WRITING REPEATABLE/ EFFECTIVE CORRECTIVE MAINTENANCE AND PREVENTIVE MAINTENANCE PROCEDURES

BY: RICKY SMITH, CMRP, CMRT, CRL

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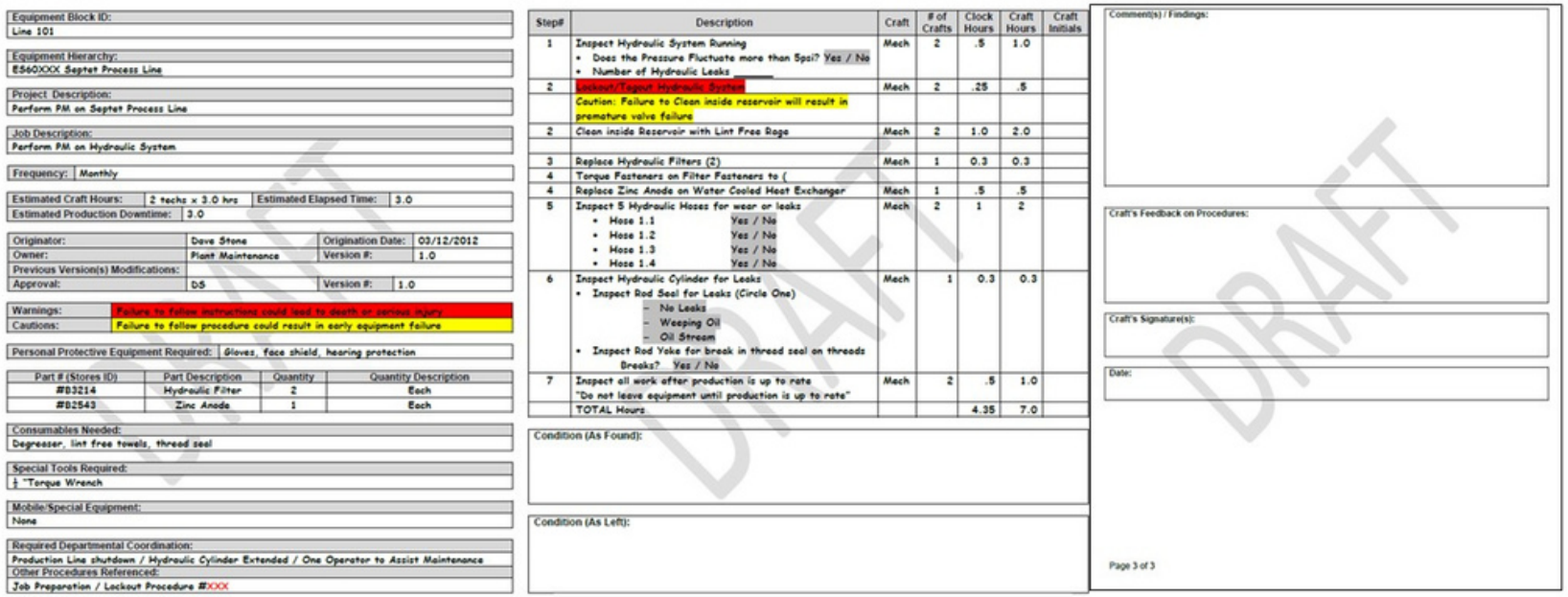
PM Procedure Example



Equipment Block ID:	Line 101
Equipment Hierarchy:	E560XXX Septet Process Line
Project Description:	Perform PM on Septet Process Line
Job Description:	Perform PM on Hydraulic System
Frequency:	Monthly
Estimated Craft Hours:	2 techs x 3.0 hrs
Estimated Elapsed Time:	3.0
Estimated Production Downtime:	3.0
Originator:	Dave Stone
Origination Date:	03/12/2012
Owner:	Plant Maintenance
Version #:	1.0
Previous Version(s) Modifications:	
Approval:	DS
Version #:	1.0
Warnings:	Failure to follow instructions could lead to death or serious injury
Cautions:	Failure to follow procedure could result in early equipment failure
Personal Protective Equipment Required:	Gloves, face shield, hearing protection

Part # (Stores ID)	Part Description	Quantity	Quantity Description
#B3214	Hydraulic Filter	2	Each
#B2543	Zinc Anode	1	Each

Consumables Needed:
Degreaser, lint free towels, thread seal

Special Tools Required:
- "Torque Wrench

Mobile/Special Equipment:
None

Required Departmental Coordination:
Production Line shutdown / Hydraulic Cylinder Extended / One Operator to Assist Maintenance

Other Procedures Referenced:
Job Preparation / Lockout Procedure #XXX

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Step#	Description	Craft	# of Crafts	Clock Hours	Craft Hours	Craft Initials
1	Inspect Hydraulic System Running • Does the Pressure Fluctuate more than 5psi? Yes / No • Number of Hydraulic Leaks ___	Mech	2	.5	1.0	
2	Lockout/Tagout Hydraulic System	Mech	2	.25	.5	
	Caution: Failure to Clean inside reservoir will result in premature valve failure					
2	Clean inside Reservoir with Lint Free Rags	Mech	2	1.0	2.0	
3	Replace Hydraulic Filters (2)	Mech	1	0.3	0.3	
4	Torque Fasteners on Filter Fasteners to (					
4	Replace Zinc Anode on Water Cooled Heat Exchanger	Mech	1	.5	.5	
5	Inspect 5 Hydraulic Hoses for wear or leaks • Hose 1.1 Yes / No • Hose 1.2 Yes / No • Hose 1.3 Yes / No • Hose 1.4 Yes / No	Mech	2	1	2	
6	Inspect Hydraulic Cylinder for Leaks • Inspect Rod Seal for Leaks (Circle One) – No Leaks – Weeping Oil – Oil Stream • Inspect Rod Yoke for break in thread seal on threads Breaks? Yes / No	Mech	1	0.3	0.3	
7	Inspect all work after production is up to rate "Do not leave equipment until production is up to rate"	Mech	2	.5	1.0	
	TOTAL Hours			4.35	7.0	

Condition (As Found):

Condition (As Left):

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Comment(s) / Findings:

Craft's Feedback on Procedures:

Craft's Signature(s):

Date:

