“How to Embed a Root Cause Analysis Culture in Your Maintenance Group”

By Ricky Smith CMRP

	THE CAUSES	THE PROBLEM: Valve fails to open	Valve fails to close	Leakage through valve	Leakage around stem	Excessive pressure drop	Opens/closes too fast	Opens/closes too slow
Pilot actuated	Dirt/debris trapped in valve seat	●	●	●				
	Galling	●	●					
	Mechanical damage (seals, seat)	●	●	●				
	Pilot port blocked/plugged	●	●	●				
	Pilot pressure too high		●				●	
	Pilot pressure too low	●		●				●
Solenoid actuated	Corrosion	●	●	●				
	Dirt/debris trapped in valve seat	●	●	●				
	Galling	●	●					
	Line pressure too high	●	●	●	●			●
	Mechanical damage	●	●	●				
	Solenoid failure	●	●					
	Solenoid wiring defective	●	●					
	Wrong type of valve (N-O, N-C)	●	●					

The Root Cause of a Specific Problem in most Causes are Known

True or False

- The Roots of Most Failures are Known and Can be identified
- Take this Hydraulic Valve for Example
- Would you agree or disagree most causes of component or parts failures are known? Text in your answer

Hydraulic Valve

THE CAUSES		THE PROBLEM: Valve fails to open	Valve fails to close	Leakage through valve	Leakage around stem	Excessive pressure drop	Opens/closes too fast	Opens/closes too slow
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	Galling	●	●					
	Mechanical damage (seals, seat)	●	●	●				
	Pilot port blocked/plugged	●	●	●				
	Pilot pressure too high		●				●	
	Pilot pressure too low	●		●				●
Solenoid actuated	Corrosion	●	●	●				
	Dirt/debris trapped in valve seat	●	●	●				
	Galling	●	●					
	Line pressure too high	●	●	●	●			●
	Mechanical damage	●	●	●				
	Solenoid failure	●	●					
	Solenoid wiring defective	●	●					
	Wrong type of valve (N-O, N-C)	●	●					

What is RCA and What is an RCA Culture?

Root cause analysis (RCA) is the process of discovering the root causes of problems in order to identify appropriate solutions.

RCA assumes that it is much more effective to systematically prevent and solve for underlying issues rather than just treating ad hoc symptoms and putting out fires.

An RCA Culture is the characteristics and knowledge embedded into a Plant or Site where everyone is aligned with a focus on Failure Mitigation and Elimination.

How to Conduct a Root Cause Analysis?

1. Define the problem. Ensure you identify the problem and align with a customer need. ...
2. Collect data relating to the problem. ...
3. Identify what is causing the problem. ...
4. Prioritize the causes. ...
5. Identify solutions to the underlying problem and implement the change. ...
6. Monitor and sustain.

If an Organization has Multiple Assets which are Not Meeting Expectations, where do you start?

