Are Your PM's Preventing or Causing Failure?

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Presented by:

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Agenda:

- Safety Message
- Purpose
- Truth About PM's
- Bathtub Curves
- Moving from Preventive to Condition-Based
- Pathway to Involving Maintenance and Production
- Examples of Condition-Based Routes
- Outcomes
- Conclusions

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Safety Message: Reliable Plant is a Safer Plant

- Studies have shown that Maintenance personnel are far more likely to be injured performing reactive work
- Operations feels safer and is far more productive with reliable equipment
- Journey towards achieving reliability enables a reduction in injury rate

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Introductions: David A Rosenthal, PE, CMRP

"Reliability and Maintenance leader with over 39 years of Chemical and Process Industry experience"

- **Reliability Consultant, Reliability Strategy and Implementation Consultancy (Owner)**
  - **Senior Consultant, Maine Pointe Consulting Group, Boston, MA**
- **Business Director, Phillip Townsend Associates, Houston, TX**
- **Reliability Delivery and Asset Management Manager, Jacobs Engineering Grp**
- **Reliability Manager, Southern Region, Marsulex Refinery Services, Texas City**
  - Coke cutting, handling, and transport assets
- **Maintenance Director, MEMC Electronic Materials, Pasadena**
  - Polysilicon manufacturing for solar cells and electronic components
- **Reliability Consultant, Celerant Consulting, Lexington, MA**
  - LANXESS, Butyl Rubber Manufacture, Sarnia, ON
  - Kellogg's, Snack Foods Division, Battle Creek, MI
- **Maintenance and Reliability Manager, Rohm and Haas Company, Deer Park, TX**
  - Acrylic Acid, Ethyl Acrylate, Butyl Acrylate, Sulfuric Acid manufacturing
- **Manager of Manufacturing Excellence, Rohm and Haas Company, Bristol, PA**
- **Reliability Engineer, Rohm and Haas Company, Bristol, PA**

Introductions: David A Rosenthal, PE, CMRP

"Reliability and Maintenance leader with over 39 years of Chemical and Process Industry experience"

