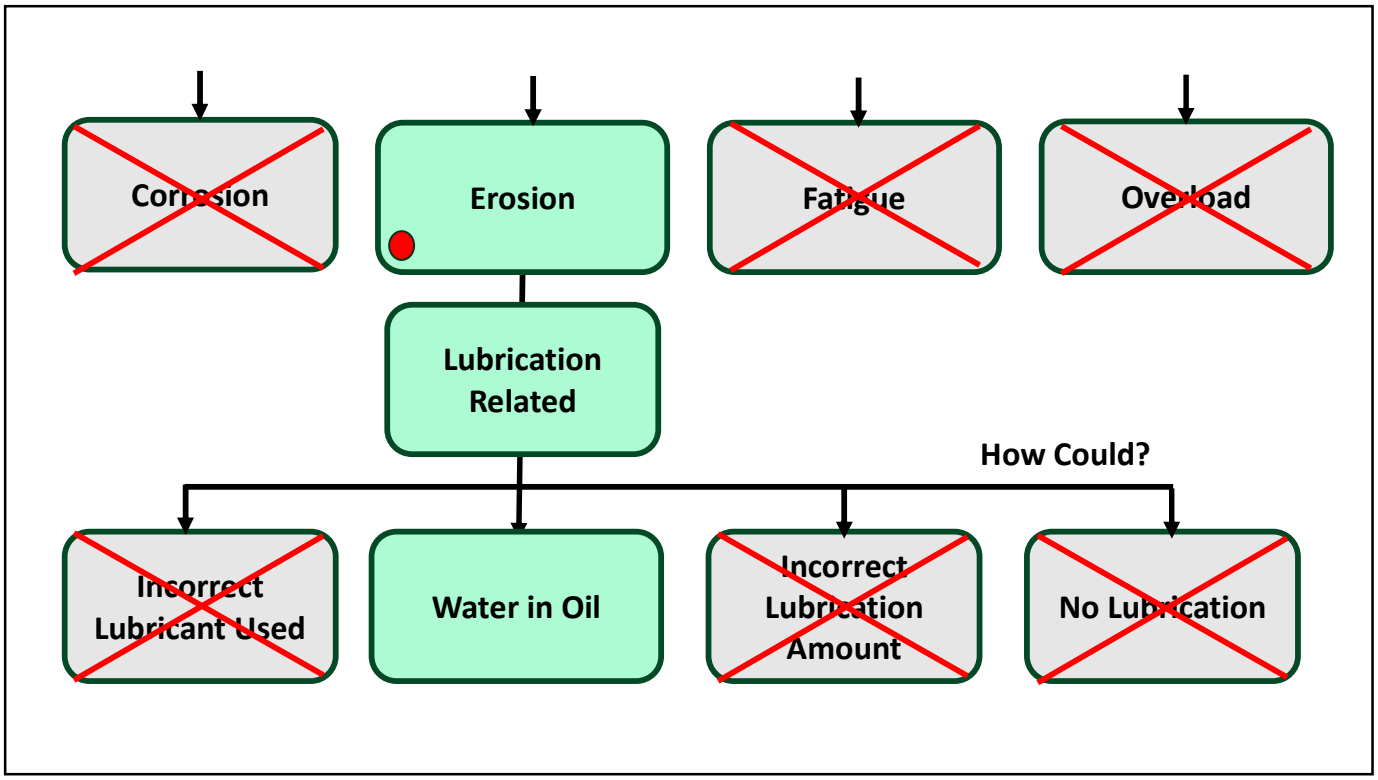
Line-Item Opportunity Analysis
10/yr x $100k/failure = $1M/year