CRITICALITY ANALYSIS of HVAC SYSTEM

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
Asset	Equipment				Acquisition Value	Mission Impact	Safety Impact	Environmental Impact	Single Point Failure	Preventive Maintenance History	Corrective Maintenance History	Reliability	Spares Lead Time	Asset Replacement Value	Planned Utilization	Visibility	Criticality Rating	% Maximum
4300301	10005137	CHILLER, CENTRIF			73,500	5	5	5	1	4	3	2	0	4	4	0		62.0
4300303	10005138	CHILLER, CENTRIF			73,500	5	5	5	1	4	1	1	0	4	4	0		56.0
4300311	10005292	HEAT EXCHANGER			19,200	5	0	0	5	5	0	0	2	2	5			
4300320	10006883	PUMP, POND WAT			6,800	5	0	0	2	5	0	1	0	1	5			
4300319	10007043	STRAINER, DUPLE			2,675	5	0	0	4	5	0	0	2	1	5			
4300344	10007017	PUMP, CONDENSE			7,925	5	0	0	1	5	0	0	0	1	3			
4300351	10007018	PUMP, CONDENSE			7,925	5	0	0	1	5	0	1	0	1	3			
4300352	10003796	PUMP, CHILLED W			8,500	5	0	0	1	4	0	1	0	1	3			
4300360	10003797	PUMP, CHILLED W			8,500	5	0	0	1	4	0	1	0	1	3			
4400355	10005410	AIR HANDLER, AH			12,900	5	0	0	5	4	1	2	1	2	5			
4300378	10005411	AIR HANDLER, AH			10,025	5	0	0	5	4	0	0	1	2	5			
4300389	10007028	AIR HANDLER, AH			11,350	5	0	0	5	4	0	0	1	2	5			
4300334	10007029	AIR HANDLER, AH			9,825	5	0	0	5	4	0	1	1	1	5			
4300326	10007030	BOILER, HOT WATE			41,750	5	5	5	5	3	1	1	1	3	4			
4300396	10007031	PUMP, HEATING HOT WATER, HHWP-1	100-B	A-100-B-MER1	$ 6,500	5	0	0	1	5	0	0	0	0	3			
4300396	10007032	PUMP, HEATING HOT WATER, HHWP-2	100-B	A-100-B-MER1	$ 6,500	5	0	0	1	5	0	1	0	0	3			

G	H	I	J	K	L	M	N	O	P	Q	R	S
Mission Impact	Safety Impact	Environmental Impact	Single Point Failure	Preventive Maintenance History	Corrective Maintenance History	Reliability	Spares Lead Time	Asset Replacement Value	Planned Utilization	Visibility	Criticality Rating	% Maximum