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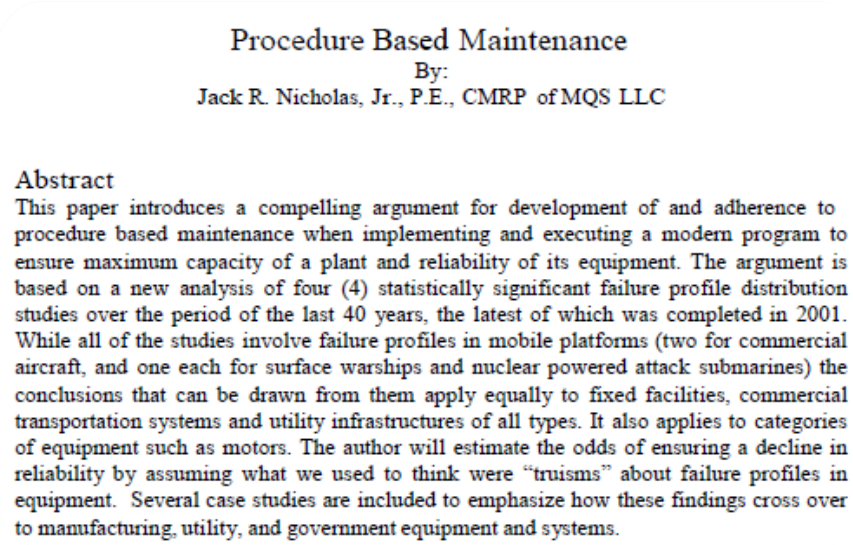
Why Companies do not use Preventive Maintenance and Corrective Maintenance Procedures?

1. Organizations have never seen an “Effective Procedure Looks Like” and their value
2. Lack of Knowledge in Preventive / Corrective Maintenance Best Practices
3. The Maintenance Culture is Reactive
4. Organizations feelRepeatable Procedures are not needed –Techs are experienced know what they are doing
5. Techs feel they know how to perform maintenancework correctively without specifications
6. Overnight deliveries sit for weeks, months
7. Everyone works as hard as they can with little if any movement seen toward proactive
8. Storeroom is Chaos (people standing in line at 7:00am waiting on parts)
9. Storeroom has excess inventory “just in case”
10. Maintenance Rework is high however no one can determine the true “Root Cause of Rework”
11. No one knows there is a problem (no scoreboard)

Procedure Based Maintenance

By: Jack R. Nicholas, Jr., P.E., CMRP of MQS LLC

- In the field of maintenance, the traditional approach has been to rely upon the intuitive knowledge and skill of the crafts-persons who conduct it.
- There is a great deal of pride of workmanship and, in all too many organizations, a great deal of psychic income in addition to significant overtime pay for successful emergency repairs to return equipment to operation after unplanned shutdowns.
- There is a mystique that accompanies all of this that many skilled crafts-person would like management to believe firmly.
- That is that there are too many variables in maintenance, making compliance with written procedures impossible and impractical; that the “way we’ve always done it” is the best and only way to conduct maintenance.
- This idea spills over into preventive maintenance, also. Crafts-persons believe that their own intuitive knowledge is preferable to a written procedure and/or a thoroughly defined checklist



Procedure Based Maintenance

By:

Jack R. Nicholas, Jr., P.E., CMRP of MQS LLC

Abstract

This paper introduces a compelling argument for development of and adherence to procedure based maintenance when implementing and executing a modern program to ensure maximum capacity of a plant and reliability of its equipment. The argument is based on a new analysis of four (4) statistically significant failure profile distribution studies over the period of the last 40 years, the latest of which was completed in 2001. While all of the studies involve failure profiles in mobile platforms (two for commercial aircraft, and one each for surface warships and nuclear powered attack submarines) the conclusions that can be drawn from them apply equally to fixed facilities, commercial transportation systems and utility infrastructures of all types. It also applies to categories of equipment such as motors. The author will estimate the odds of ensuring a decline in reliability by assuming what we used to think were “truisms” about failure profiles in equipment. Several case studies are included to emphasize how these findings cross over to manufacturing, utility, and government equipment and systems.

Download a Copy at www.worldclassmaintenance.org

Cost of NOT Using Repeatable Procedures

TABLE 7.2. Maintenance Costs in Typical and World-Class Companies

Metric	Typical	World Class
Maintenance cost/replacement asset value		
Maintenance cost must include labor (including overtime), materials, contract maintenance, and capital replacements, and maintenance (replacing worn-out assets because they were never properly maintained)	3.5–9%	2.0–3.0%
Maintenance materials cost/replacement asset value		
Maintenance materials cost must include material in storeroom stock plus material in other locations (maintenance shop, plant floor, etc.)	1.0–3.5%	0.25–0.75%

Reworkis corrective work done on previously maintained equipment that has prematurely failed due to maintenance, operations or material problems. The typical causes of rework are maintenance, operational or material quality issues. –Source: SMRP Metrics

Attributes of a Typicalorganization vs a World Class Maintenance Organization

Typical Maintenance Organization Attributes

1. **All Maintenance work is not captured by a Work Order**
2. **Maintenance Work is based on a Techs knowledge**
3. **Maintenance Procedures are not repeatable**
4. **•Example: Check Chain Drive?**
5. **•Example: Lubricate Bearings**
6. **Maintenance Rework is high**

World Class Maintenance Organization Attributes

1. **All Planned and Scheduled Maintenance Work using repeatable procedures**
2. **When repeat failures occur Maintenance Procedures are analyzed to determine Root Cause of the problem**
3. **Maintenance Rework is minimal and controlled**
4. **Maintenance Cost is controlled**

Human Induced Failures

80% of equipment failures are human-induced, meaning the failure was caused by the actions of people.

Examples of Human Induced Failures:

•Repairs are not made with a repeatable procedure, so everyone does it a little (or a lot) differently, creating uncontrolled deviation to the reliability of the equipment.

•Mechanic #1Lubricates an asset and follows a repeatable procedure and does the job the right way; Resulting Mean Time Between Failure (MTBF) far exceeds expectations.

•Mechanic #2lubricates the same equipment without a procedure, and just does it like he always has, not knowing the proper contamination control method; MTBF is out of control, but no one knows it because it is not measured.