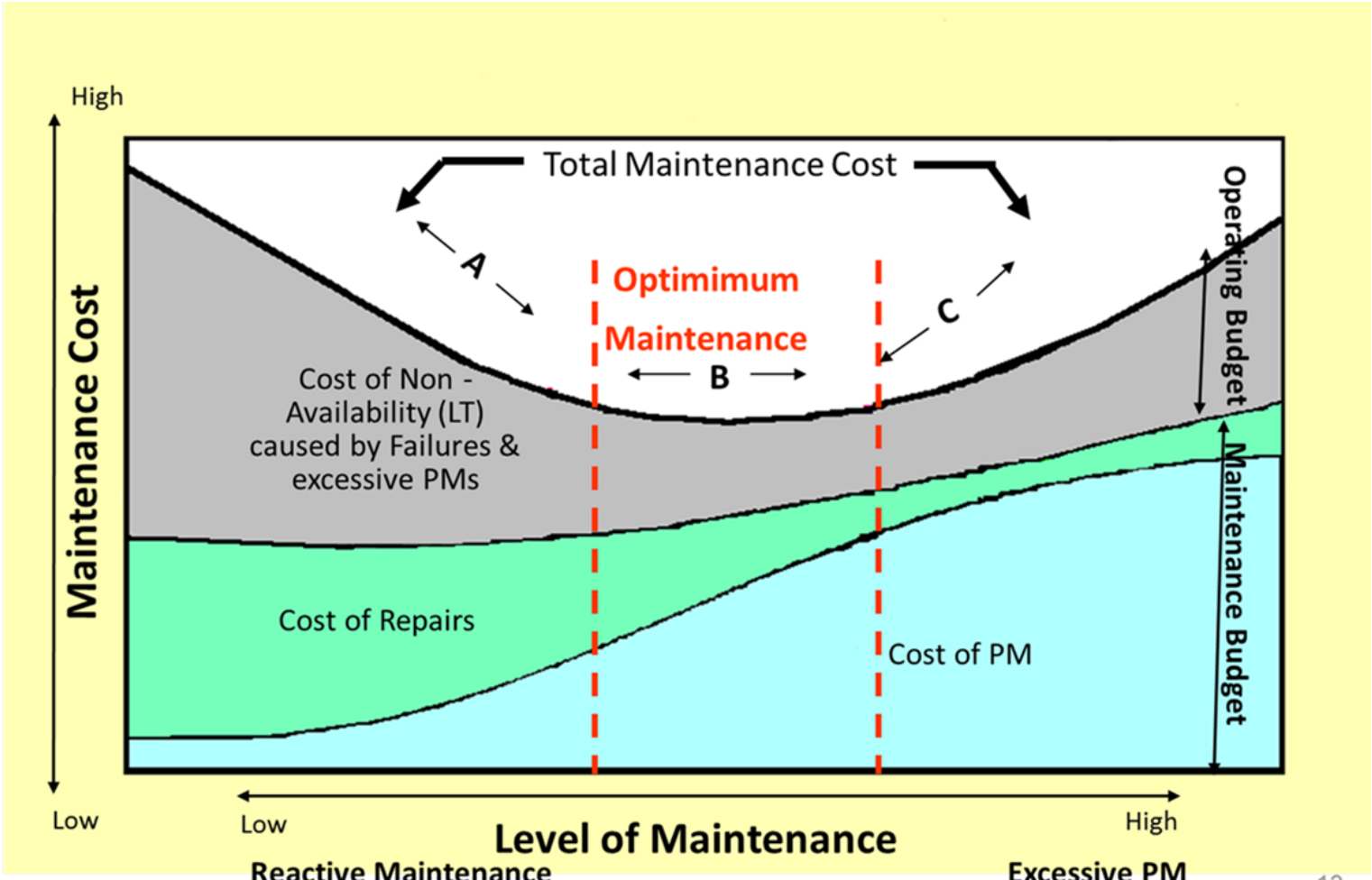
- MS in Chemical Engineering, University of Texas, 1981
- BS in Chemical Engineering, Drexel University, 1979
- Past President American Institute of Chemical Engineers, 2012
- Member of Society of Maintenance and Reliability Professionals (SMRP)
- Chair of the SMRPCO Board of Directors
- Certified Maintenance and Reliability Professional (CMRP)

Purpose

- Reliance on PM's as a component of asset care does not deliver expected cost and productivity goals.

- Redirecting PM content towards condition-based routes for Maintenance and Operations tasks is shown to lower operating and maintenance costs and improve productivity (OEE)

Truth About PM's : Why is There a "Sweet Spot?"



Truth About PM's : Why is There a "Sweet Spot?"

- PM's are intrusive and if poorly performed can result in early failure upon startup which drives up Maintenance costs and reduces uptime
- PM's are time-based and may never catch an early sign of failure which waste the Maintenance Department's resources.
- PM's require machine downtime which hurts the business in meeting its OEE objectives.
- Many sites have reported 30% more PM's than required which also wastes Maintenance resources and diverts them from more impactful condition-based and higher skilled tasks.
- Many PM's have low "hit rates" meaning that failures are not detected within 5-8 times performing the PM.