Criticality Rating
31
28
20
20
18
11
12
13
13
23
20
20
20
33
10
11

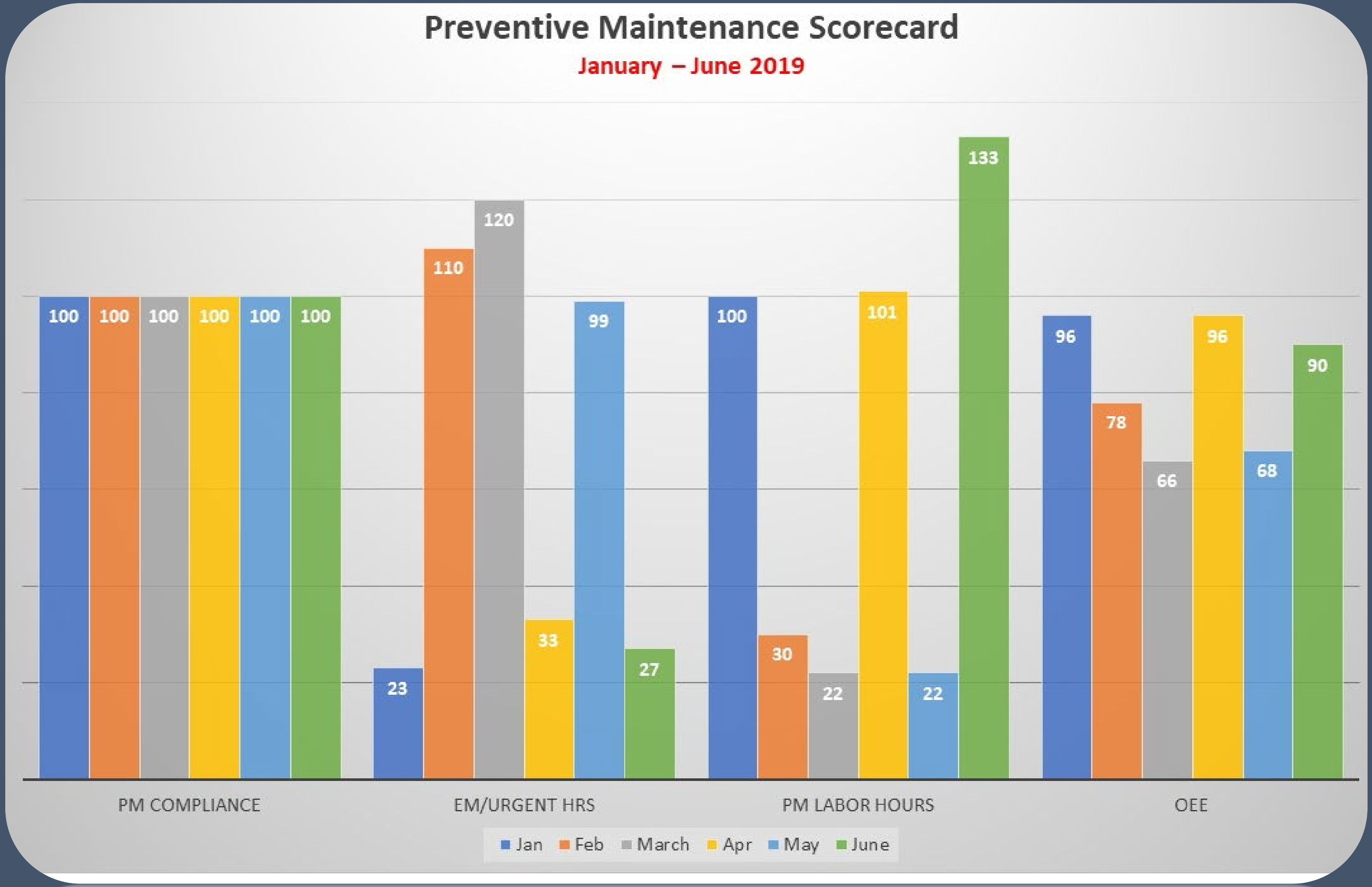
EVALUATION CRITERIA

- **G** Mission Impact: Relative criticality of system or asset on the ability to meet mission or production demands
- **H** Safety: Could a failure of this asset or system result in a potential safety incident?
- **I** Environmental: Could a failure of this asset or system result in a potential reportable incident?
- **J** Single Point Failure: Relative value of asset that considers work-around and ability to by-pass failure in the short-term
- **K** Preventive Maintenance History: Average annual cost of preventive maintenance for each asset. Absence of effective PM reduces the reliability of assets
- **L** Corrective Maintenance History: Average annual cost for each asset. Level of expenditures is indicative of reliability
- **M** Reliability: From maintenance history, this is a relative ranking based on the number of breakdowns/corrective maintenance tasks required for the asset
- **N** Spare Parts Lead Time: Relative measure of time required to obtain spare parts or asset replacement should a failure occur.
- **O** Asset Replacement Value: Relative cost to replace the asset should total failure occur
- **P** Planned Utilization: Relative value of the planned asset utilization. Assets that are needed more than 75% are rated highest (5)
- **Q** Visibility: How important is the visibility impact to the general public and staff?
- **R** Criticality Rating: Relative number that is the sum of the eleven evaluation criteria.

Common Types of Root Cause Analysis Techniques

- Pareto Analysis
- Fishbone Diagram (Ishikawa Diagram)
- The 5 Whys
- Failure Mode and Effects Analysis (FMEA)
- JDI – Just Do It

Which RCA Technique would you use if your PM Program is Meeting Expectations? (Text in your answer)