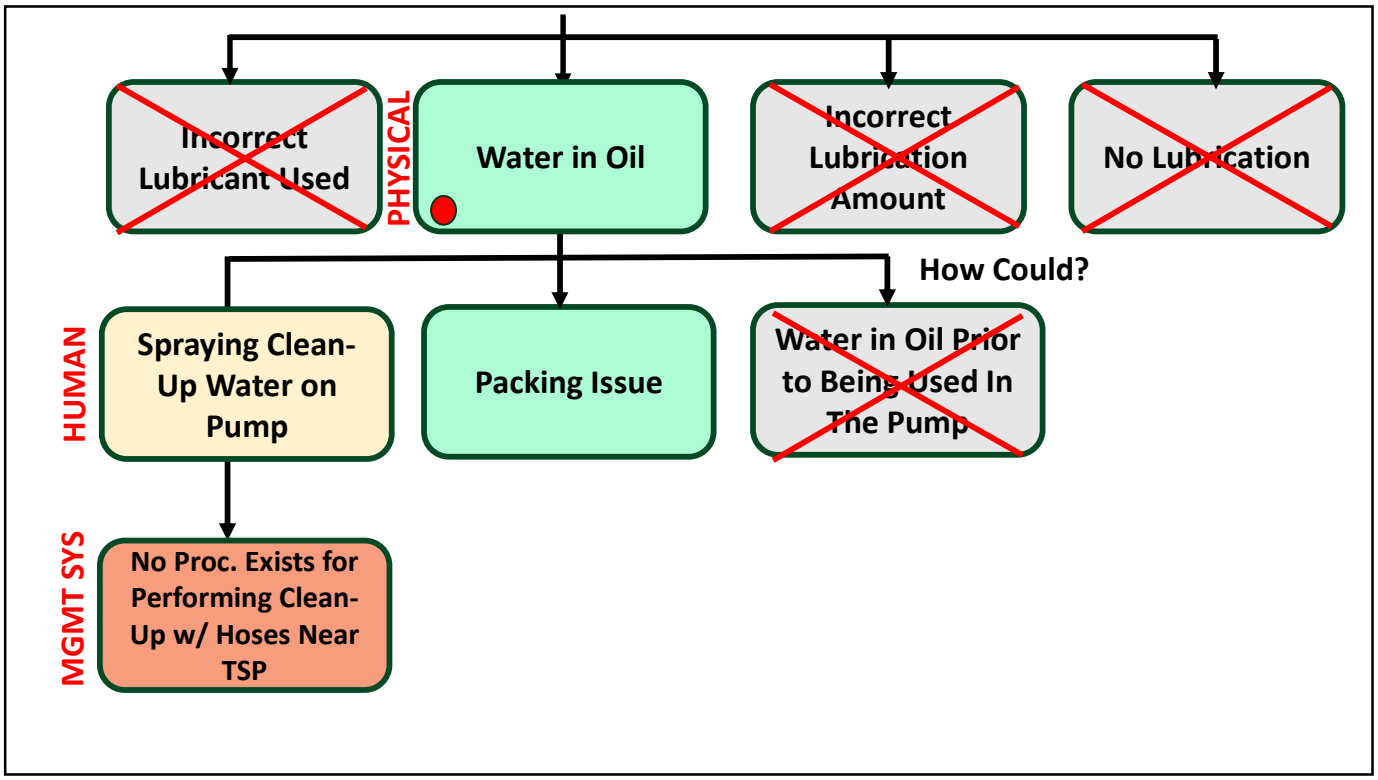
172


NOT TRUE
Consistency of Stock Too High
TRUE
Bearing Failure
TRUE
Foreign Object From Upstream
How Could?
Corrosion
Erosion
Fatigue
Overload

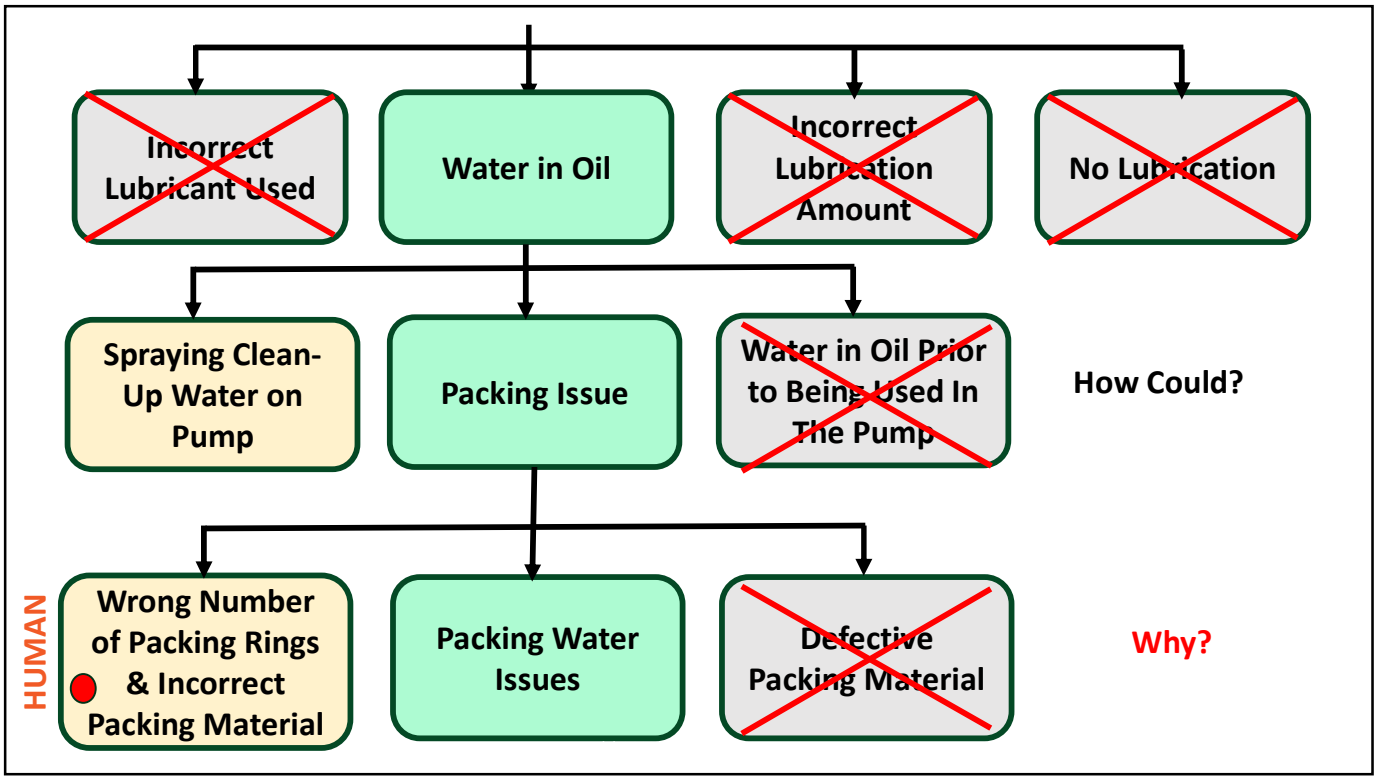
173


Corrosion
Erosion
Fatigue
Overload
Lubrication Related
How Could?
Incorrect Lubricant Used
Water in Oil
Incorrect Lubrication Amount
No Lubrication

