

Asset LifeCycle and Maintenance Best Practices

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Failure Modes and Effects Analysis



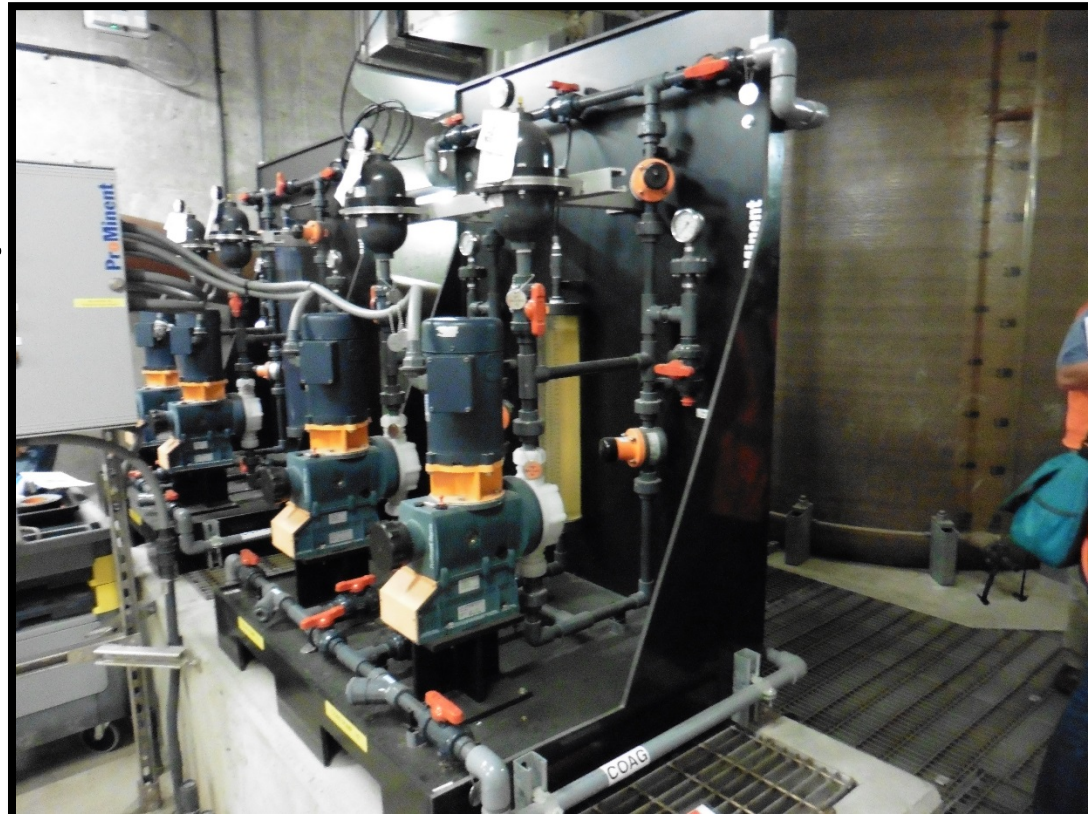
FMEA Failure Modes and Effects Analysis

- FMEA also known as Fault Hazard Analysis
 - Identify single points of failure
 - What is the failure mode
 - What is the effect of the failure
- What is the benefit >>> Increase Reliability



FMEA Failure Modes and Effects Analysis

- Define the system
 - Identify the functional purpose the system
 - Consider boundaries of analysis
 - Pump
 - Pump, seal water system, motor, etc..



FMEA Failure Modes and Effects Analysis

- Identify critical failure **modes** (O&M manual; O&M personnel)
- Define cause of failure
- Define the **effect** of failure
- How can failure mode be addressed
 - Indicators > Diagnosis



FMEA Failure Modes and Effects Analysis

Centrifugal Pump FMEA Excerpt

Failure
Mode

Vibration at low
flows

Failure
Cause

Operating outside
POR
Closed discharge
valve and no bypass
...
...

Failure
Effect

Cavitation
High discharge
pressure
...
...

FMEA Failure Modes and Effects Analysis

- Outcome of the Analysis: Increase Reliability
 - Accept the effects and use derated equipment
 - Increase preventative maintenance, replacement frequencies
 - Reduce the level of service expectation or change environmental factors that the equipment is exposed to
 - Redundancy
 - Specify extremely robust equipment
 - Redesign/fundamental change





Computer Maintenance Management System

Computerized Maintenance Management System



Standard				Details
Asset Desc	Asset Number	Fault Code	Work Type	Orig Date
RAW SEWAGE PUMP MOTOR #1A	BW-M210811	CAPITAL	Capital Work	6/6/2014
RAW SEWAGE PUMP MOTOR #1A	BW-M210811	DIRTY	PM-Generated	5/26/2015
RAW SEWAGE PUMP MOTOR #1A	BW-M210811	LEAKING	Warranty Work	6/26/2015
BEARING LUBE OIL SYSTEM RSP 1A	BW-ME210111	DIRTY	PM-Generated	1/29/2015
RAW SEWAGE PUMP #1A	BW-P210111	DIRTY	PM-Generated	2/11/2013
RAW SEWAGE PUMP #1A	BW-P210111	ALARMING	Corrective Maintenance	3/28/2013