- Pareto Analysis
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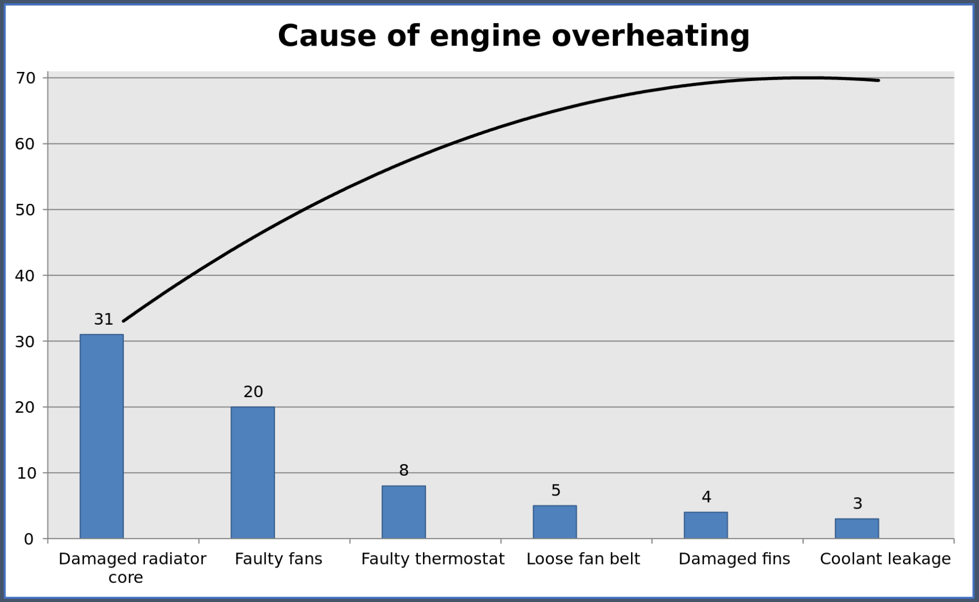
Pareto Analysis



This technique helps to identify the top portion of causes that need to be addressed to resolve the majority of problems.