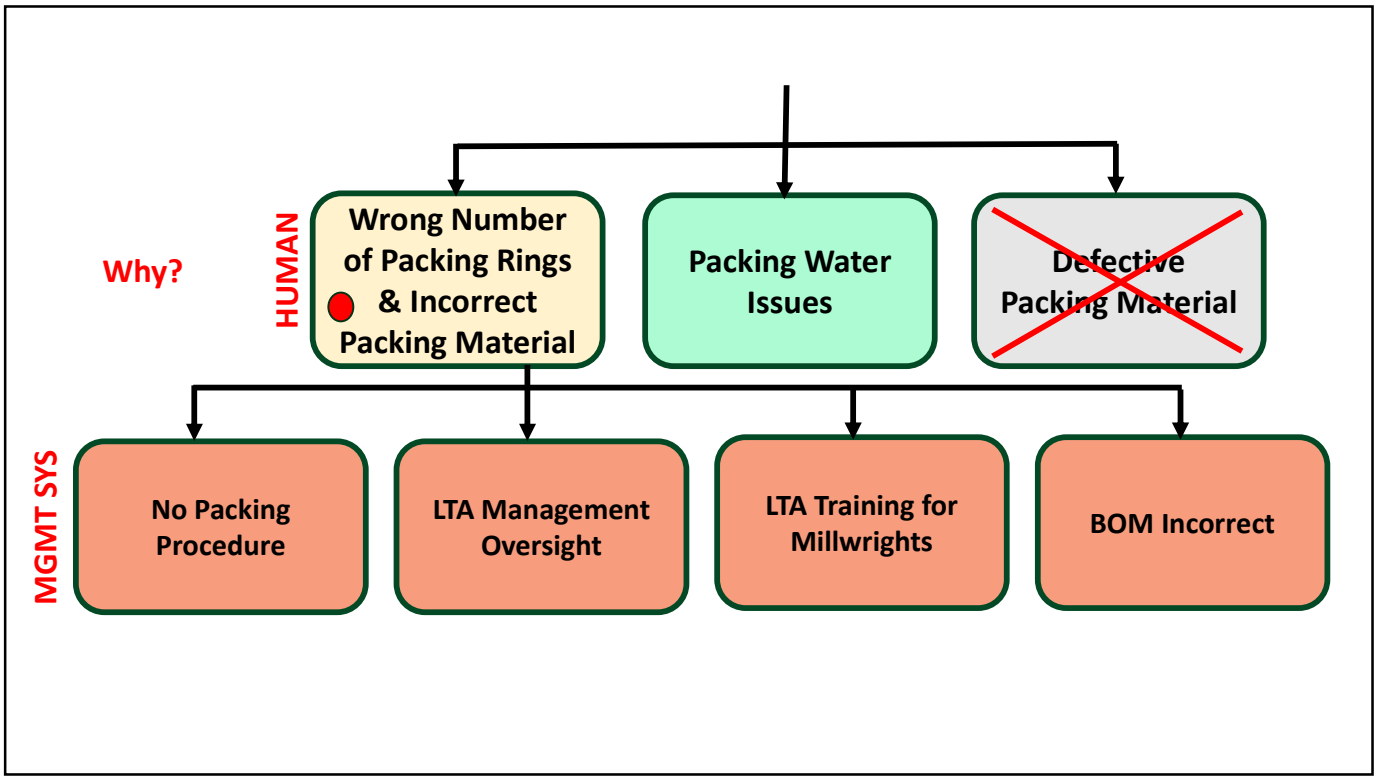
174


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

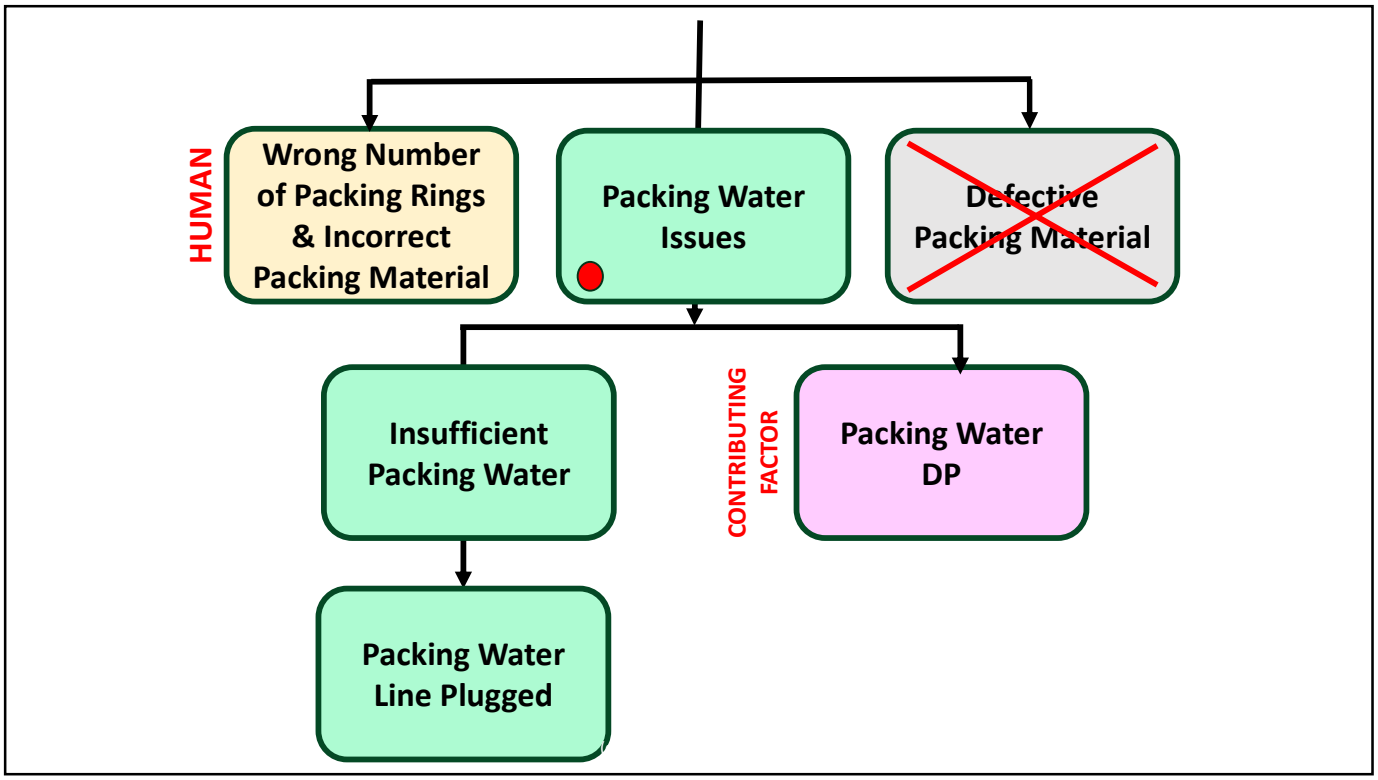
175


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?