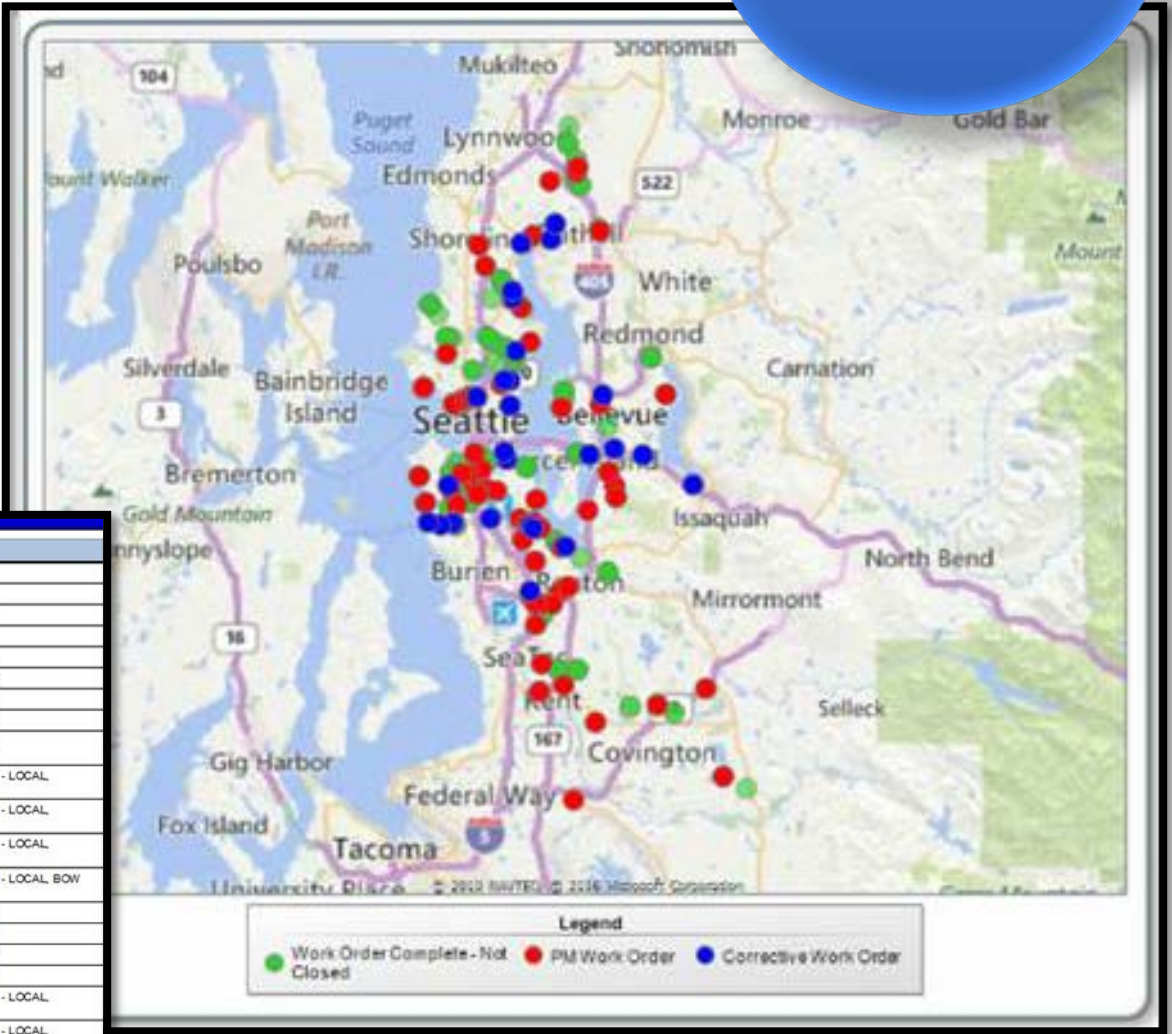
Standard				Details
Asset Desc	Asset Number	Fault Code	Work Type	Orig Date
RAW SEWAGE PUMP #1A	BW-P210111	DIRTY	PM-Generated	6/3/2015
RAW SEWAGE PUMP #1A	BW-P210111	ALARMING	Corrective Maintenance	6/7/2015
RAW SEWAGE PUMP #1A	BW-P210111	DIRTY	PdM-Generated	8/21/2015
RAW SEWAGE PUMP #1A	BW-P210111	DIRTY	PM-Generated	11/10/2015
RAW SEWAGE PUMP #1A	BW-P210111	ALARMING	Corrective Maintenance	12/28/2015
RAW SEWAGE PUMP #1A	BW-P210111	DIRTY	PdM-Generated	1/21/2016

RAW SEWAGE PUMP #1A	BW-P210111	ALARMING	Corrective Maintenance	6/7/2015
RAW SEWAGE PUMP #1A	BW-P210111	DIRTY	PdM-Generated	8/21/2015
RAW SEWAGE PUMP #1A	BW-P210111	DIRTY	PM-Generated	11/10/2015
RAW SEWAGE PUMP #1A	BW-P210111	ALARMING	Corrective Maintenance	12/28/2015
RAW SEWAGE PUMP #1A	BW-P210111	DIRTY	PdM-Generated	1/21/2016
RAW SEWAGE PUMP #1A	BW-P210111	LOSS OF CONTROL	Corrective Maintenance	1/25/2016
RAW SEWAGE PUMP #1A	BW-P210111	ALARMING	Corrective Maintenance	3/14/2016

Looking at the Bigger Picture



- Open workorders
 - List specifics including needed parts
- Prioritize activities
- Efficiency