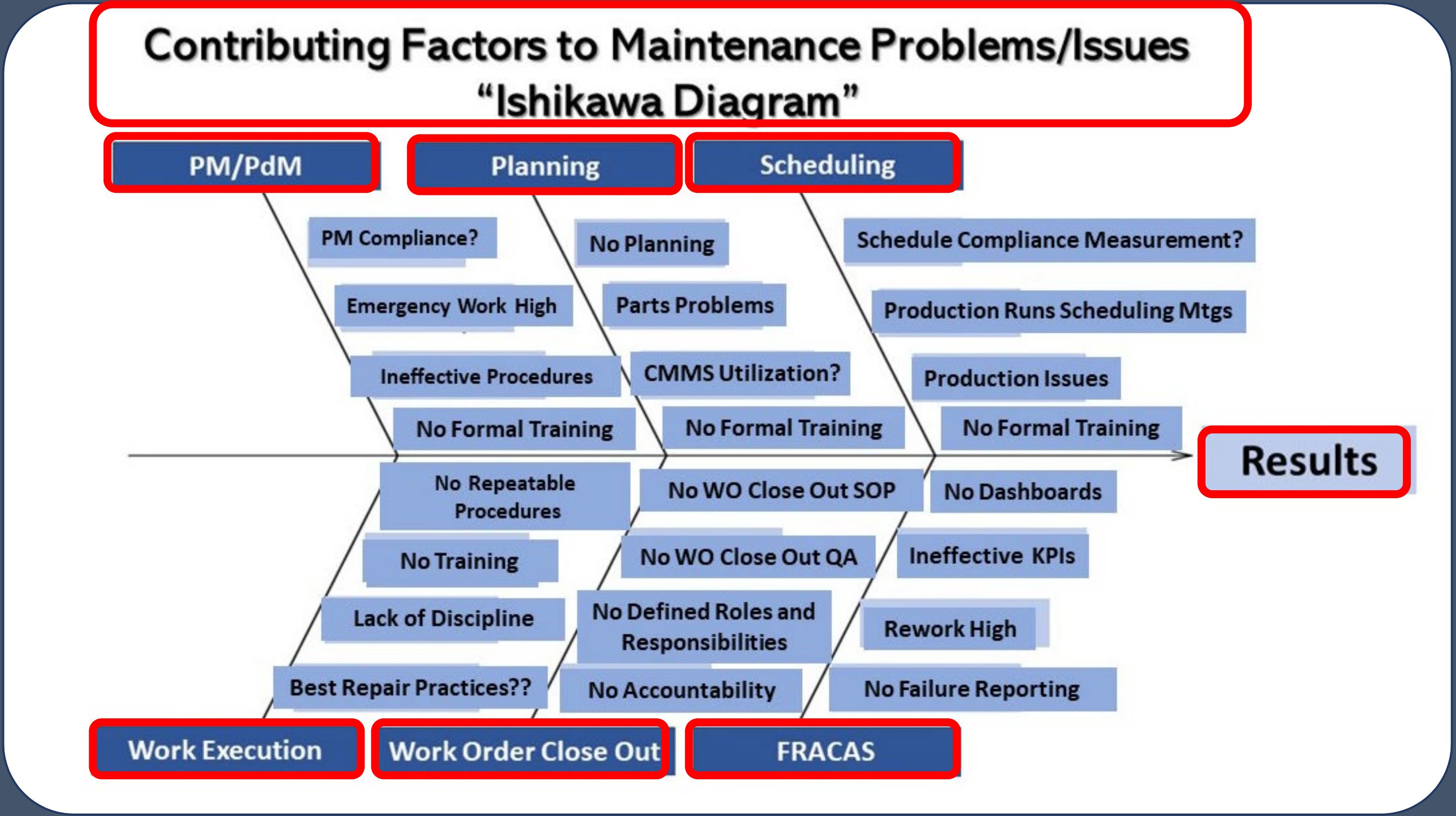
Once the predominant causes are identified, then tools like the Ishikawa diagram or Fishbone Analysis can be used to identify the root causes of the problems.