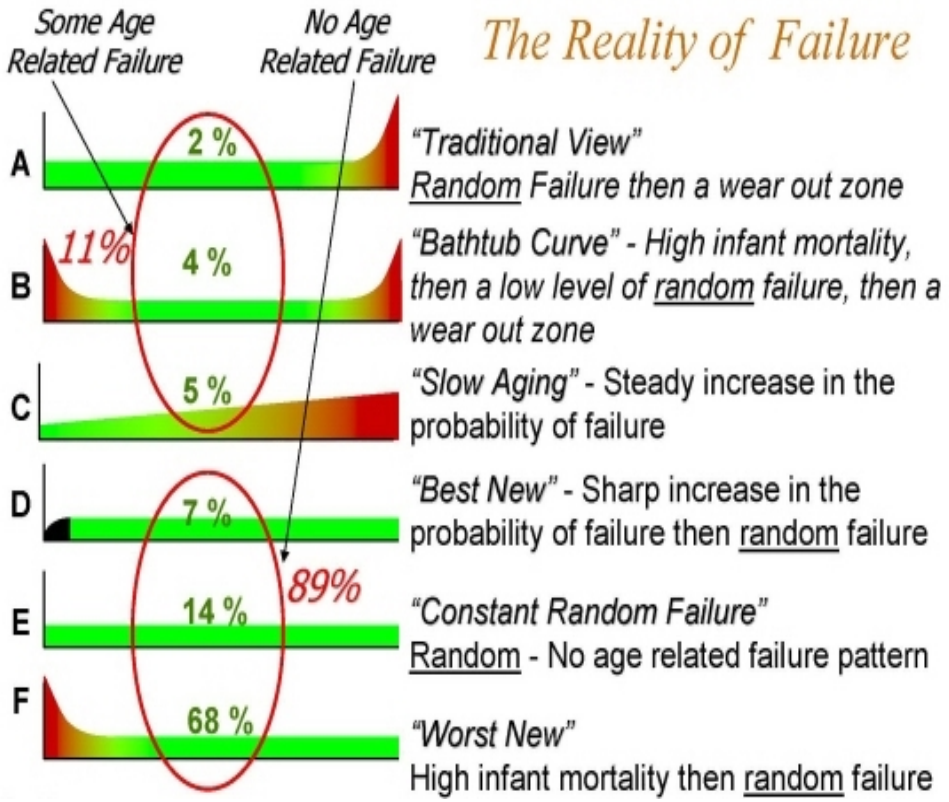
Bathtub Curves: What Do They Tell Us?

Prior to the late 70's aircraft manufacturers and airline owners believed that overhauls at certain intervals would maintain reliability until the next overhaul.

They discovered that reliability of the plane did not improve but worsened

Study performed by Nowlan and Heap from United Airlines (prior to the Boeing 747) uncovered how machines fail and by preserving critical functions was the key to reliability.

Tearing planes apart exposed them to premature failures and infant mortality, increased the probability of failure.