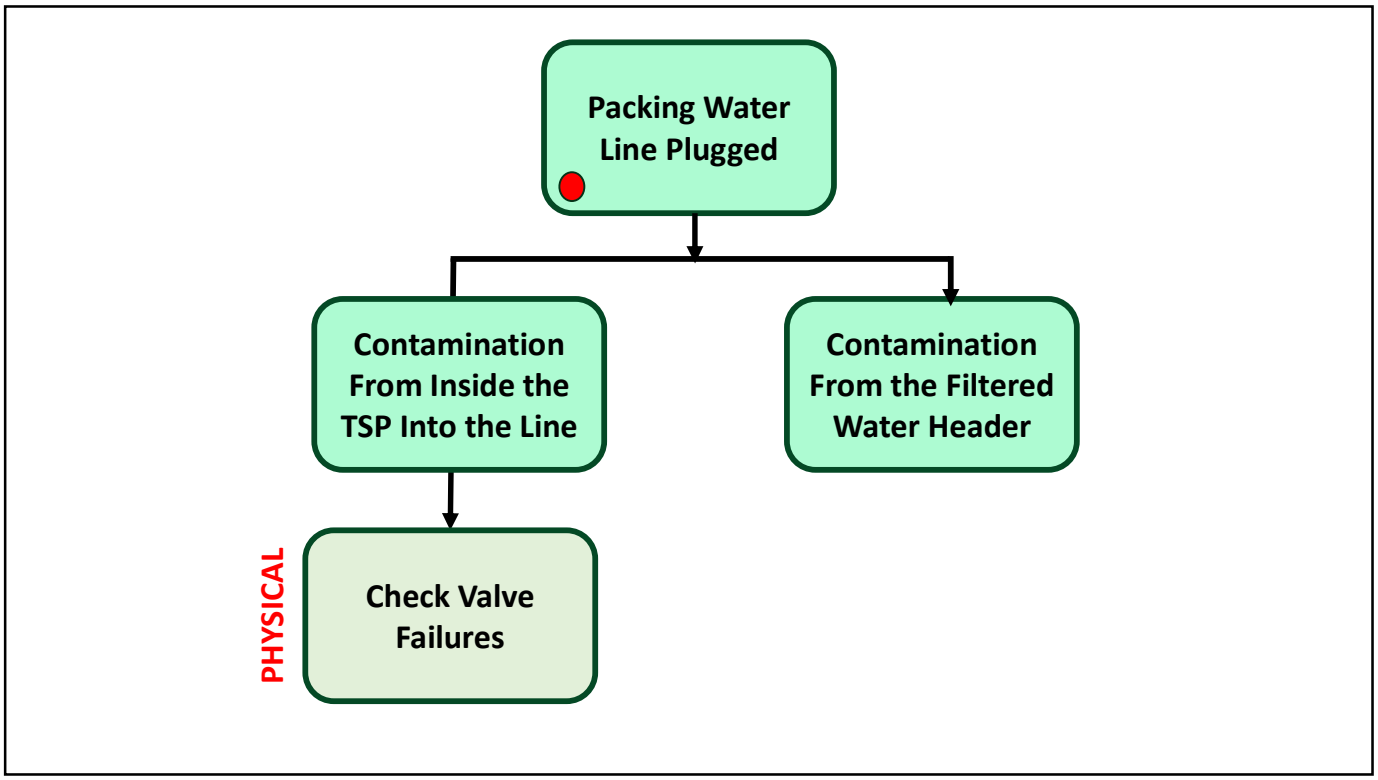
176


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

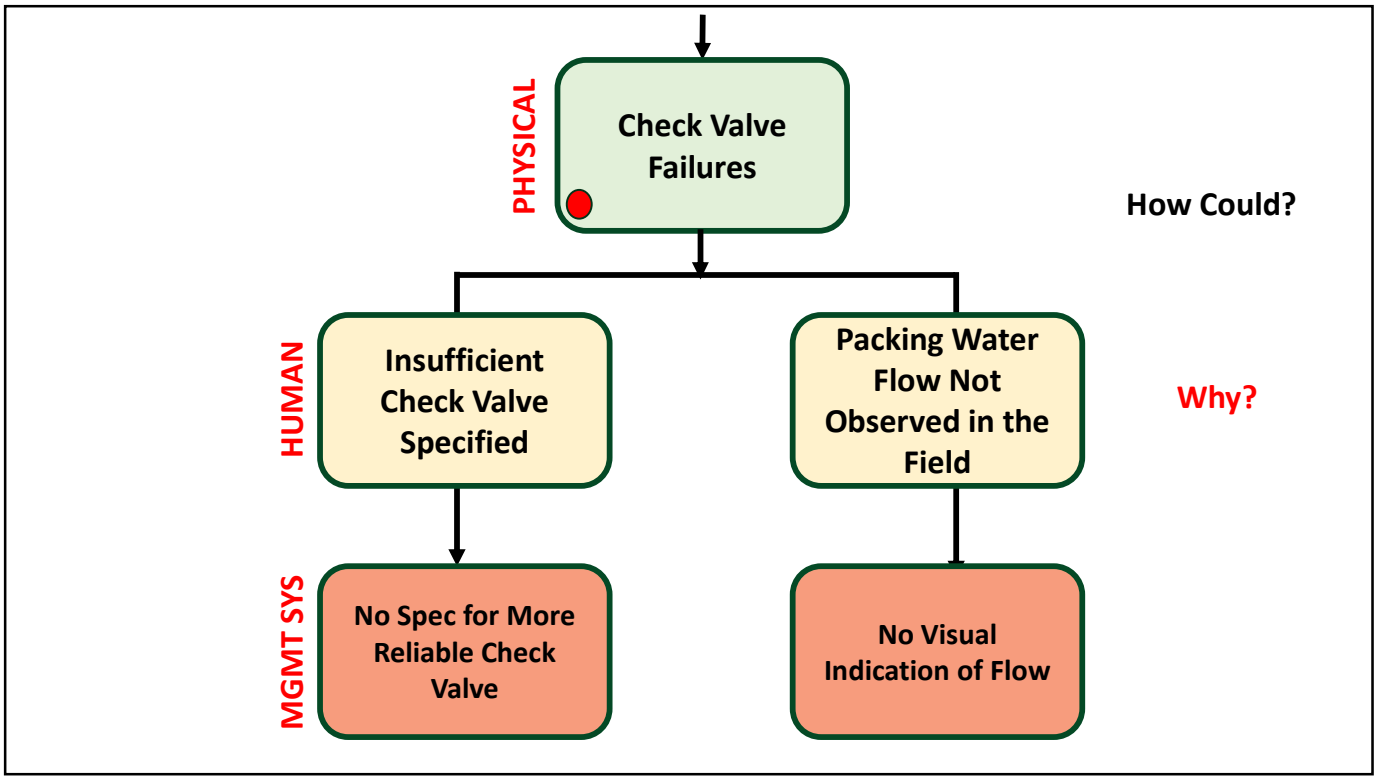
177


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