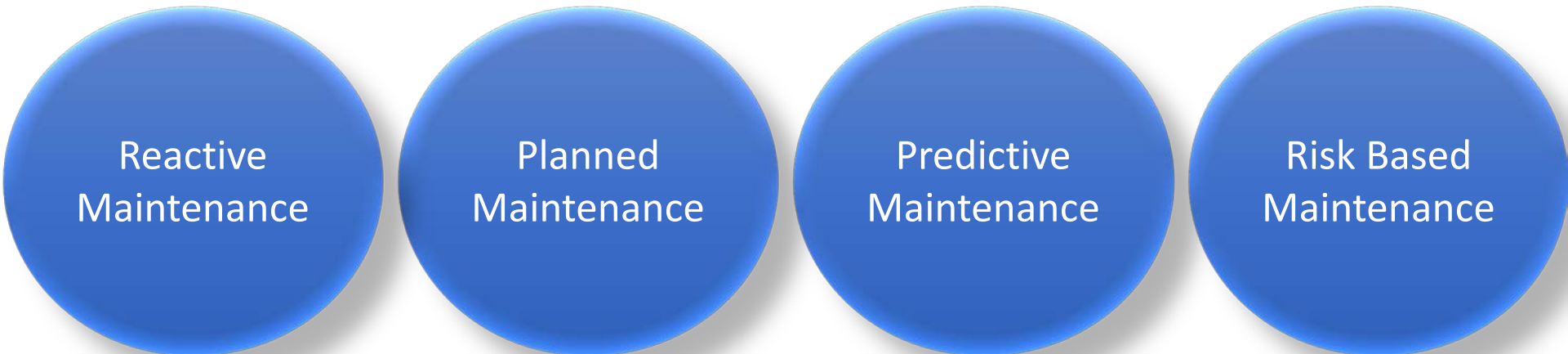


Work Order :	WO Status :	Asset :	Parent :	Asset Short Desc
C784118	PCP	COS037-347	COS037-347	LOGGER, FL800
C784113	PCP	EGATE89A	EGATE89A	LOGGER, ADS 5000-AG
C784212	PCP	HNFORD200	HNFORD200	LOGGER, ADS 5000-AG
C784180	PCP	MCALE004	MCALE004	LOGGER, ADS 5000-AG
C784109	PCP	SEA044A	SEA044A	LOGGER, ADS TRITON+
C784114	PCP	SWW2001	SWW2001	SENSOR, ADS VELOCITY
P873329	IWS	BRINDWN	AE"BEACH-B-05	FLOW MONITORING SITE
P873314	IWS	BARTONPS	AE"BEACH.BARTON	FLOW MONITORING SITE
P873316	IWS	BEACHCSO	AE"BEACH.M-17_AE"BEACH.M-18	FLOW MONITORING SITE
P873312	IWS	ALD048	ALDERWOOD WATER & WASTEWATER DISTRICT	FLOW MONITORING SITE - LOCAL, ALDERWOOD
P873310	IWS	ALD011	ALDERWOOD WATER & WASTEWATER DISTRICT	FLOW MONITORING SITE - LOCAL, ALDERWOOD
P873318	IWS	BEL091	BELLEVUE UTILITY SERVICES	FLOW MONITORING SITE - LOCAL, BELLEVUE
P873327	IWS	BOW LAKE	KING COUNTY SOLID WASTE	FLOW MONITORING SITE - LOCAL, BOW LAKE
P873321	IWS	BLACK114	RE"BLKDA. 114	FLOW MONITORING SITE
P873324	IWS	BLS43B	RE"BYNMAWR.R01-43B	FLOW MONITORING SITE
C783751	IWS	ISSAQ033	RE"FACTOR.R06-04	FLOW MONITORING SITE
C783906	IWS	LKHL5001	RE"LKHILLS.R03-01	FLOW MONITORING SITE
C783910	IWS	COS081-168	SEATTLE PUBLIC UTILITIES	FLOW MONITORING SITE - LOCAL, SEATTLE
C783914	IWS	COS076-301	SEATTLE PUBLIC UTILITIES	FLOW MONITORING SITE - LOCAL, SEATTLE
P873323	IWS	BLS013	SKYWAY WATER & SEWER DISTRICT	FLOW MONITORING SITE - LOCAL, SKYWAY



Maintenance

- *Basic Definition: Maintenance is the work that needs to be done to ensure assets deliver the standard of services that the asset owner requires. Maintenance does not increase the service potential or life of the asset, but rather ensures that the asset provides service for the expected amount of time. (International Infrastructure Management Manual V3.0, 2006)*



Reactive
Maintenance

Planned
Maintenance

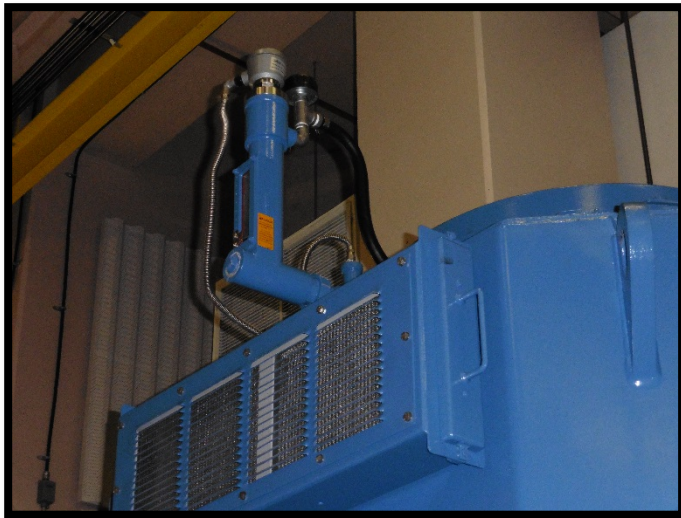
Predictive
Maintenance

Risk Based
Maintenance

Maintenance Strategies

Planned Maintenance

- Basic Definition: *Planned, or proactive, maintenance is work undertaken to reduce the probability of asset failure to an acceptable level of risk. (International Infrastructure Management Manual V3.0, 2006)*
- (PM) Preventative Maintenance
- Servicing
- PDM – Predictive Maintenance



Maintenance Strategies

- Servicing
 - Replenish consumables
 - Oil
 - Cleaning / remove fouling
 - Flush