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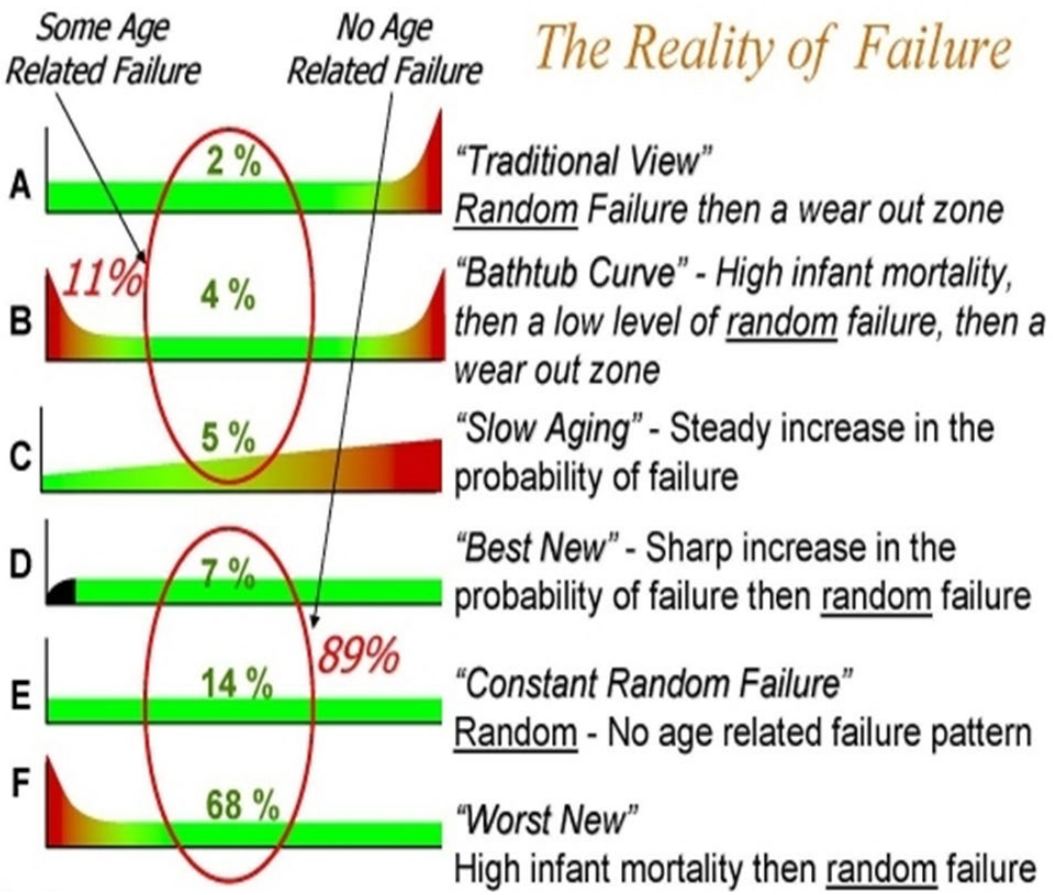
Bathtub Curves: What Do They Tell Us?

- Majority of failures are random (89%) not time-based
- PM's are generally the wrong action since the start of failure can be missed
- Invasive PM actions bring assets back to initial high failure rate (infant mortality and end-of-life high probability curves)
- Continual monitoring of condition finds early signs of random failure
- **Operations has the most exposure to equipment condition at the facility to continually monitor for the early signs of failure.**



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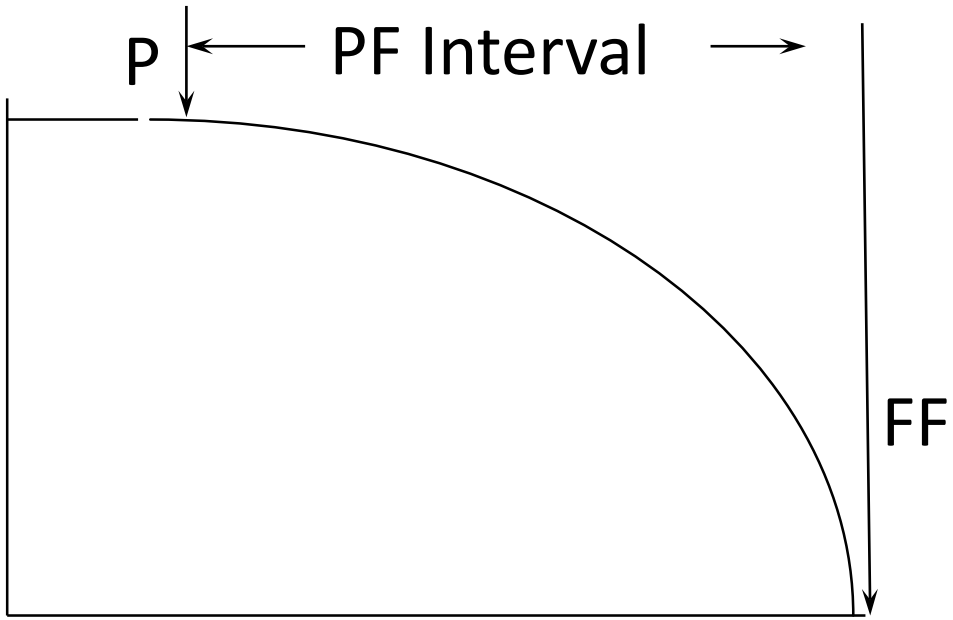
What Does Your Equipment Exhibit?