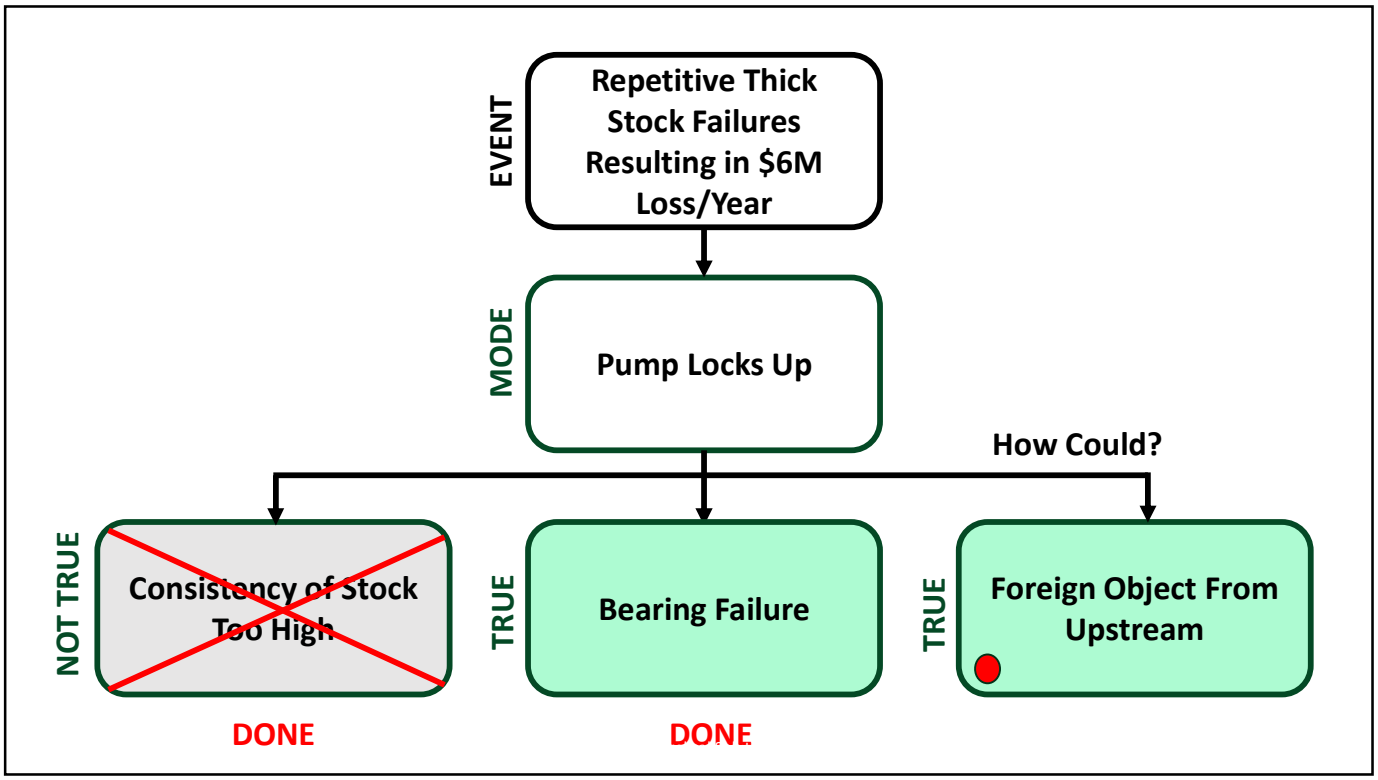
178


Packing Water Line Plugged
Contamination From Inside the TSP Into the Line
Contamination From the Filtered Water Header
PHYSICAL
Check Valve Failures