Table 1: Cut 'em down at the roots

Bearings	
Problem	**Root cause**
Bearing failure due to contamination of grease with dirt, dust or silica	Failure to wipe grease fitting or the end of the grease gun nozzle clean
Bearing failure due to contamination of grease by dirt, dust or silica	Seal not holding due to over-lubrication
Bearing failure due to lubricant not providing barrier to prevent metal-to-metal contact	Wrong grease/oil or heat-reduced viscosity due to temperature rise beyond range of lubricant
Gear reducers	
Problem	**Root cause**
Failed bearings and damaged gear teeth due to contamination causing interference between gears, thus overloading bearings	Gear oil added to gearbox through a dirty funnel or dirty container or bucket
Failed bearings due to contamination of lubricant with dirt, dust or silica	Seal leaking due to over-pressurization of gear-box caused by blocked air intake on housing
Electric motors	
Problem	**Root cause**
Bearing failure due to contamination of the grease with dirt, dust or silica	Failure to wipe grease fitting or the end of the grease gun nozzle clean
Bearing failure due to contamination of the grease with dirt, dust or silica	Seal not holding due to over-lubrication
Windings failed because of grease buildup inside the motor	Relief plug not removed before introducing grease into zerk fitting
Windings failed because of grease buildup inside the motor	Sealed bearings – grease cannot enter the bearing

Question?

Text in “1” Human Induced Failure” you have seen/experienced

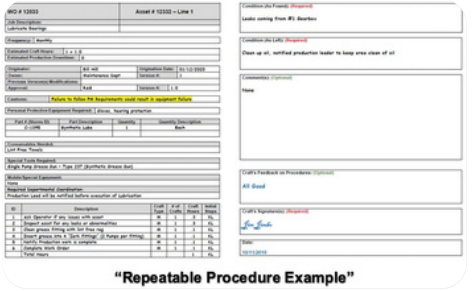
Indicators of Human-Induced Failures

Have you seen any of the following issues? If you have, you are likely to have a serious problem with human induced-failures.

- Lubricating electric motors without removing the relief plug
- Welding on equipment without grounding close to the welded area
- ExcessiveEquipment failures occurwithout a known root cause resulting loss capacity
- Operators not operating the equipment to specifications; people are allowed todo their own thing, costing the company millions
- Zinc anodes are not replaced on water cooled heat exchangers, causing tube damage and water intrusion into oil
- Maintenance personnel making quick repairsand not returning to restore later
- No Repeatable Procedures

Over-Torque

Improper Lubrication

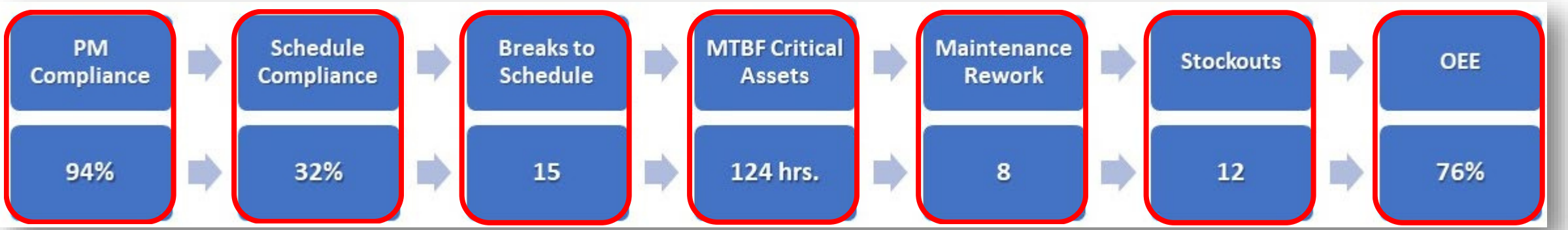


"Repeatable Procedure Example"

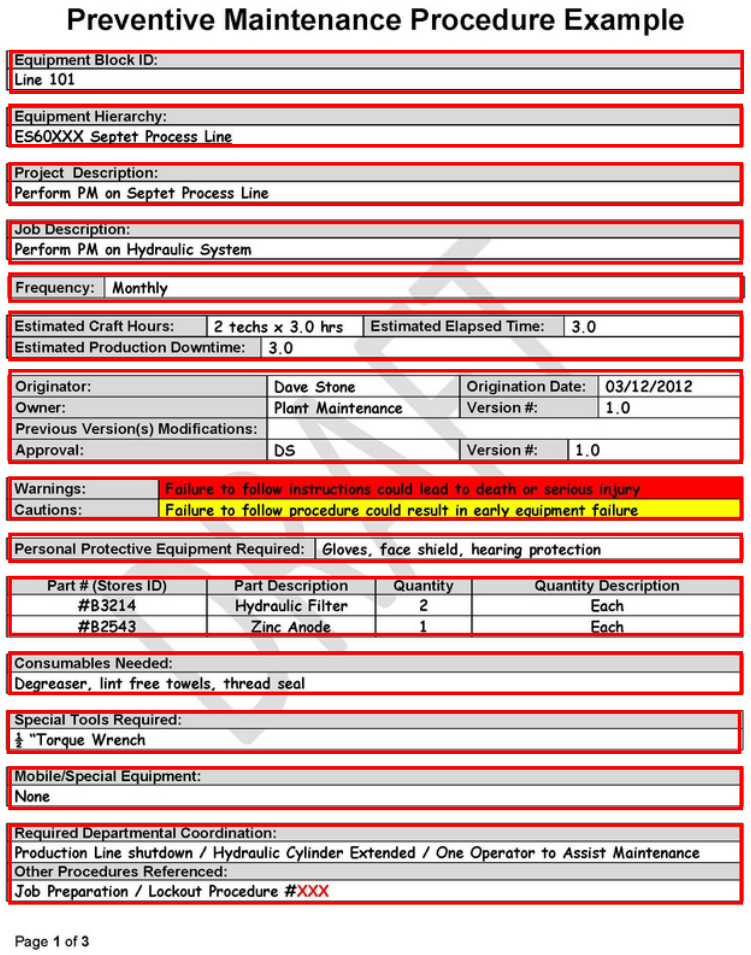
NO REPEATABLE PROCEDURE

Baseline KPIs/ Metrics Before Creating New or Updating Current Procedures

1. **Create a team to assist in creation of a Maintenance Dashboard to measure effectiveness of the new metrics –2 Maintenance Technicians, Maintenance Supervisor, Maintenance Manager, Production Leader, Storeroom Manager**
2. **ID which *current*metrics will be influenced through creating more effective procedures**
3. **Identify 4-5 metrics to create a KPI Dashboard to ensure "New Procedures" are effective**
4. **Post dashboard for all to see, as one enters the plant, in maintenance shop, etc.**