The PF interval is the lead time between the ability to detect a failure process and the actual loss of function. It is unrelated mathematically to the failure rate.

- Interval will vary with machine and its individual components
- For some machines and components it is long allowing for the planning and scheduling of repair
- For some machines and components it's short requiring more monitoring and immediate attention
- It is unrelated to MTBF



P - The point in time when failure can first be detected.

FF - Loss of Function

Moving from Preventive to Condition-Based

Existing PM's	Route-Based Tasks – Maintenance (Each Week)	Route-Based Tasks – Operations (Every Day)
1 Mo: Check lacing and belt for tears, check gearbox for leaks, check sprockets for wear, chain for stretch, check missing hardware, check structure, check return rolls and bearings for travel and noise, check head and tail roll for grip, check electrical cords, check motor for temperature and vibration, check disconnect, keep motor clear of mud and dirt	Check lacing and belt for tears, check gearbox for leaks, check sprockets for wear, chain for stretch, check for missing hardware, check structure, check return rolls and bearings for travel and noise, check head and tail roll for grip, check electrical cords for damage, check motor for temperature with IR gun and for excessive vibration, keep motor clear of mud and dirt	Ensure belt is turning and tracking in center, check lacing and belt for tears, check for oil leaks beneath motor, check for any missing hardware (bolts), check structure for any tow motor damage, check return rolls and bearings are turning, check for any smells or excessive vibrations, keep motor clear of mud and dirt
1 Wk.: Check spiral infeed for wear and debris, check cage assembly, check walls, ceiling, flashing, check amp draw, grease bearing fan motors, check conduit, fans for bearing noise , lights for broken conduit, 1 YR: Inspect main drive gear box, change oil and belts, inspection tension drive, tension drive gear box, 1 MO: Inspect oil cleanliness, level, Lovejoy coupling, grease	Check spiral infeed belt for wear and debris, check cage assembly, check walls, ceiling, flashing, check amp draw check conduit for damage, check fan bearings for noise , check lights and for broken conduit, check main drive gear box for noise and leaks, inspect for correct tension on drive, check joy coupling for damage, check for cleanliness	Check for correct temperature and any alarms, check spiral infeed for wear and debris, check walls and ceiling, flashing for damage, check for any broken lights, maintain cleanliness, check for any smells, noise, or excessive vibration
Check picker, unloader cups, grease rod end, tie roads, bearings conveyer chains, refill auto lube grease pot, magazine cylinder, vacuum pump oil level, HEPA Filter, 1 MO: Grease rod ends, zerks, bearings, gearbox oil level, top sealer bellows for cracks, clean picker filters, top sealer position, diaphragm switch alarm, float switch, check carton tension alignment, 6 MO: Change secondary filters, 1 YR: Change primary filters	Check picker and unloader cups for function, check bearings conveyer chains for wear, refill auto lube grease pot, check vacuum pump oil level and HEPA Filter, clean picker filters, check diaphragm switch alarm for function, check carton tension alignment, check for any machine alarms, listen for any abnormal noises or any smells, check for missing hardware	Check picker and unloader cup for function, listen for any unusual noises, out-of-place smells, excessive vibration, review any machine alarms, check filter pressures for high readings, check structure for damage, check for any oil leaks

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Pathway to Involving Maintenance and Production

- Conduct a Criticality Exercise ranking your assets by RPN number
- Review PM's first for Critical and then for Non-Critical Assets
- Eliminate PM's with low "hit-rates"
- Identify tasks that can be performed without machine intervention tied to known failure modes
- Remove tasks from the PM's and construct condition-based routes for Maintenance and Production
- Issue Maintenance routes (slowly at first) and begin to plan and schedule corrective repairs upon the early signs of failure
- Issue Operations routes for Startup, Normal Operation, and Shutdown tasks to ensure both standardization and operating within "windows". Look for systemic issues and partner with Maintenance for signs of failure
- Operations needs to "act as an owner" to understand how to recognize the early signs of failure and drive out the "normalization of the abnormal"