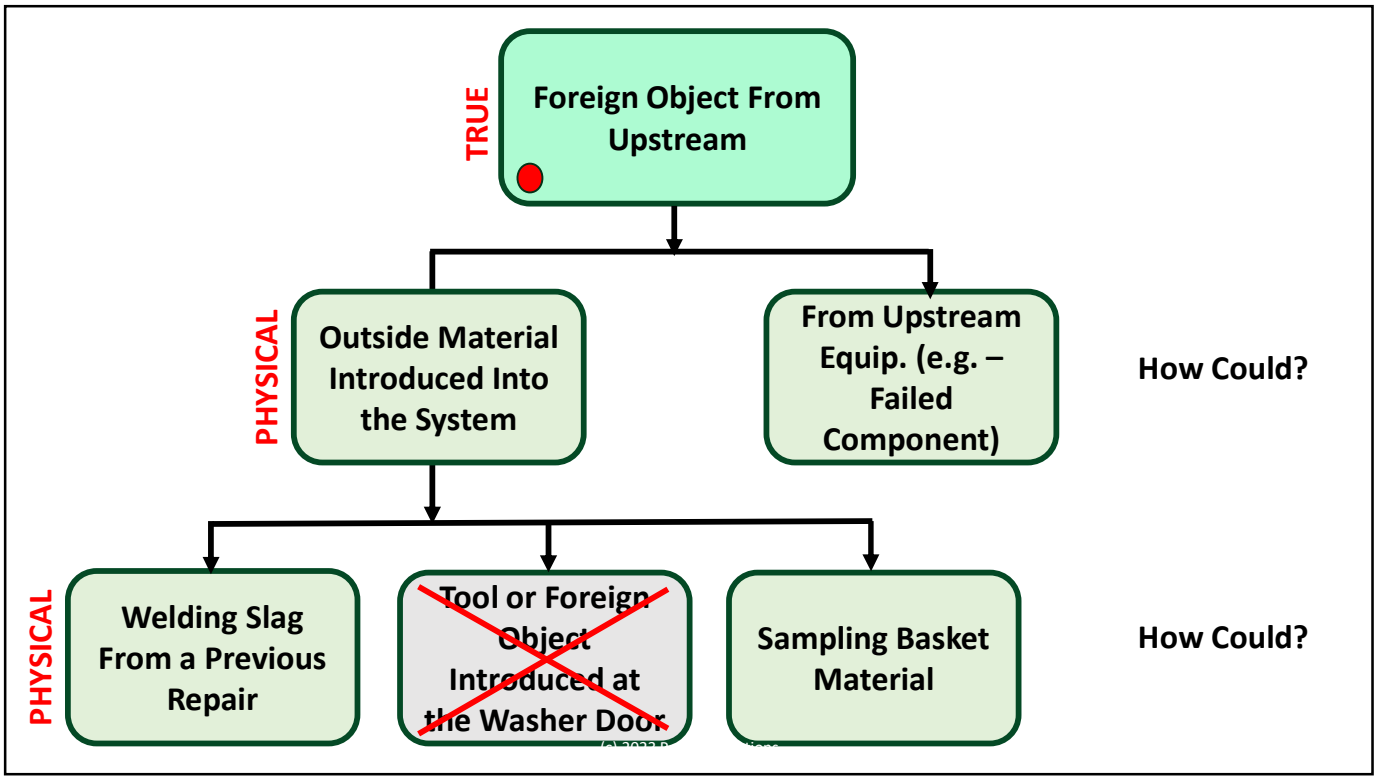
179


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

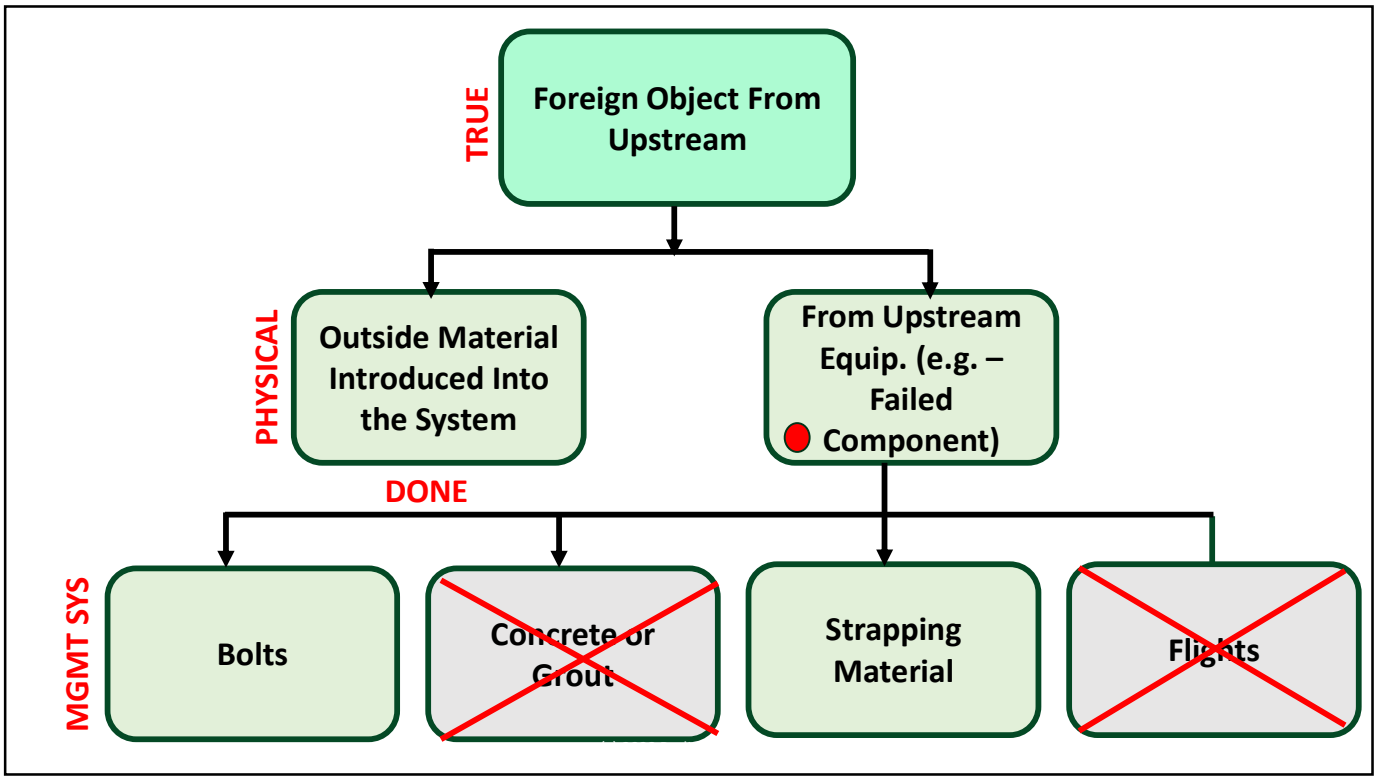
180


EVENT
Repetitive Thick Stock Failures Resulting in $6M Loss/Year
MODE
Pump Locks Up
How Could?
NOT TRUE
Consistency of Stock Too High
DONE
TRUE
Bearing Failure
DONE
TRUE
Foreign Object From Upstream

181


TRUE
Foreign Object From Upstream
PHYSICAL
Outside Material Introduced Into the System
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?

182



183

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Additional Cases

- Cooling Tower Fan #2 Motor Failure
- Lubrication Degradation Mechanisms RCA
- Industry Example
- RCA on RCA

184

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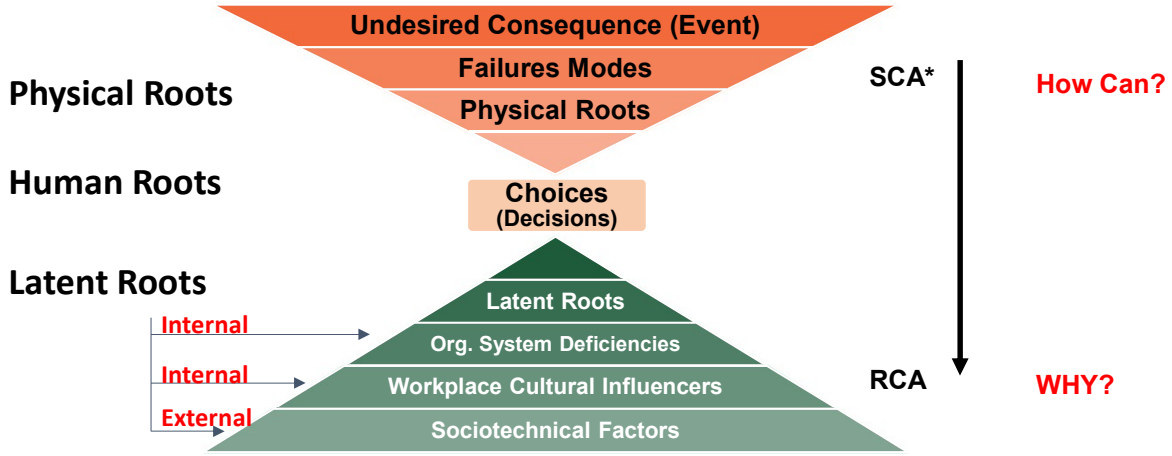
Root Cause vs Shallow Cause