What is Required of a Repeatable Procedure? (Page 1)



Preventive Maintenance Procedure Example

Equipment Block ID:	
Line 101	
Equipment Hierarchy:	
ES60XXX Septet Process Line	
Project Description:	
Perform PM on Septet Process Line	
Job Description:	
Perform PM on Hydraulic System	
Frequency:	Monthly
Estimated Craft Hours:	2 techs x 3.0 hrs
Estimated Elapsed Time:	3.0
Estimated Production Downtime:	3.0

Originator:	Dave Stone	Origination Date:	03/12/2012
Owner:	Plant Maintenance	Version #:	1.0
Previous Version(s) Modifications:			
Approval:	DS	Version #:	1.0

Warnings:	Failure to follow instructions could lead to death or serious injury
Cautions:	Failure to follow procedure could result in early equipment failure
Personal Protective Equipment Required:	Gloves, face shield, hearing protection

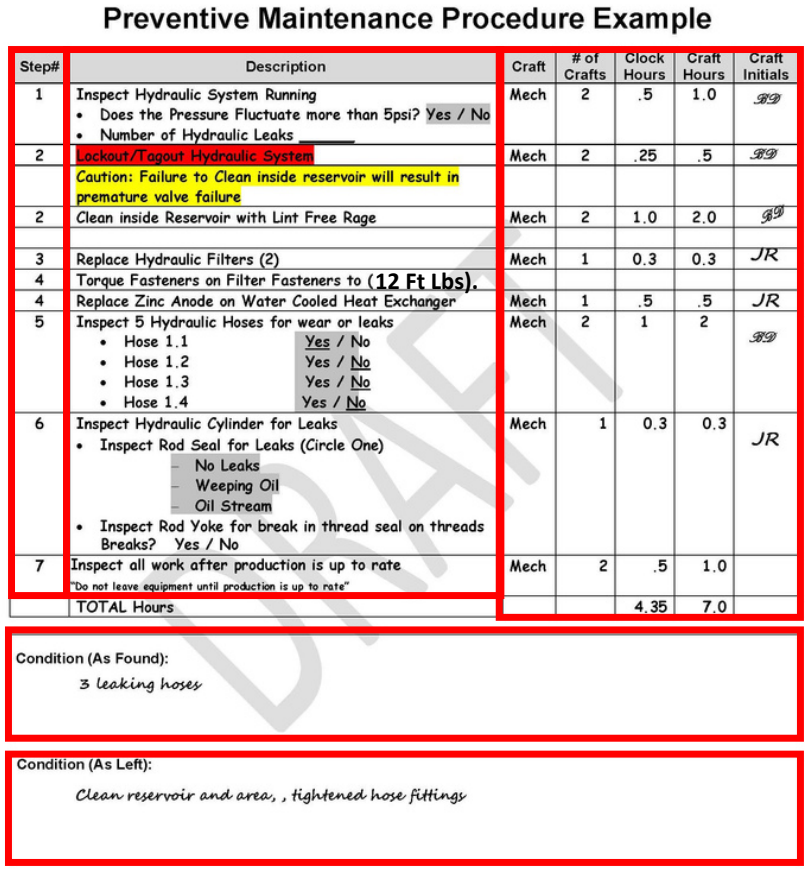
Part # (Stores ID)	Part Description	Quantity	Quantity Description
#B3214	Hydraulic Filter	2	Each
#B2543	Zinc Anode	1	Each

Consumables Needed:
Degreaser, lint free towels, thread seal
Special Tools Required:
½ "Torque Wrench
Mobile/Special Equipment:
None
Required Departmental Coordination:
Production Line shutdown / Hydraulic Cylinder Extended / One Operator to Assist Maintenance
Other Procedures Referenced:
Job Preparation / Lockout Procedure #XXX

Page 1 of 3

1. Equipment Block ID
2. Equipment Hierarchy
3. Project Description (PM, CM, Etc.)
4. Job Description
5. Frequency (if a time-based PM Or Time Based Changeout
6. # Craft and Total Hours required
7. Origination Date and Version
8. Warnings / Cautions
9. PPE
10. Parts or Material, quantity and part number
11. Consumables
12. Special Tools
13. Mobile or Special Equipment
14. Shutdown or Coordination required

What is Required of a Repeatable Procedure? (Page 2)



Preventive Maintenance Procedure Example

Step#	Description	Craft	# of Crafts	Clock Hours	Craft Hours	Craft Initials
1	Inspect Hydraulic System Running • Does the Pressure Fluctuate more than 5psi? Yes / No • Number of Hydraulic Leaks ____	Mech	2	.5	1.0	BD
2	Lockout/Tagout Hydraulic System	Mech	2	.25	.5	BD
	Caution: Failure to Clean inside reservoir will result in premature valve failure					
2	Clean inside Reservoir with Lint Free Rage	Mech	2	1.0	2.0	BD
3	Replace Hydraulic Filters (2)	Mech	1	0.3	0.3	JR
4	Torque Fasteners on Filter Fasteners to (12 Ft Lbs).					
4	Replace Zinc Anode on Water Cooled Heat Exchanger	Mech	1	.5	.5	JR
5	Inspect 5 Hydraulic Hoses for wear or leaks • Hose 1.1 Yes / No • Hose 1.2 Yes / No • Hose 1.3 Yes / No • Hose 1.4 Yes / No	Mech	2	1	2	BD
6	Inspect Hydraulic Cylinder for Leaks • Inspect Rod Seal for Leaks (Circle One) – No Leaks – Weeping Oil – Oil Stream • Inspect Rod Yoke for break in thread seal on threads Breaks? Yes / No	Mech	1	0.3	0.3	JR
7	Inspect all work after production is up to rate "Do not leave equipment until production is up to rate"	Mech	2	.5	1.0	
	TOTAL Hours			4.35	7.0	

Condition (As Found):
3 leaking hoses

Condition (As Left):
Clean reservoir and area, , tightened hose fittings

Page 2 of 3

1.Procedure Steps
2.Description for each step, to include:
- "RED" Warnings and "YELLOW" Cautions
- Steps to follow along with action items
- Quantitative Values (Ft Lbs.)
- Subjective Values (Yes/No)
  - Subjective Values (No Leaks, Weeping Oil, Oil Stream)
  - "Inspect all work after production is up to Rate"

3.Craft Type, # of Craft, Craft Hours / Clock Hours, Initials
4.Sum of Total Hours

What is Required of a Repeatable Procedure? “Page 3”

Preventive Maintenance Procedure Example

Comment(s) / Findings:

3 leaking hoses, need to replace all 3 hoses and fittings, Rod Seal "Weeping Oil"?