Examples of Condition-Based Routes

Shift Inspection: Packaging Line 1 **Procedure Code - 112 Version 1.0** **July 10, 2019**

Area: Packaging Line 1 = Lockout/Tagout Required ① = See Notes

PPE: Hard hats, Safety Glasses, Ear Plugs, Shoe Covers, and Hair / Beard nets

Tools: Flashlight, Screwdrivers, Wrenches, and Safety Knife

SHIFT PROACTIVE MAINTENANCE ROUTE **Start Time _____ Stop Time _____**

SKILLS = **COMPLETED BY 9 AM and 6 PM EACH SHIFT (NOTIFY SUPERVISOR/LEAD IF NOT ON TRACK)**

SKILLS = ☐ V (Visual) ☐ M (Mech Skills) ☐ E (Electrical) ☐ U (Utilities) ☐ C (Electrical)

LOCATION #: EQUIPMENT	WHAT TO CHECK	DESIRED CONDITION	Condition Found	Action Take WO # (if needed)
#1: RYSON SPIRAL	BELT	TRACKING OK, NOT JERKING, NO DAMAGED OR WORN		
	COUNTERWEIGHT POSITION	CORRECT SETTING		
	MOTOR	NO NOISE, NO VIBRATION, TEMPERATURE (<160F)	_____ F	
	STRUCTURE	NOT DAMAGED		
	CHECK MOVEMENT	SMOOTH, NO JERKING MOTION		
	MOUNTING	NO MISSING HARDWARE, MOUNTED TO FLOOR		
	LUBRICATION	EVIDENCE OF GREASE		
#2: CONVEYER STAGING FEEDING TOP TIER	BELT	TRACKING OK, NOT WORN, ALIGNMENT IS GOOD, NOT RUBBING		
	MOTORS (10)	NO NOISE, NO VIBRATION, TEMPERATURE (<160F) (GREEN LEDS ON)	_____ F	
	SENSORS	ALL FUNCTIONING		
	WIRING	NO DAMAGE		
	DISCONNECTS	ALL ON		
	STRUCTURE, MOUNTING	NOT BENT, NOT DAMAGED, NO MISSING HARDWARE		

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Examples of Condition-Based Routes

Shift Inspection: South Kitchen (Lines 2 and 3) Procedure Code - 105 Version 1.0 July 10, 2019

Area: South Kitchen (Lines 2 and 3) 🔒 = Lockout/Tagout Required ① = See Notes

PPE: Hard hats, Safety Glasses, Ear Plugs, Shoe Covers, and Hair / Beard nets

Tools: Flashlight, Screwdrivers, Wrenches, and Safety Knife

SHIFT PROACTIVE MAINTENANCE ROUTE **Start Time _____ Stop Time _____**

SKILLS = COMPLETED BY 9 AM and 6 PM EACH SHIFT (NOTIFY SUPERVISOR/LEAD IF NOT ON TRACK)

SKILLS = ☐ V (Visual) ☐ M (Mech Skills) ☐ E (Electrical) ☐ U (Utilities) ☐ C (Electrical)