*SCA = Shallow Cause Analysis

185

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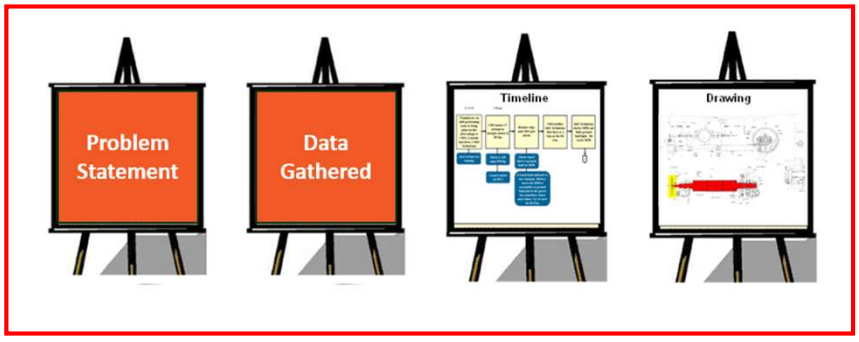
Exercise #8: 5-Y's & Logic Tree Construction



186

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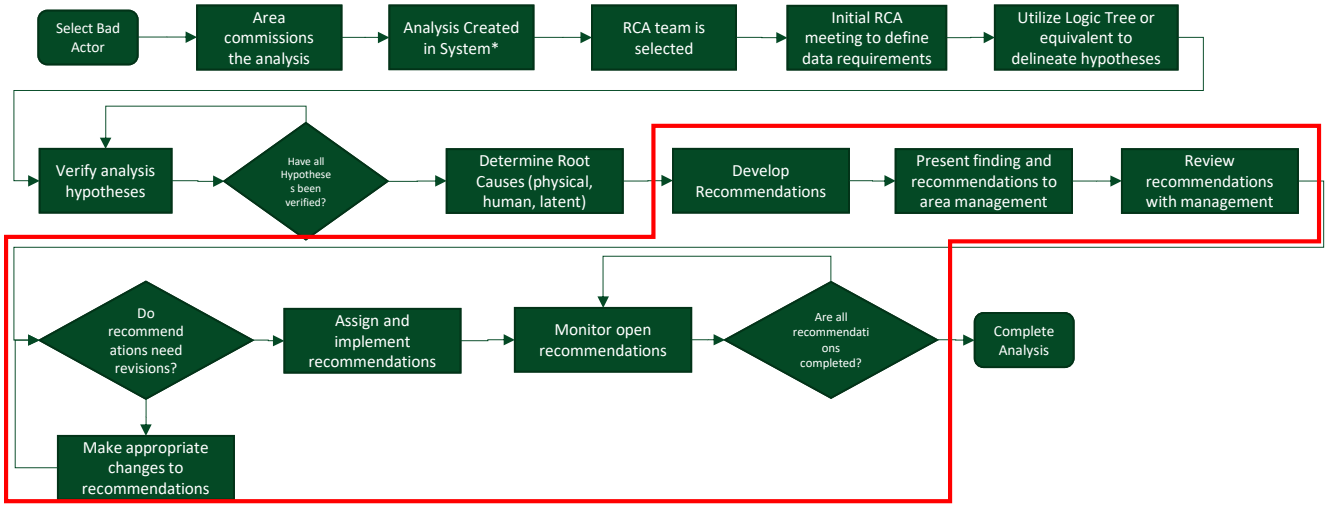
Simplified Failure Elimination Workflow (Chronic)



* System denotes the software solution where the RCA will be created.

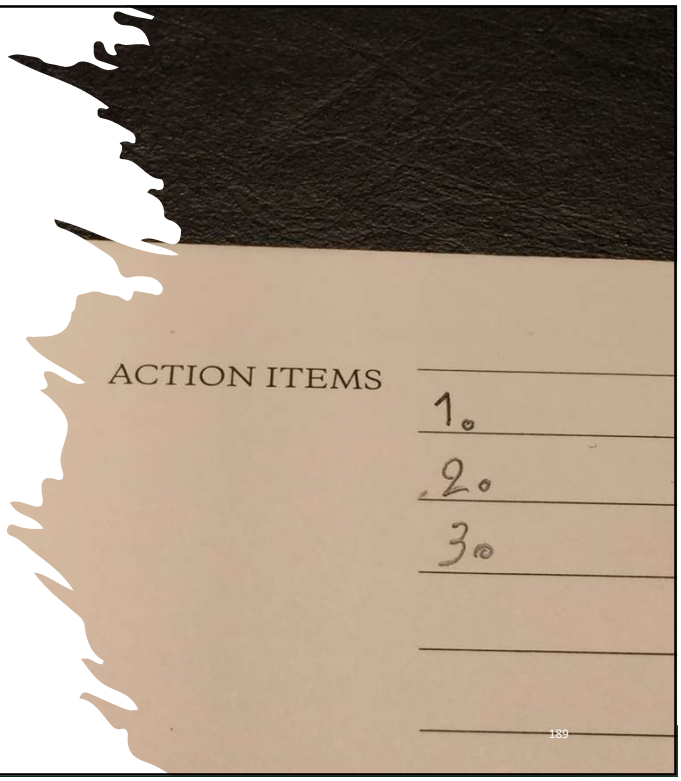
187

8

Writing Corrective Actions that Work

188

Creating & Executing Corrective Actions



189

189

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Corrective Actions

When **systemic root causes** are discovered, their corrective actions justified and their elimination finalized, the facilities will have been raised to unprecedented high level of performance and reliability.