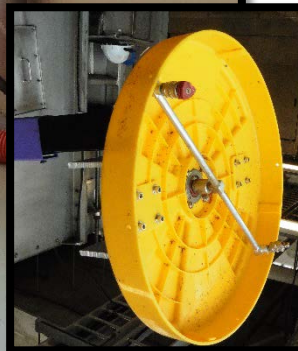
Planned
Maintenance



Planned
Maintenance

Maintenance Strategies

- Servicing of 2mm band screens



Planned
Maintenance

Maintenance Strategies

- Excessive servicing leading to capital improvement



Maintenance Strategies

- Spare parts
- Inventory
- Lead time to get parts

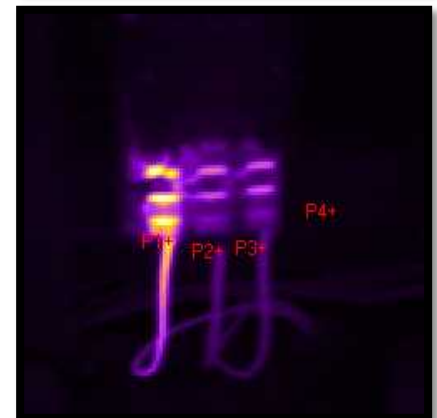
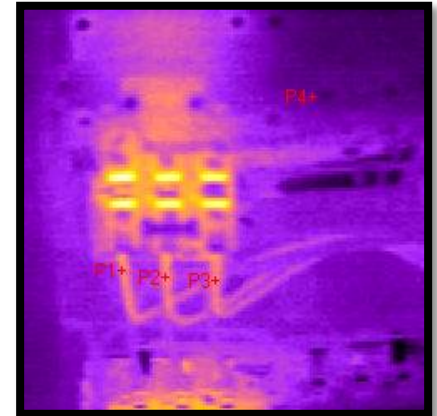
Planned
Maintenance



Maintenance Strategies

- Goal: Predict when failure may occur, and then do something to prevent failure.
- Minimize
 - Preventative Maintenance
 - Equipment downtime
 - Resources (Time, Spare Parts inventory, supplies)

Predictive
Maintenance



Predictive Maintenance

Maintenance Strategies

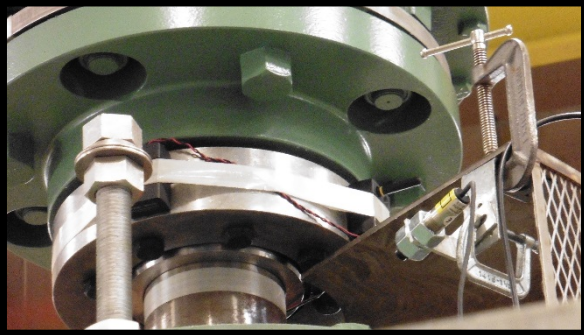
- Condition Assessment
 - Inspection / Testing
 - Can trigger preventative or corrective maintenance
- Examples
 - Vibration monitoring
 - Thermal scanning
 - Sonic (hear arcing, sparks, operation at low flows)
 - Oil analysis
- Can be expensive
 - Specialized equipment
 - Specialized expertise



Maintenance Strategies

Vibration Monitoring

Predictive
Maintenance



Reactive Maintenance

Maintenance Strategies

- Run to failure
- Repair
- Modify
- Replace
- Non-critical assets
- Redundancy
- Note: *Planned maintenance can never be completely effective. Some items will still fail before the preventative task is due to be performed due to inaccuracies in predicting the rate of deterioration nor the occurrence of **random failures** not associated with the identified deterioration pattern.*
(International Infrastructure Management Manual V3.0, 2006)



Event during construction, limited impact

Maintenance Strategies

Risk Based Maintenance

- Prioritize maintenance resources on the assets that pose the greatest risk of failure.
- Risk assessment (consequence * probability)
- Mitigation = Maintenance Strategy (to reduce probability of failure)
- Re-assess risk



Maintenance Strategies



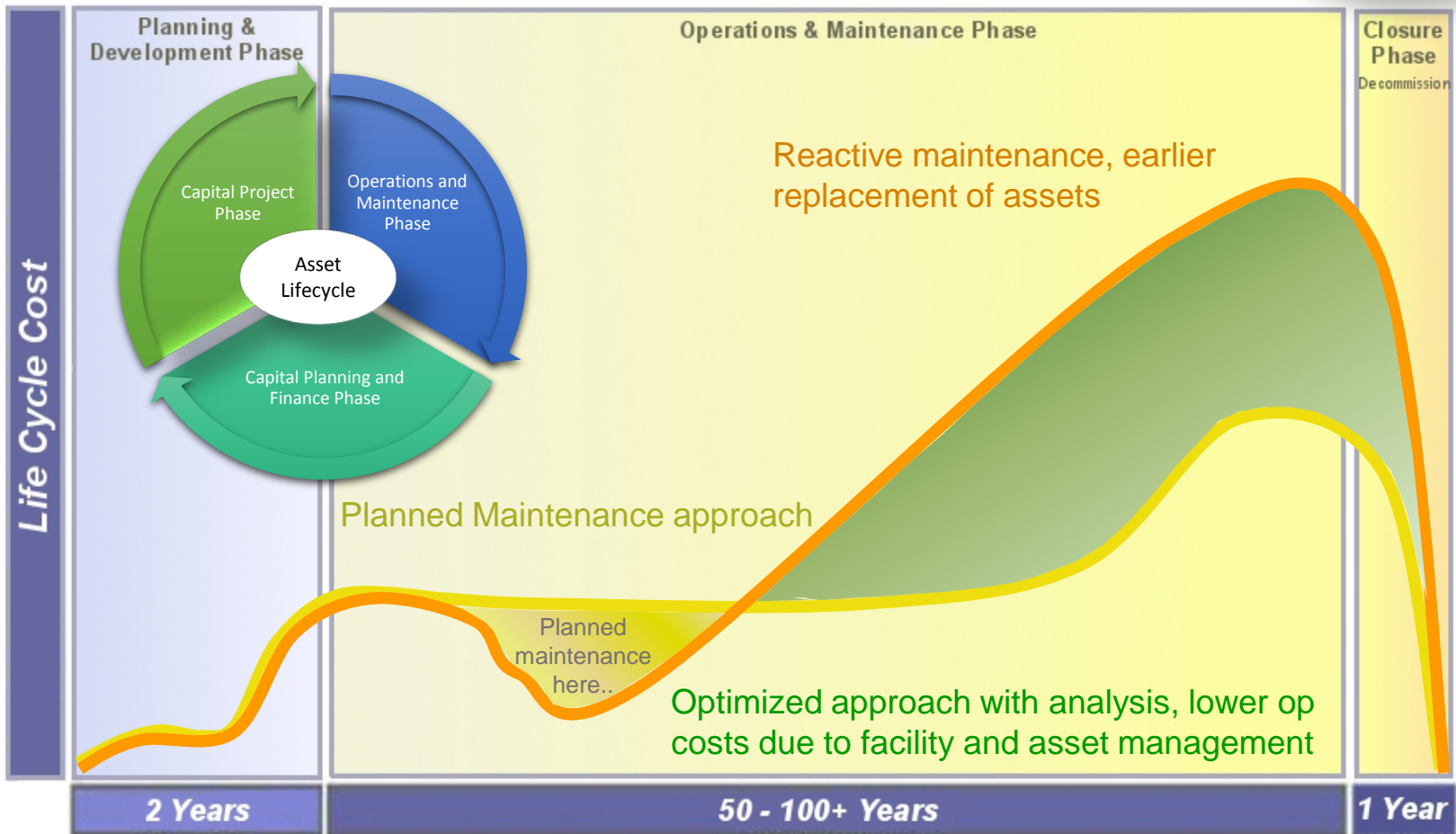
- Green = accept (Servicing, Reactive Maintenance)
- Yellow = monitor (Servicing, Reactive Maintenance, Inspection)
- Orange = mitigate (Servicing, Reactive Maintenance, Inspection)
- Red = mitigate (Servicing, Reactive Maintenance, Inspection Predictive Maintenance)