LOCATION #: EQUIPMENT	WHAT TO CHECK	DESIRED CONDITION	Condition Found	Action Take WO # (if needed)
#1: BURPER SHAKER INFEED – LINE 2	FIBER ARMS	NOT BROKEN		
	SPRINGS	NOT DEFORMED		
	LATCHES	TIGHT, NO MISSING, NOT BROKEN		
	SCREEN	NO DAMAGE, CLEAR OF DEBRIS		
	MOTOR	NO NOISE, NO VIBRATION, TEMPERATURE (<160F)	_____ F	
	STRUCTURE	NOT DAMAGED, NO MISSING HARDWARE, SUPPORTS ARE ATTACHED TO THE FLOOR		
	GEARBOX	NO LEAKS		
#2, 5, 6: WATER BLANCHER LINE 2	TEMPERATURE	186 F, STEAM CONTROL VALVE OPERATING AS EXPECTED	_____ F	
	STEAM LEAKS	NONE FROM PIPING OR CONTROL VALVES		
	ROTATION	CORRECT SPIN		
	MOTOR	NO NOISE, NO VIBRATION, TEMPERATURE (<160F)	_____ F	
	STEAM PRESSURE	200 PSIG	_____ PSIG	
	AIR FUNCTION	NO LEAKS, CORRECT PRESSURE		
	HARDWARE	NONE MISSING		
	STRUCTURE, MOUNTING	NO CRACKS, NONE MISSING		
	SCREEN	IN PLACE		
	GEARBOX	NOT LEAKING		
	COUPLING	NOT DAMAGED OR WORN		
	ELECTRICAL CONNECTIONS	NO DAMAGE		
	STEAM SYSTEM GUARDS AND WALKWAY RAILINGS	IN PLACE		

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Examples of Condition-Based Routes

Equipment and Area Ownership Program

Hourly Equipment and Area (5S) Inspections

for Downtime Prevention and Facility Organization

Equipment: Line 1 Day:

Normal Operation : Cook

Equipment/Area Inspection Description		Expected Condition	7AM	Noon	5PM	Comments:
Print Inspector Name: _____ Signature: _____ Date: ____ / _____ / _____						
Door Foamer		ON				
Quat		On floor				
Grates		In place				
Hoses		Hung				
Drain Baskets		In place				
Housekeeping		Trash taken out, None on floor				
HMI Status						
	Potatoes	**Sweets**				
Steam	12 Sec	12 Sec				
Capacity	23000 lbs.	23000 lbs.				
Optimization	100	100				
Batch Weight	285 lbs.	285 lbs.				
In Feed / Out Feed	AUTO / 60 HZ	AUTO / 60 HZ				
SCRN-0005						
	Potatoes	**Sweets**				
Grates	Down	Down				
Valves	Shut	Shut				
Structure	No damage, No leaks	No damage, No leaks				
PUMP-0001						
	Potatoes	**Sweets**				
Power	ON	ON				
Operation	No noises, No leaks	No noises, No leaks				

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Examples of Condition-Based Routes

Equipment and Area Ownership Program

Hourly Equipment and Area (5S) Inspections

for Downtime Prevention and Facility Organization

Equipment: Line 2 Day:

Normal Operation

Equipment/Area Inspection Description	Expected Condition	7AM	Noon	5PM	Comments:
Print Inspector Name: _____ Signature: _____ Date: ____ / _____ / _____					
Normal Operation : Cook Line					
COOK ROOM					
Door Foamer	ON				
Quat	On floor				
Grates	In place				
Hoses	Hung				
Housekeeping	Clean, Trash out				
Drain Baskets	In place				
Guards / Covers	In place				
PUMP-0022					
Power	ON				
Operation	No noises, No leaks				
SCRN-0003					
Grates	Down				
Valves	Shut				
Structure	No damage, No leaks				
PUMP-0025					
Power	ON				
Operation	No noises, No leaks				
AUGR-0012					
Valves	Closed				
Doors and Latches	Closed and Tight				
Structure and Operation	No noises, No damage				

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Outcomes from Clients

Metric	Response	Comment
Safety	Increases Near Miss Reporting, Less reactive	Breaks “Normalization of the Abnormal”
OEE	>3-5%	Mechanical uptime improves, Reduces missed orders
Work Order Generation	>100% (approximately)	Discovery work increases (PM04), Reactive work decreases (PM01)
Maintenance Cost	<10% (Over first two years)	Reduces “Hot Shots”, Less parts ordered