Craft's Feedback on Procedures:

Need to add "clean outside reservoir"

Craft's Signature(s):

Jimmy Rogers

Bo Dudley

Date: December 21, 2020

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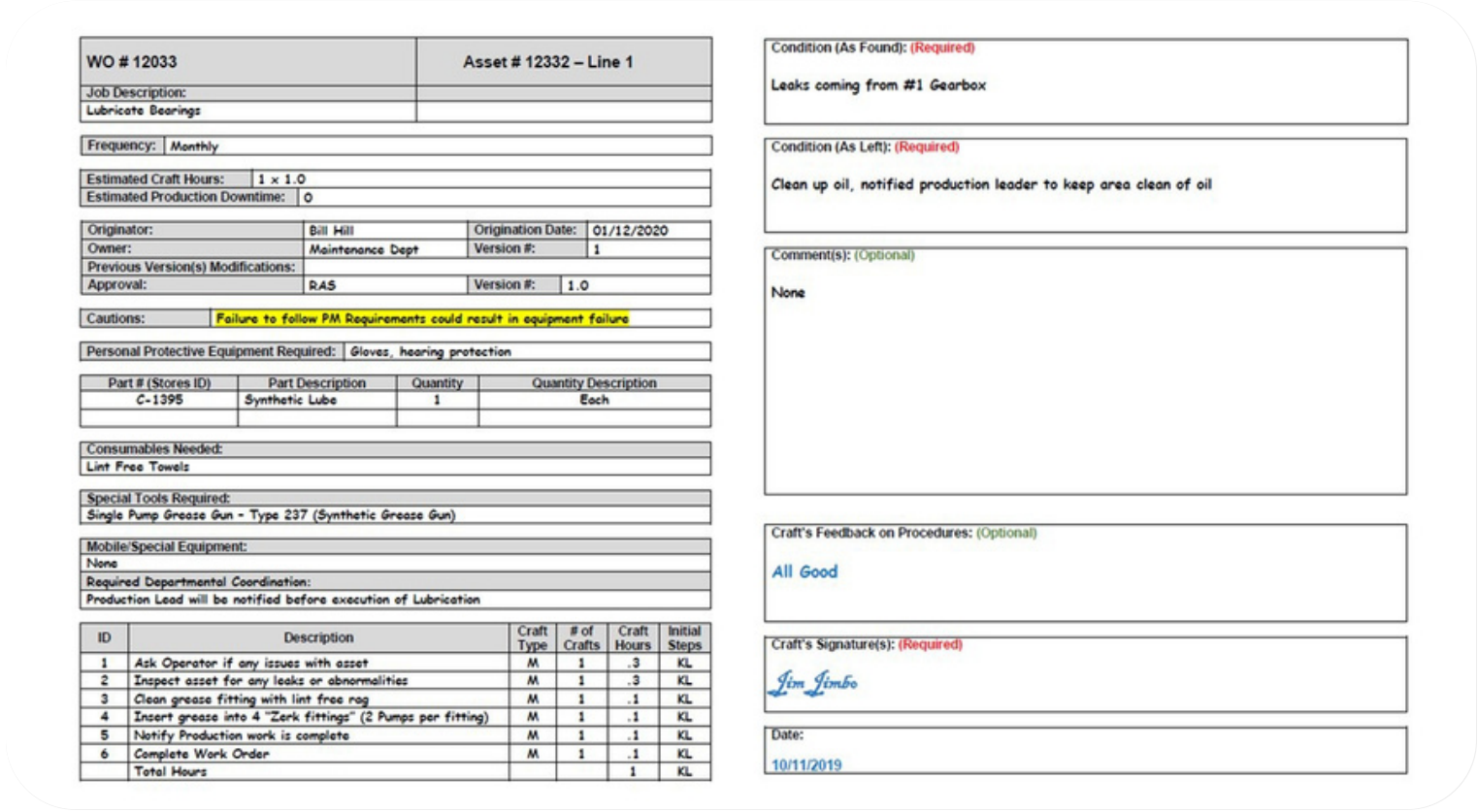
1.Comments / Findings for Planner and Supervisor for Possible Future Work
2.Craft Feedback on Procedures
3.Craft Signatures

A copy of a similar Procedure Template can be found at:
www.worldclassmaintenance.org

Requirements for Writing a Procedure To Ensure Repeatability



WO # 12033	Asset # 12332 – Line 1
Job Description:	
Lubricate Bearings	

Frequency:	Monthly
Estimated Craft Hours:	1 x 1.0
Estimated Production Downtime:	0

Originator:	Bill Hill	Origination Date:	01/12/2020
Owner:	Maintenance Dept	Version #:	1
Previous Version(s) Modifications:			
Approval:	RAS	Version #:	1.0

Cautions:	Failure to follow PM Requirements could result in equipment failure
Personal Protective Equipment Required:	Gloves, hearing protection

Part # (Stores ID)	Part Description	Quantity	Quantity Description
C-1395	Synthetic Lube	1	Each

Consumables Needed:
Lint Free Towels

Special Tools Required:
Single Pump Grease Gun - Type 237 (Synthetic Grease Gun)

Mobile/Special Equipment:
None
Required Departmental Coordination:
Production Lead will be notified before execution of Lubrication

ID	Description	Craft Type	# of Crafts	Craft Hours	Initial Steps
1	Ask Operator if any issues with asset	M	1	.3	KL
2	Inspect asset for any leaks or abnormalities	M	1	.3	KL
3	Clean grease fitting with lint free rag	M	1	.1	KL
4	Insert grease into 4 "Zerk fittings" (2 Pumps per fitting)	M	1	.1	KL
5	Notify Production work is complete	M	1	.1	KL
6	Complete Work Order	M	1	.1	KL
	Total Hours			1	KL