			Consequence of Failure (COF) Impact Rating				
			1	2	3	4	5
			Minor impact		Major impact (e.g. NPDES violation)		
Likelihood of Failure (LOF) Rating	1	Proven / highly reliable	1	2	3	4	5
	2		2	4	6	8	10
	3		3	6	9	12	15
	4		4	8	12	16	20
	5	Unproven / highly unreliable	5	10	15	20	25

Asset Lifecycle

Maintenance Strategies

Analysis by type of approach: Typical and optimal



Balanced Performance



OEE – Overall Equipment Efficiency



Availability



Performance



Quality

$$\text{Overall Equipment Efficiency} = \text{Availability} * \text{Performance} * \text{Quality}$$

OEE – Overall Equipment Efficiency



Availability

EVENTS THAT IMPACT AVAILABILITY:

Breakdowns, Machine idle time, stoppages

POTENTIAL ACTIONS TO TAKE:

Preventative Maintenance, training and knowledge transfer, Spare Parts strategy

Overall Equipment Efficiency = Availability * Performance * Quality

OEE – Overall Equipment Efficiency

EVENTS THAT IMPACT PERFORMANCE:

Poorly operating, higher use of consumables (e.g.oil), older eqpt/end of life cycle

POTENTIAL ACTIONS TO TAKE:

equipment rebuild, replacements, increase preventative maintenance, increase servicing



Performance

$$\text{Overall Equipment Efficiency} = \text{Availability} * \text{Performance} * \text{Quality}$$

OEE – Overall Equipment Efficiency

EVENTS THAT IMPACT QUALITY:

misalignment, influent change,
inconsistent raw
materials/consumables

POTENTIAL ACTIONS TO TAKE:

improve quality of raw
materials/consumables, adjust process
to deal with changes of consumables



Quality

Overall Equipment Efficiency = Availability * Performance * Quality

OEE – Overall Equipment Efficiency



Availability



Performance



Quality

$$\text{Overall Equipment Efficiency} = \text{Availability} * \text{Performance} * \text{Quality}$$

Metrics / Key Performance Indicators (KPIs)

Examples:



Complaints/violations



Equipment downtime



Spare parts inventory



Redundancy



Preventative maintenance



Predictive maintenance

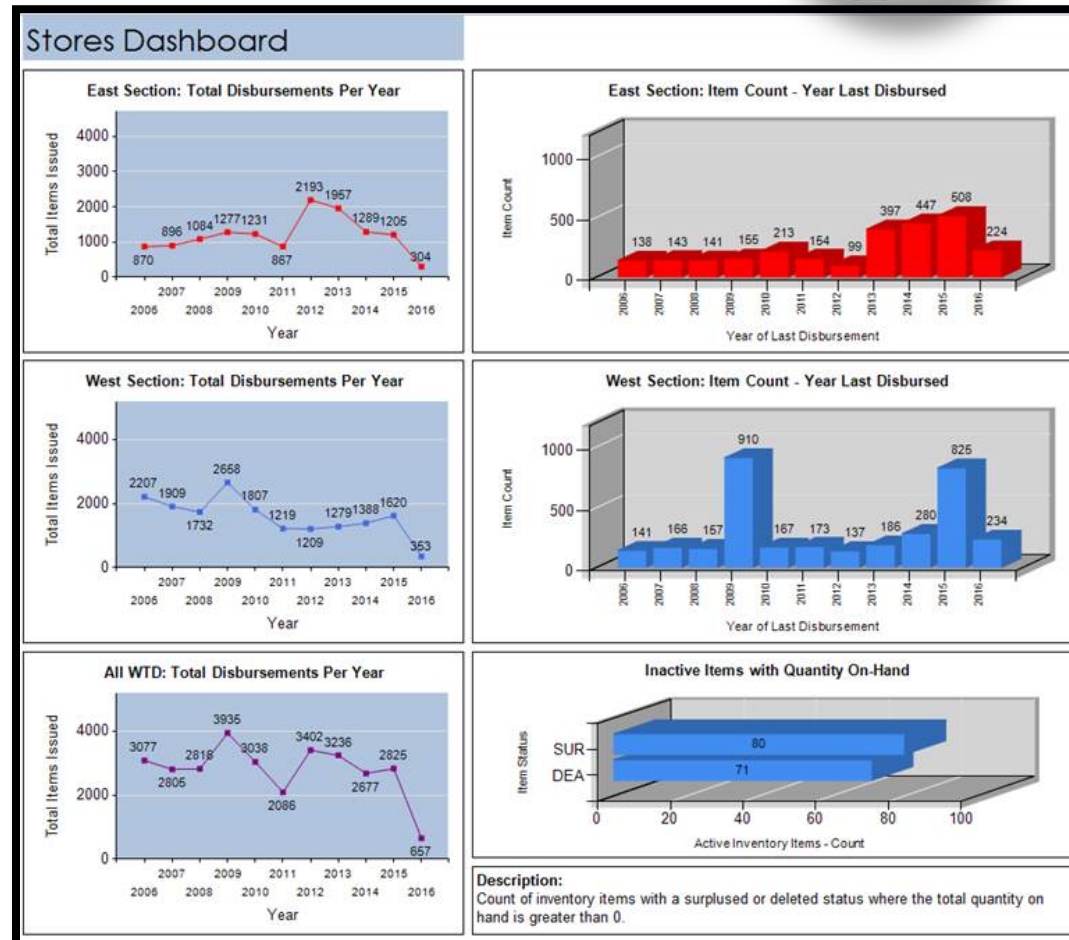


Reactive maintenance



Dashboard

- Measure the outcome of what you're doing
- Is it what you expect
- Metrics / Key Performance Indicators (KPIs)
 - Complaints/violations
 - Equipment downtime
 - Spare parts inventory
 - Preventative maintenance
 - Predictive maintenance
 - Reactive maintenance
- Do not manage to the KPI

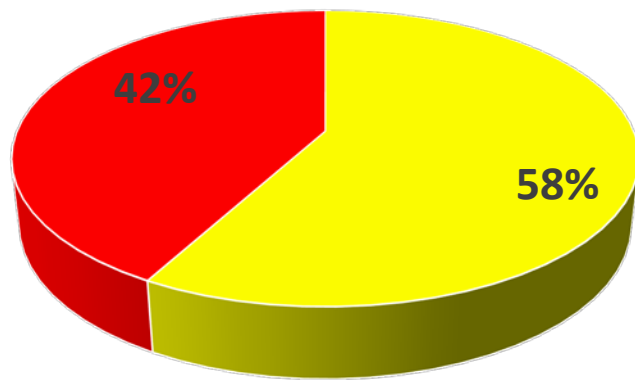


Dashboard: Spare Parts Inventory

- Spare Parts Inventory
- Deal with emergencies and common repairs
- Long lead items
- Well organized

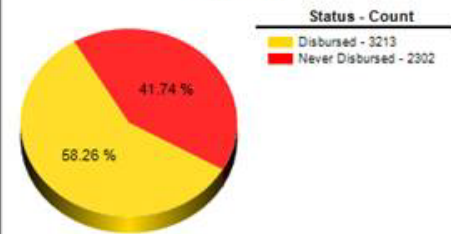


Spare Parts Inventory - Total

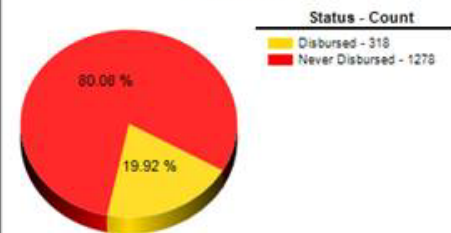


■ Dispersed ■ Never Dispersed

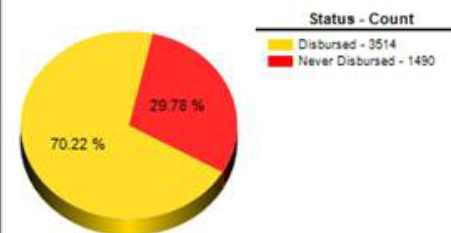
South Plant: Active Items - Lifetime Disbursements