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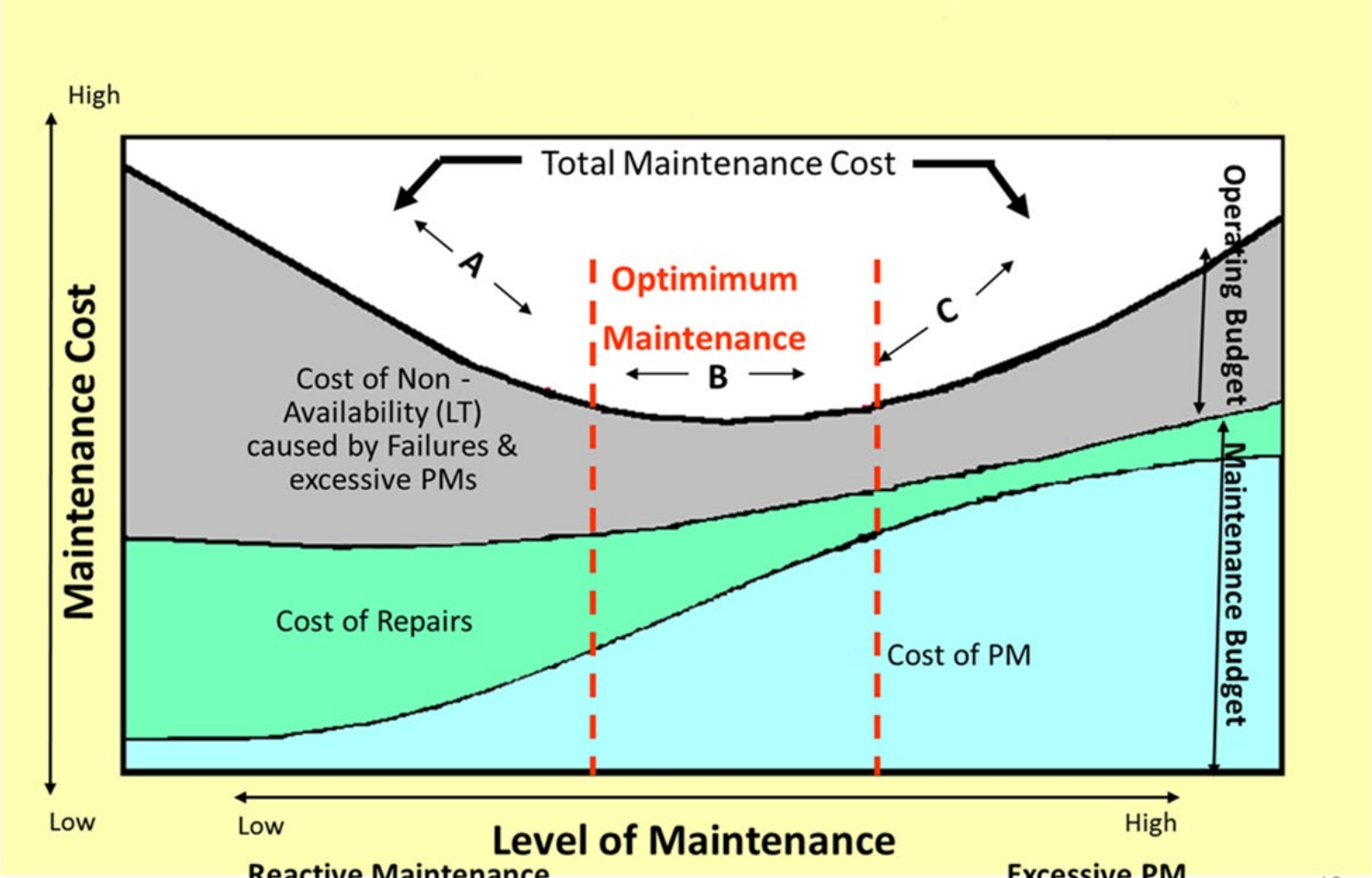
Conclusions : You Need to Understand Why There is an Optimum!



Thank You and Contact

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