While it is common to refer to pareto as "80/20" rule, under the assumption that, in all situations, 20% of causes determine 80% of problems, this ratio is merely a convenient rule of thumb and is not nor should it be considered an immutable law of nature.

Fishbone – Ishikawa Diagram

Ishikawa diagrams are causal diagrams created by Kaoru Ishikawa that show the potential causes of a specific event.

Common uses of the Ishikawa diagram are maintenance design and quality defect prevention to identify potential factors causing an overall effect.

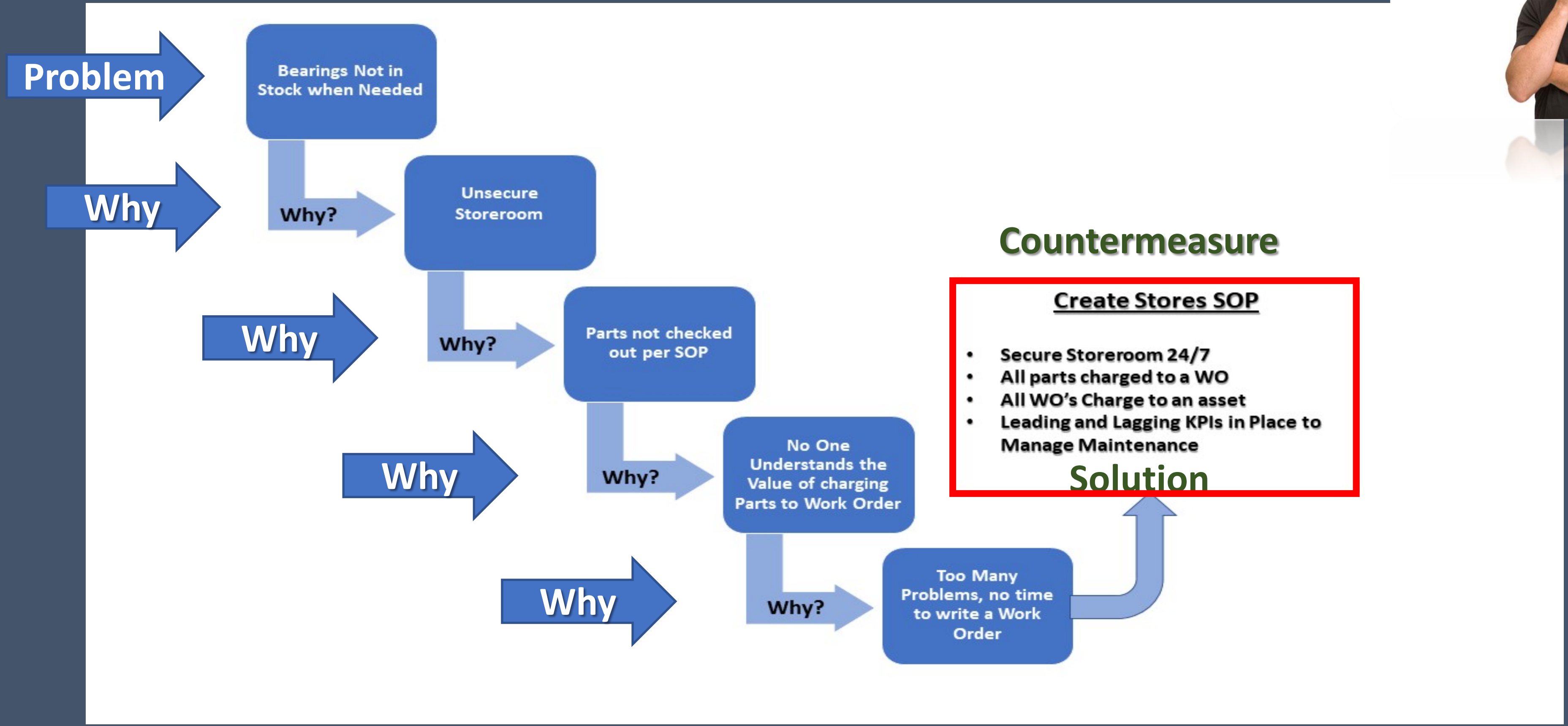


The 5 Whys

An iterative interrogative technique used to explore the cause-and-effect relationships underlying a particular problem.

The primary goal of the technique is to determine the root cause of a defect or problem by repeating the question "Why?".

Each answer forms the basis of the next question.



Failure Modes and Effective Analysis

Failure mode and effects analysis is the process of reviewing as many components, assemblies, and subsystems as possible to identify potential failure modes in a system and their causes and effects.

TABLE 5.2. Simple FMEA

Component	Mode	Effect	Comment
1. Switch Al	1.1 Fails open 1.2 Fails closed	1.1 System fails 1.2 None	1.1 Cannot turn on light. If A2 also fails closed, then system fails by premature battery depletion.
2. Switch A2	(Same as Al)	(Same as Al)	(Same as A1)
3. Light bulb C	3.1 Open filament 3.2 Shorted base	3.1 System fails 3.2 System fails; possible fire hazard	3.1 Cannot turn on light. 3.2 Cannot turn on light. May cause secondary damage to rest of system.
4. Battery B	4.1 Low charge 4.2 No charge 4.3 Overvoltage charge	4.1 System degraded; dim light bulb 4.2 System fails 4.3 System fails by secondary damage to light bulb C	4.1 May be precursor to no charge. 4.2 Cannot turn on light. 4.3 Secondary damage to light bulb C caused by overcurrent.