Condition (As Found): (Required)

Leaks coming from #1 Gearbox

Condition (As Left): (Required)

Clean up oil, notified production leader to keep area clean of oil

Comment(s): (Optional)

None

Craft's Feedback on Procedures: (Optional)

All Good

Craft's Signature(s): (Required)

Jim Jimbo

Date:

10/11/2019

- Clearly Define Best Practice
- Consistency and Continuity
- Reinforce Best Practice
- Define Training and Certification
- Enable Quality, Safety and Environmental Compliance

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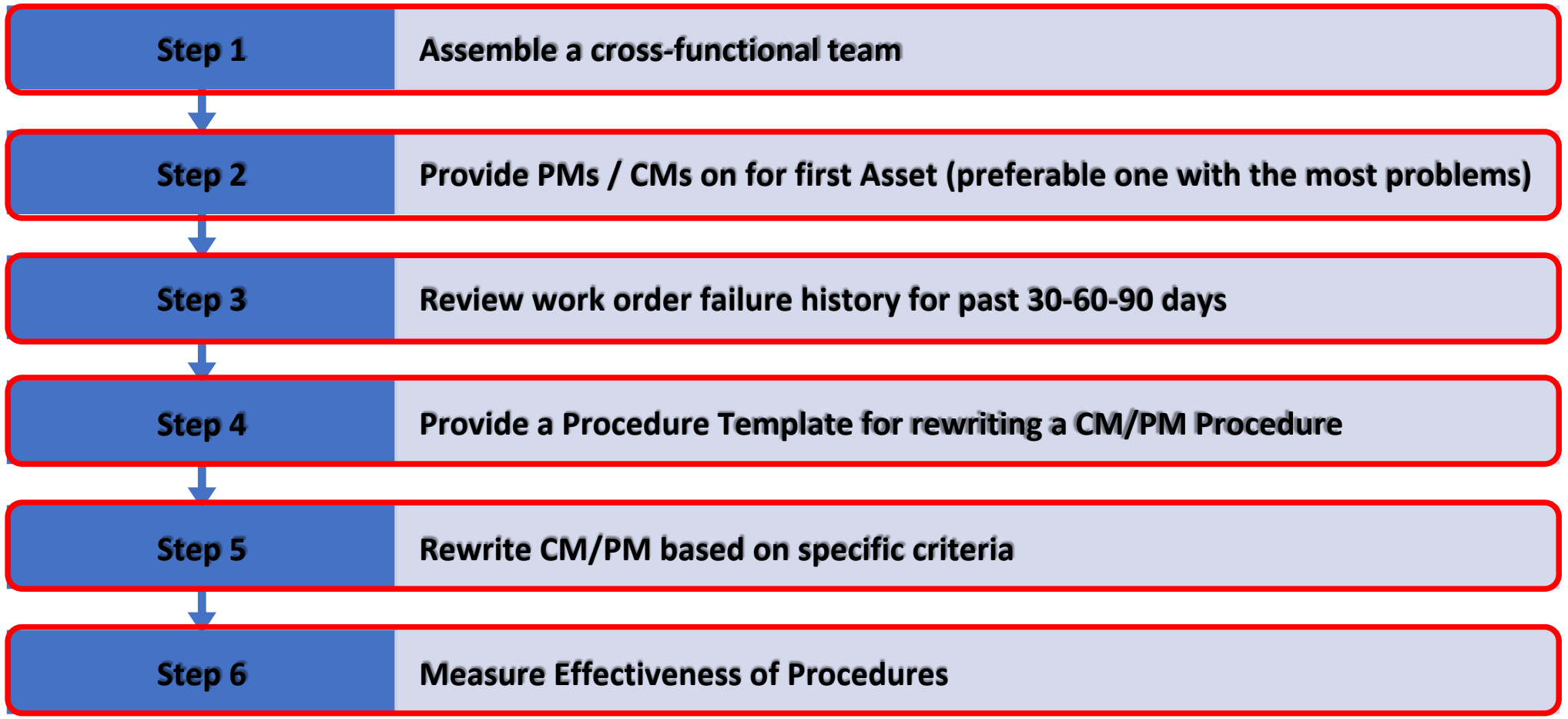
Steps to Write / Re-Write PM or CM Procedures



Maintenance Procedures Optimization

"Roles and Responsibilities"

Tasks Positions → Decisions ↓	Maintenance Manager	Maintenance Supervisor	Maintenance Planner	Maintenance Tech	Production Leadership
Assemble Cross Functional Team	A	R	R	R	C
Provide PMs / CMs on for first Asset (preferable one with problems and highest criticality)	A	C	R		I
Review work order failure history for past 30-60-90 days	A	R	R	R	C
Rewrite CM/PM based on specific criteria	A	R	C	R	I
Measure Effectiveness of New Procedures	A	R	R	R	I
Move to Next Asset	A	R	R	C	C

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

Knowledge of Best Practices is a Requirement

Step 1: Education in Best Practices

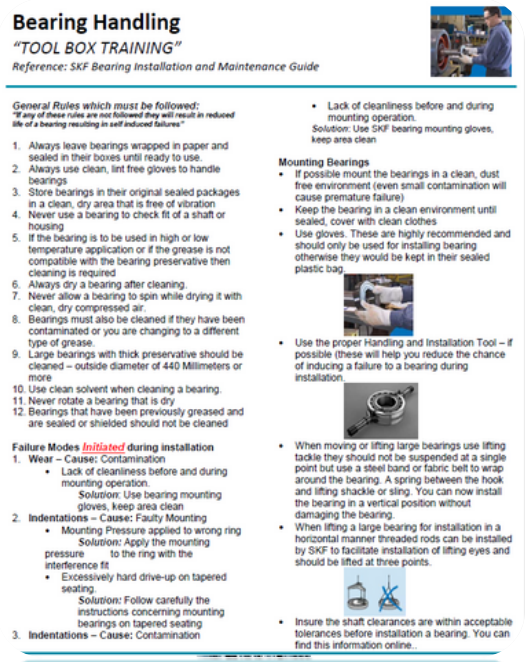
- **Best Maintenance Technician Practices**
- **PM Best Practices**
- **Single Point Lessons**