190

190

Effective Corrective Actions

Address the System....not the people

- ★ Go beyond addressing just the Physical Roots
- ★ Target the weaknesses in the organizational system
- ★ **Do not make recommendations for Human Roots**

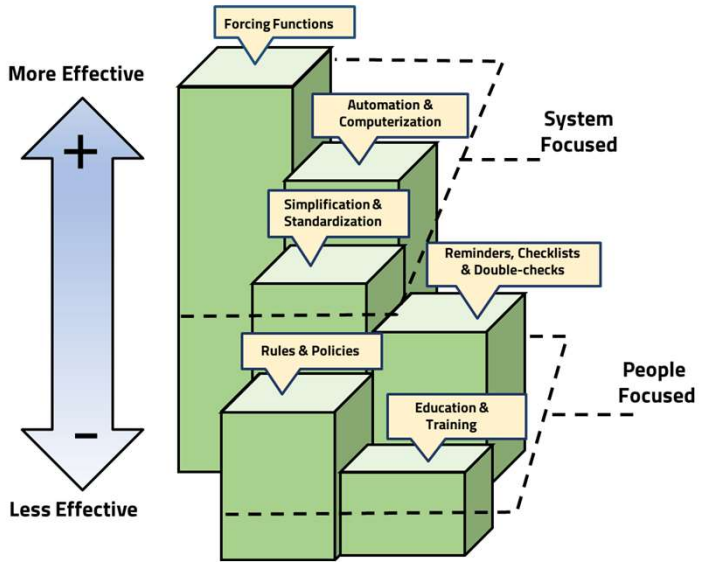
Change the System....make it easier for people to consistently perform correctly

- ➔ Or, make it difficult (*more painful?*) to perform in error
- ➔ Automate to reduce the human decisions
- ➔ Standardize to promote consistent decisions
- ➔ Simplify to remove confusion when deciding

191

191

Hierarchy of Intervention Effectiveness



Source: http://www.cassiemcdaniel.com/blog/hierarchy-of-effectiveness-process/

192

192

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Action Plan Rigor Test

The more criteria that are met, the stronger the action plan becomes.

>/= 6 is Strong
</= 3 is Weak

- ☐ 1. Does the recommendation directly impact the latent root?
- ☐ 2. Is the recommendation "**SMART**" (**S**pecific-**M**easureable-**A**ttainable-**R**ealistic-**T**imely)
- ☐ 3. If the new process is dependent on a person/role or time(s)-of-day, is there a fail-safe backup to ensure it's done? (Must have to be viable 24/7)
- ☐ 4. Does the recommendation survive changes in personnel?
- ☐ 5. Is the recommendation supported by data and/or best practices (literature/research)?
- ☐ 6. Are procedural verifications, audits, and/or organizational checks & balances in place to ensure the sustainability of the Action Item? (If we come looking again in 6 or 12 months, will these preventions still be alive and functioning?)
- ☐ 7. Has the Financial Impact of the Action Item been considered? (Is solution cost prohibitive?)
- ☐ 8. Will removing this LR from the combination of the others, by itself, prevent recurrence?

193

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Develop a presentation for management on the findings and corrective action plan

194

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Exercise #9: ID Corrective Actions for Identified Root Causes and their Associated Tracking Metrics

195

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"Those who say something is impossible, should get out of the way of those doing it!"

- Joel Barker
Futurist – The Business of Paradigms

196

Analyst Summary Sheet

1. **Define the problem:** Clearly define the problem or issue that you want to analyze. Write a brief description of the problem, including what happened, when it occurred, where it occurred, and who was involved.
2. **Assemble the team:** Assemble a team of people who have knowledge and expertise related to the problem. This team should include people from different departments or areas of the organization, if applicable.
3. **Gather data:** Collect data and information related to the problem. This step involves reviewing documents, conducting interviews, and observing the situation. Use data collection tools such as checklists, surveys, or questionnaires to gather information.
4. **Identify possible causes:** Brainstorm and list all possible causes of the problem. Use tools such as Fishbone Diagrams, 5 Whys, or Mind Mapping to help identify possible causes. Encourage the team to think creatively and consider all possible causes.
5. **Analyze the data:** Analyze the data and information you have collected to determine the most likely causes of the problem. Use tools such as Pareto Charts, Histograms, or Scatter Diagrams to help analyze the data. Look for patterns, trends, or correlations that can help identify the root cause(s) of the problem.
6. **Determine the root causes:** Identify the root cause(s) of the problem. The root causes are the underlying reason for the problem, and they must be addressed to prevent the problem from recurring. Use the information gathered in steps 3-5 to identify the root cause(s) of the problem.
7. **Develop corrective actions:** Develop a list of corrective actions that address the root cause(s) of the problem. These actions should be specific, measurable, achievable, relevant, and time-bound. Involve the team in developing the corrective actions and ensure that they are feasible and practical.
8. **Implement corrective actions:** Implement the corrective actions and monitor the situation to ensure that the problem does not recur. Assign responsibilities for implementing the corrective actions and establish a timeline for completion.
9. **Verify effectiveness:** Verify that the corrective actions have been effective in addressing the problem. This step involves monitoring the situation and reviewing data to ensure that the problem has been resolved. Use metrics or performance indicators to measure the effectiveness of the corrective actions.
10. **Document the process:** Document the RCA process, including the problem definition, data collection, analysis, root cause determination, corrective actions, implementation, and verification of effectiveness. This documentation can be used for future reference or to help address similar problems that may arise.

197

Reference Guide

Leveling Up ☺

Traditional RCA	Best Practices RCA
1. RCA is a Task	1. RCA is a System
2. RCA Focuses on Outcomes	2. RCA Focuses on Intent
3. Most All RCA Tools Are Equal	3. RCA Tools are NOT Created Equal
4. RCA Analyzes Broken Parts	4. RCA Analyzes Undesirable Outcomes
5. People are the Problem	5. People & Systems are the Solution
6. Often Results in 'Shallow Cause Analysis'	6. Results in Effective 'Root Cause Analysis'
7. Focuses on 'Work As Imagined'	7. Focuses on 'Work As Done'
8. RCA is Reactive (Focus on Urgent)	8. RCA is also Proactive (Focus on Important)
9. RCA Focuses Only on Short-Term (Preventing Recurrence)	9. RCA Focuses on Long-Term (Knowledge Management)

198

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Do YOU Have 'The Knack' For RCA?

199

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Thx for your time and the opportunity to share our experiences with you!

Q & A

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200