JDI – Just Do It

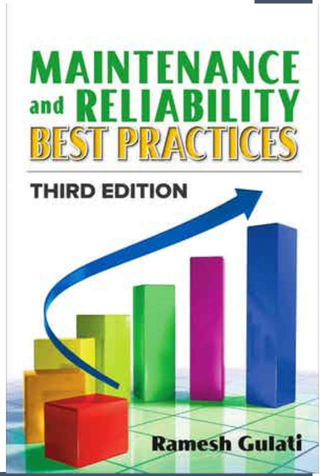
- JDI is A simple approach to solving simple problems
- Many problems are simple to solve and does not require analysis
- Look at the data below and text in which area would you focus on first and identify a possible Root Cause and what would be your first step

Line Assets	# of Failures	Production Losses	EM/Urgent Labor Hrs.	PM Compliance
Board Infeed	127	1123	346	100%
Conveyor	21	489	469	100%
Press Unit	2	2312	18	98%
Hydraulics	47	324	110	95%
PLC / DCS	8	978	943	100%
DocArm Lift	64	1934	86	98%
Total	269	7160	1,999	99.8%

Lack of Knowledge is "1" Root Cause of Equipment Failure

"Answer these questions"

1. Best Practices are practices that are defined and applied by an organization to improve their operation. These practices may or may not be proven, but results are found to be acceptable.
   a. True
   b. b. False
2. Maintainability is measured by PM schedule compliance.
   a. True
   b. b. False
3. All maintenance personnel's time should be covered by work orders.
   a. True
   b. False
4. Operations and Maintenance must work as a team to achieve improved OEE.
   a. True
   b. False
5. Best practices would indicate that 90% or more of all maintenance work is planned.
   a. True
   b. False
6. 100% of PM and PdM tasks should be developed using FMEA / RCM methodology.
   a. True
   b. False
7. Utilization of assets in a world-class facility should be about 85%.
   a. True
   b. False
8. 100% of maintenance personnel's (craft) time should be scheduled.
   a. True
   b. False
9. Time-based PMs should be less than 20% of all PMs.
   a. True
   b. False
10. The 10% rule of PM is applied on critical assets.
    a. True
    b. False



Questions from "Maintenance and Reliability Best Practices" by Ramesh Gulati

158. The two basic categories of bearings are:
   a. Plain and anti-friction
   b. Ball and roller
   c. Journal and ball
   d. Pillow-block and roller

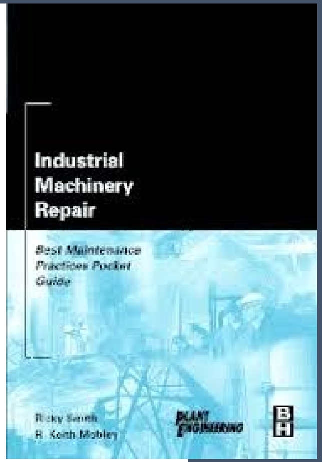
159. When cooling an overheated bearing, what should you do first?
   a. Wrap the bearing housing in hot, wet rags
   b. Spray cool water on the bearing
   c. Inject cool oil in the bearing
   d. Wrap the bearing housing in cool, wet rags

160. What is the most undesirable by-product of oil misting?
   a. Bearing failure
   b. Shaft damage
   c. Explosion potential
   d. Oil breakdown

161. Which of the following is <u>not</u> a factor affecting the selection of a lubricant?
   a. Machine speed
   b. Environmental humidity
   c. Operating temperature
   d. Environmental temperatures

162. When conducting power factor (pf) testing of an in-service oil filled transformer, test results indicate a pf of 1.8%. Is this:
   a. Within spec
   b. Out of spec
   c. Inconclusive
   d. Power factor testing of in-service oil filled transformers is not required

163. When using the force deflection method to measure belt tension, standard belt deflection distance is ______ per inch.
   a. 1/16
   b. 1/32
   c. 1/64
   d. 1/128