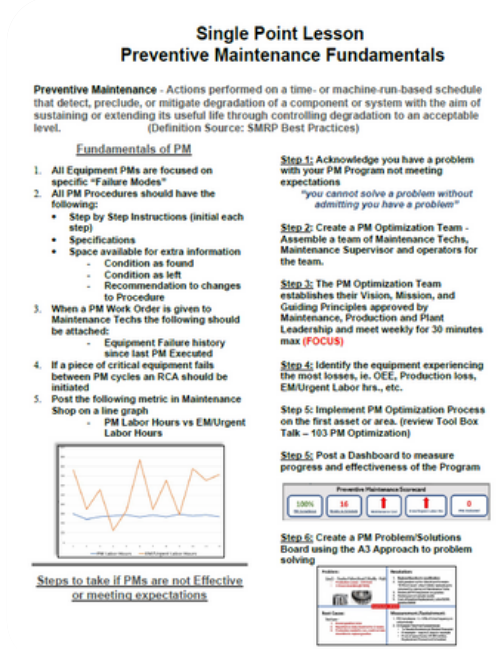
Step 2: Write General Procedures

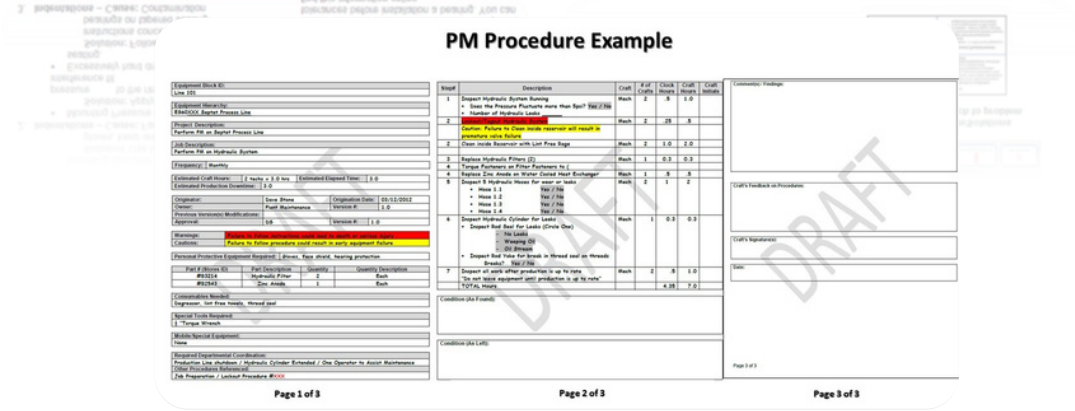
- **Ex: Replace Electric Motor**
- **Ex: Replace Chain Drive**
- **PM Hydraulic System**
- **PM Conveyors**
- **Etc.**

Step 3: Measure Effectiveness

PM /PdM Compliance	PM/PdM Yield	Schedule Compliance	Rework	Stockouts	Emergency Labor Hours
100%	34%	90%	14%	22%	14%



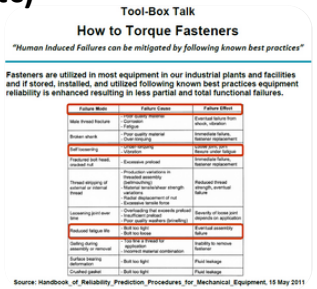




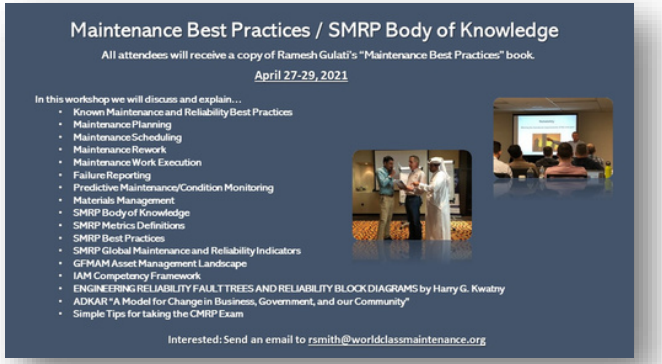
Recap –BLUFF

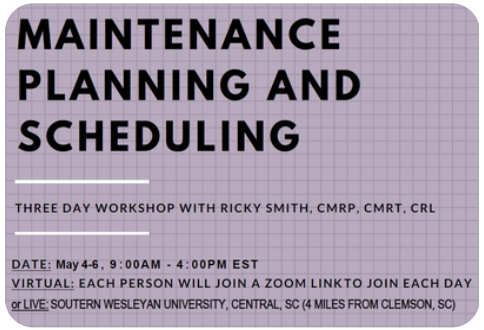
BLUFF –Bottom Line Up Front

- **Create a Procedure Template which can be used for PM or CM -Download a template at: www.worldclassmaintenance.org**
- **Assemble a Team of SMEs and Proactive People (Maint., Engr., Mgt, etc)**
- **Create an Action Plan using the Crawl –Walk –Run Methodology**



- **Define Roles and Responsibilities of the Team using a RACI Chart**
- **Educate your team in Best Practices using Single Point Lessons (download at same website)**
- **Send 1 –2 Maintenance Techs to "Maintenance Technician Best Practices Workshop"**
- **Send a Maintenance Planner to "Planning and Scheduling Workshop"**
- **Send your senior Maintenance Tech to "PM Best Practices plus PM Optimization Workshop" Tell Maintenance Leadership about "Maintenance Best Practices Workshop"**
- **Join "The Maintenance Community by UpKeep".**