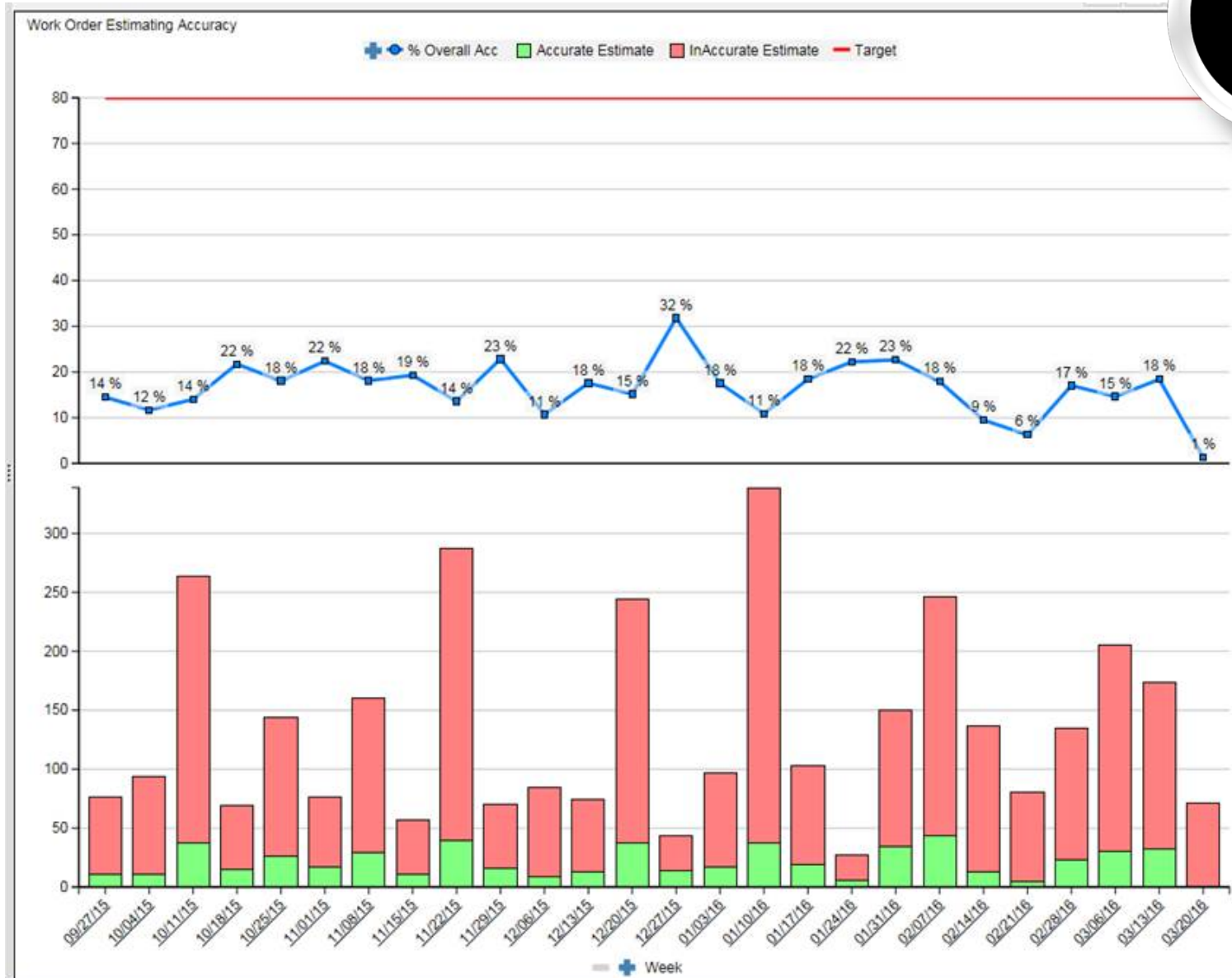


Brightwater: Active Items - Lifetime Disbursements



West Point: Active Items - Lifetime Disbursements





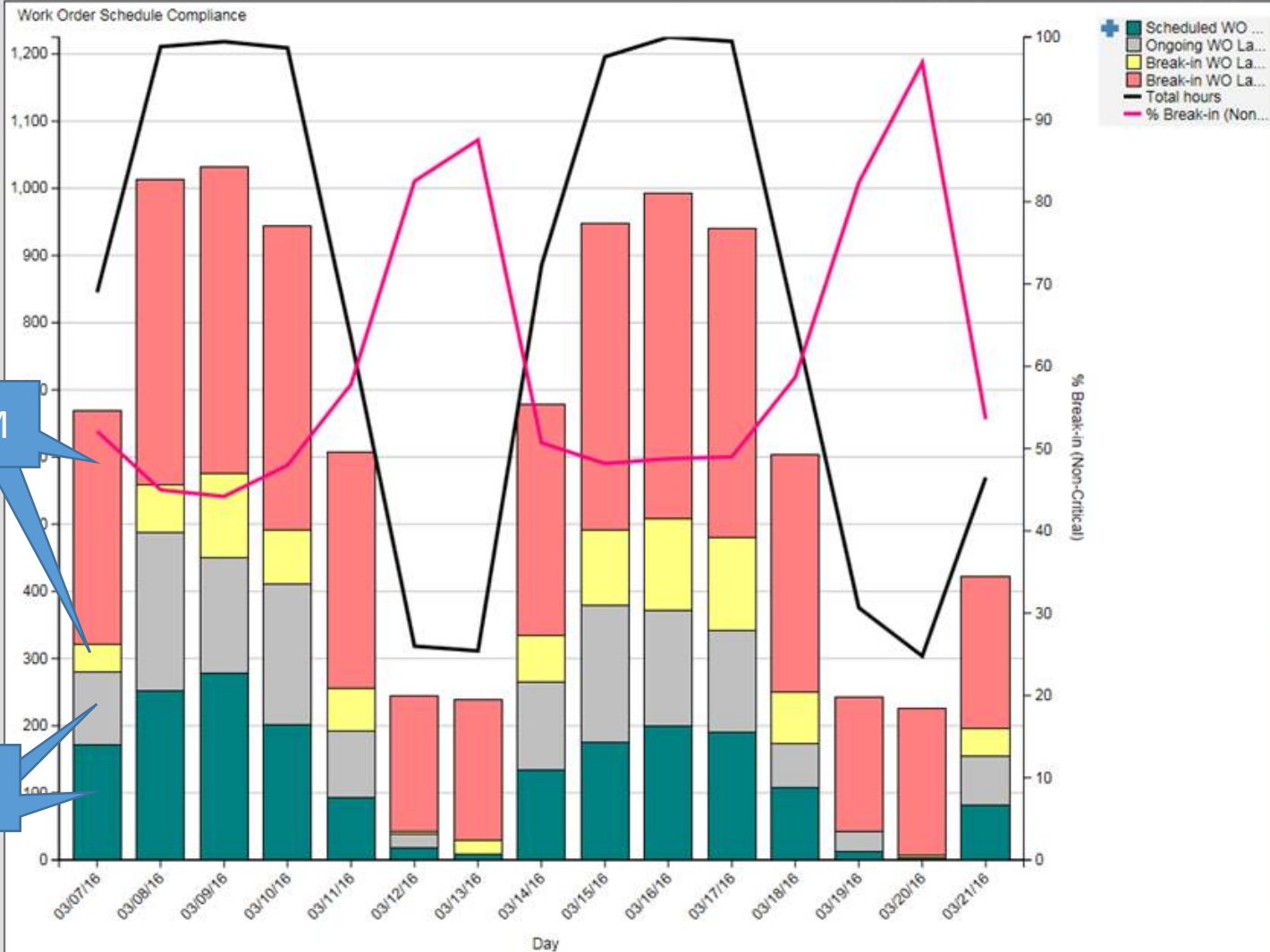


Schedule Compliance Time Card Analysis Pending WR Daily_Schedule

Daily Labor Breakdown for Scheduled or Unscheduled Labor Hours

Days

3/7/2016 - 3/21/2016



RM

PM



MBP Reports Report Export Print Options Search Admin Help

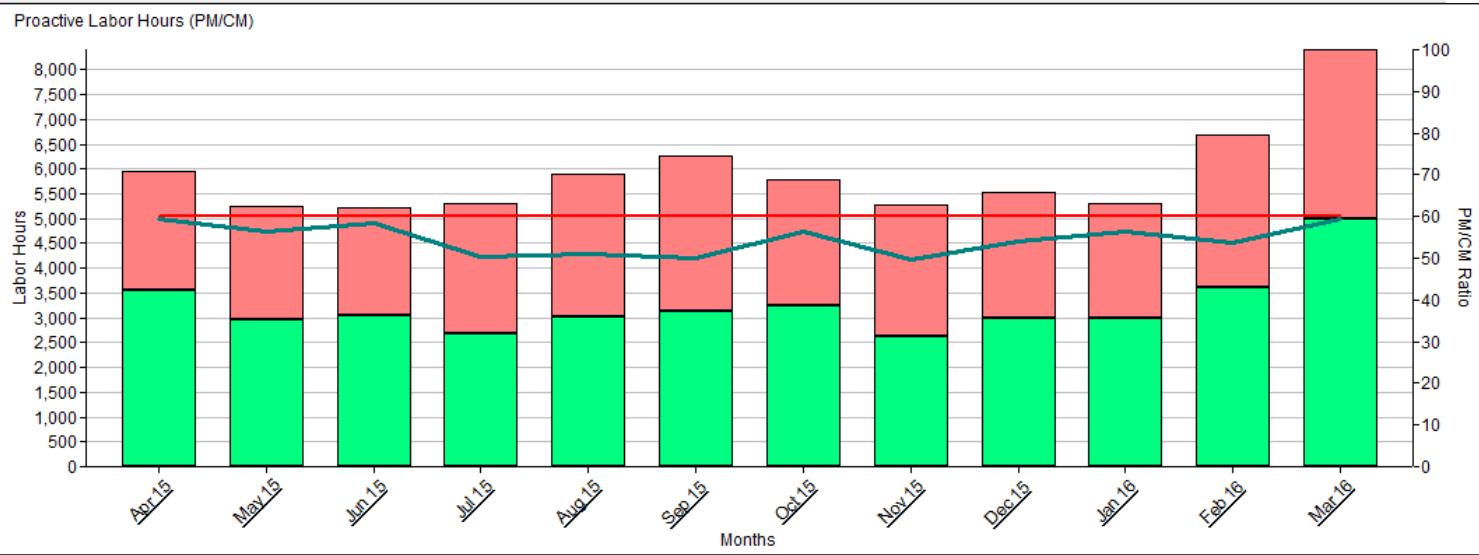
Strategic KPIs Reliability Asset Condition Work Execution Supplemental Daily Summary Monthly Dashboard

Proactive Maintenance Time Analysis

Apr 15 - Mar 16 Indicators Filter Group By All Worktype Chart Grid Transposed Settings Favorites Comments...