Questions from Industrial Machinery Repair / Ricky Smith and Keith Mobley

Steps to Embed an RCA Culture in Your Organization

1. Key Influencers Gain Knowledge in Root Cause Analysis and Maintenance Best Practices through Training and experience (Production and Maintenance Leadership)
2. Ensure Work Orders are written for all work and closed out to specifications
3. Create Triggers based on specific criteria
   - Level 1 – Accidents/Incidents
     - More than 3 near misses = 1 Senior Operator / 1 Maintenance Tech / Safety Manager
     - More that 6 near misses = 2 Maintenance Techs / 1 Reliability Engineer / 1 Senior Operator / Safety Manager
   - Level 2 – Loss Production
     - Losses of more than “X” in capacity or OEE = 1 Senior Maintenance Tech / 1 Production Operator
     - Losses of more than “X” in capacity or OEE = 1 Senior Maintenance Tech / 1 Production Supervisor / 1 Reliability Engineer
4. Post a Scorecard for Asset and Process Reliability

PM Compliance	Schedule Compliance	Maintenance Rework	EM / Urgent Labor Hours	Stores Stockouts	Breaks to Production Schedule	OEE
100%	80%	14	33%	8	11	66%

Steps to Embed an RCA Culture in Your Organization, Cont.

4. RCA Teams Require the following:
   - Project Charter
   - Targets and Goals
   - Roles and Responsibilities
   - Training in RCA Techniques
5. RCA Event Effectiveness Reviewed by stakeholders

Level 1 Project Charter – Optimize Production (OEE) "Example"

OEE OPTIMIZATION PROJECT

Project Title – Increase/Stabilize OEE | Project Leader – Jim Franks | Project Sponsor – Jill Langine

Steps	Start / End Date	Team Leader (Accountable)	Team Members (Responsible)	Objective	Measurements
ID Best Demonstrated Rate Production and Maintenance Data in past 365 Days	March 1 - March 15	Jim Franks	Sam Odis, Cindy Tolt, Manny Tie, Ricky Smith	Stabilize and increase OEE by 5%	• OEE • EM Lb. Hrs. • PM Compliance • Maint. Schedule Compliance
Educate Team in RCA Tools	March 1 – March 30	Sam Odis	• 4 Maintenance Techs • 4 Operators • 1 Maintenance Supervisor • 1 Production Leader	Prepare to implement OEE Optimization Plan	• % Attendee complete training with score above 90%
Create a Master Plan using Crawl/Walk/Run Methodology	March 31 – April 7	Cindy Tolt	• Production Manager • Maintenance Manager • 2 Techs • Maintenance Planner	Create a Plan that is successful	Completed by April 7
Implement the Plan	April 10 – Sept 14	Jim Franks	All Plant Personnel	Measure and Manage the plan	OEE, EM Lb. Hrs., PM Compliance, Schedule Compliance, Rework

Erratic Production OEE
Root Cause Analysis Action Plan
"Roles and Responsibilities"

Tasks Positions ⇨ Decisions ⇩	Maintenance Manager	Maintenance Supervisor	Maintenance Planner	Plant Manager	Production Leadership
ID Problem/Incident	R	C	C	A	R
Gather all Data and Information	C	C	R	A	R
Follow Steps in RCA Process	R	R		A	R
Create a Master Plan	C	R	R	A	R
Create RACI Chart	C	C	R	A	C
Create a Metric Dashboard	C	C	R	A	C

Responsibility	"the Doer"	(Could be more than 1 person)
Accountable	"the Buck stops here"	(One person only)
Consulted	"in the Loop"	(Two-way communication)
Informed	"kept in the picture"	(One-way communication)

QUESTIONS / COMMENTS

Upcoming Workshops for 2021

Maintenance Planning and Scheduling --- January 19-21 (completed)

Maintenance Best Technician Practices --- February 23-25 (completed)

Preventive Maintenance Best Practices plus PM Optimization --- March 23-25 (next week)

Maintenance Best Practices / SMRP Body of Knowledge --- April 27-29

Maintenance Planning and Scheduling --- May 4-6

Root Cause Analysis --- June 15-17

Maintenance Best Technician Practices --- July 20-21

MRO - Storeroom Best Practices ----- August 16-18

Maintenance Planning and Scheduling --- September 21-23

Maintenance Leadership Best Practices ---- October 19-21

Root Cause Analysis – November 9-11

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