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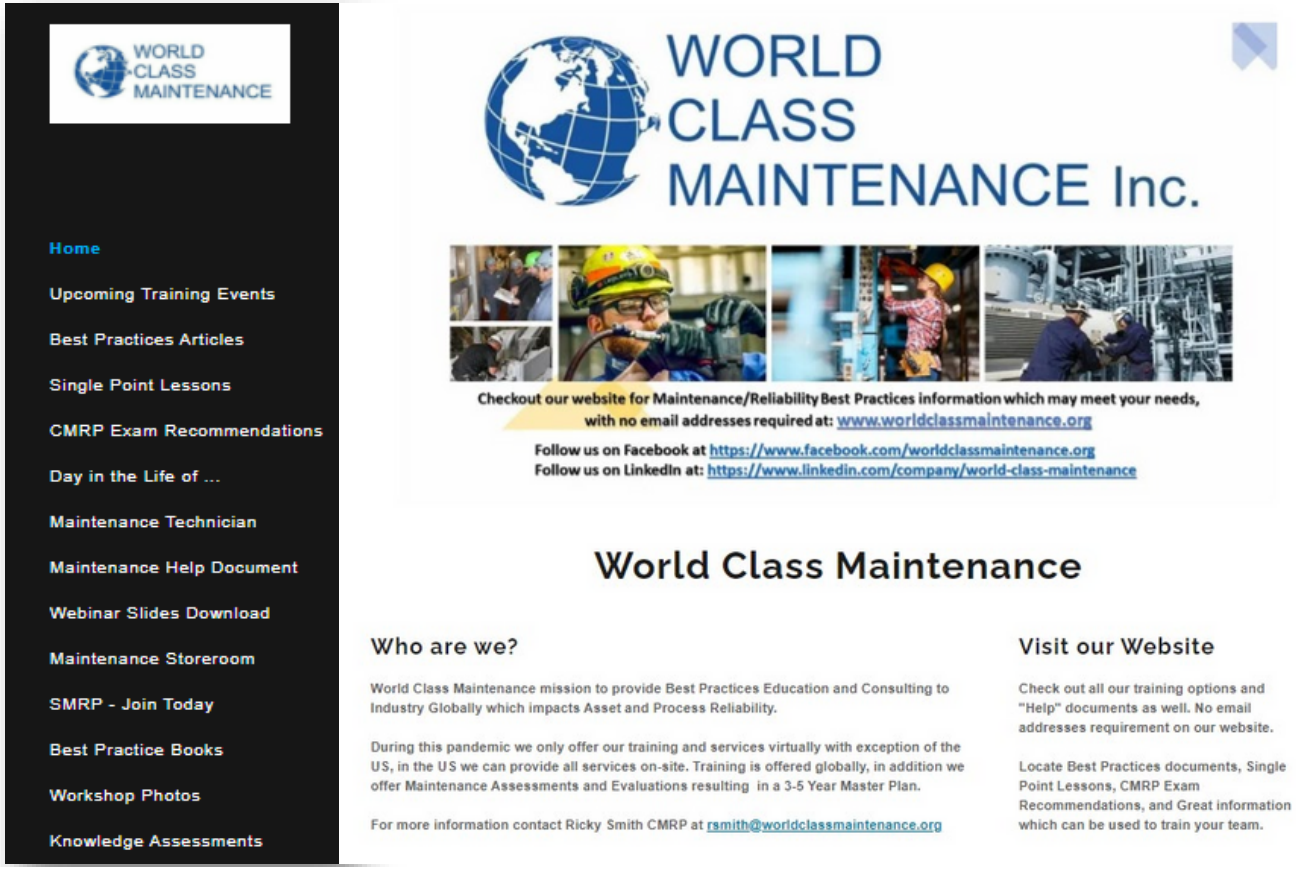
Questions?

Checkout my website for free Proactive Maintenance Information to include "Procedure Templates"

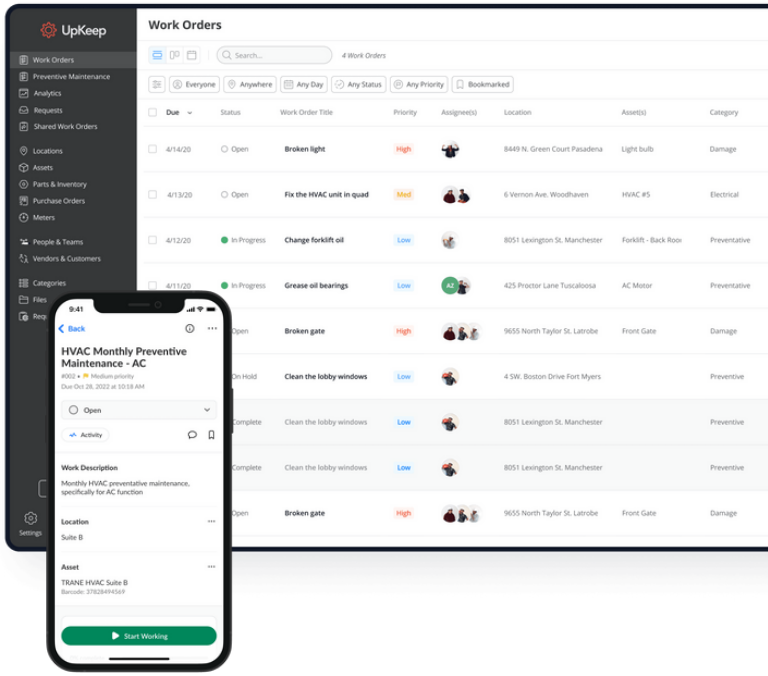
www.worldclassmaintenance.org



#1 Software for Maintenance & Reliability Teams

UpKeep is a service-first company that builds software designed to make maintenance easier for technicians and managers everywhere. Reduce downtime up to 18% by switching over to a preventative maintenance solution!

www.upkeep.com



Our Products

UpKeep

Mobile-first maintenance management and collaboration across all location, assets, and teams

"With nearly 340 different machines in our work environment, it's an impossible task to manually assign and track PM's. With UpKeep we can schedule regular maintenance without overlapping tasks with other critical jobs."

★★★★★ **Paul D, Health and Safety Coordinator**

edge by UpKeep

An end-to-end solution for remote condition-based monitoring

Connected and secure IoT sensors for real-time remote condition asset monitoring

DATAHUB UpKeep

Integrated & Centralized Data Ecosystem for World Class Asset Operations

The only purpose built Asset Data Platform. Asset Focused ELT Solution for advanced analytics and integrated, real-time asset data.

TMCC THE MAINTENANCE COMMUNITY COALITION

The Maintenance Community Coalition was founded on the belief that working together will benefit everyone within our community

Committed to helping each other thrive in our individual professional journeys by sharing resources and expertise, granting scholarships, hosting events, and unlocking knowledge – always at no cost.