■ Proactive Labor Hours
■ Reactive Labor Hours
— % Proactive
— %Proactive Target (60)

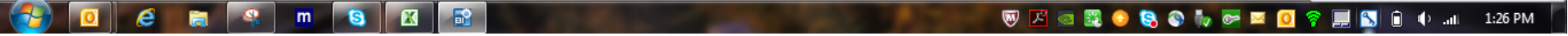
■ Proactive Labor Hours
■ Reactive Labor Hours
— % Proactive
— %Proactive Target (60)



Parent - Craft	RN
Time Window	Apr 2015 - Mar 2016
Time Cards	Proactive Labor Hours; Reactive Labor Hours
Formulas	% Proactive (Right)
KPI's	%Proactive Target (60) (Right)
Group By	Months

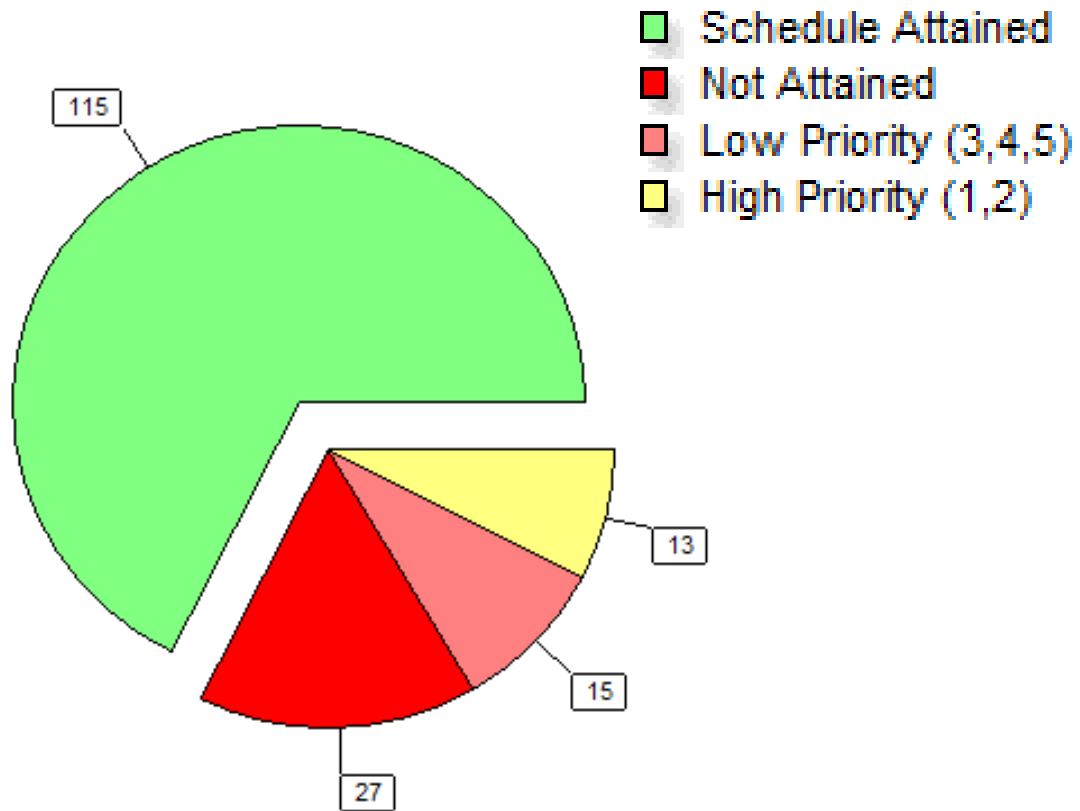
♥ Changed Morning Meeting and General Checklists to "TASK" Worktypes instead of "PM" Worktypes

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Scheduled Maintenance



Questions

