Refinery Maintenance: Achieving a Zen State by Leveraging 'Lean Thinking'

Effective maintenance is the key to success in any process industrial plant-- making money requires keeping machines humming while maximizing product production. Maintenance is often the single largest cost for process plants and doing it well can enable the transformation to a "reliability centered" organization with exceptional performance. Reliability-centered maintenance programs lower costs, improve consistency & machine uptime and provide organizations with greater insight into risk management.

Situation:
The Familiar "Death Spiral" of a Process Plant

KPI	2015	2017
Reliability	High	High
Throughput	212 work orders per week	311 work orders per week
Lead Time	300 Days for Priority 2 work orders	37 Days for Priority 2 work orders
	184 Days for all work orders	40 Days for all work orders
Resources	400+	130
Backlog	11,700	4,075
Productivity	0.53 Work Orders Completed / Resource	2.39 Work Orders Completed / Resource

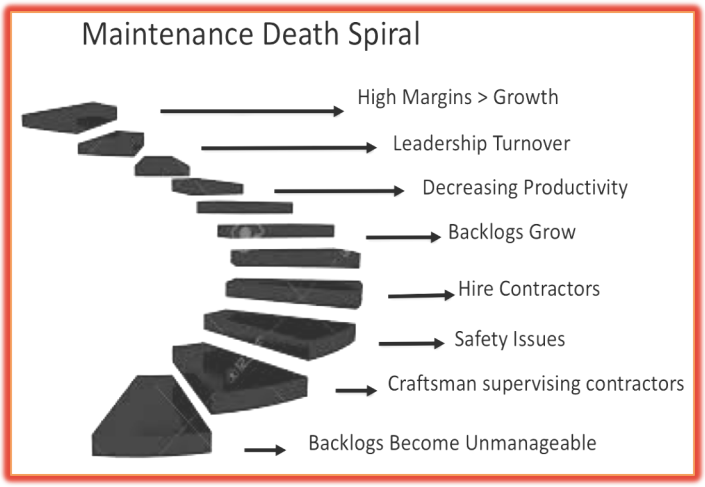
Often initiated by a shock like a decline in margins or rising input prices, process plants can easily drift into a "death spiral" (also known as the "capability trap")[1].

For this client, the death spiral was triggered by admirable goals. The client, experiencing high margins, established project teams staffed with top talent to lead a growth initiative. Moving people out of the maintenance organization to join project teams created a leadership vacuum. Soon, backlogs began to grow, creating additional needs that could only be met with contractors.

Safety problems began to surface. To ensure work was being conducted safely, stricter rules and procedures and more contractor oversight (by experienced maintenance personnel) were put into place. While these countermeasures helped address the safety issues, they pulled additional site resources away from maintenance and the backlog stacked even higher – a vicious circle.

By May 2015, work orders in the system at the plant grew to a staggering 11,700, representing 58,000 craft hours of ready work. The plant ranks work orders on a scale of one to four, with Priority 1 tagged as emergency work and Priority 4 deemed least important. At this juncture, the cycle time – the time from entry of work order to work completed and verified – for Priority 2 was more than a year. Not only was work progress drastically reduced, but the site needed the support of 400 contractors embedded into the maintenance organization.

[1] See http://web.mit.edu/nelsonr/www/Repenning=Sterman_CMR_su01_.pdf



Maintenance Manager Perspective:

"Pull enabled our craftsman to utilize their skills within their capabilities to go out and get things done!

From a team perspective, it broke down walls between Operations and Maintenance and I am getting the most positive feedback from my customers in 20 years."

Approach:

Implement Lean Concepts

The plant brought in ARGO Consulting to help understand and improve performance. To use lean concepts the plant began applying 5S to the maintenance shops. Lean concepts and tools were introduced through multiple "Lean Boot Camps" where the leadership taught the concepts of 5S, Smooth Flow, Zero Defects Pass to The Next Step, Visual Management, TIMWOODS waste elimination, the benefits of low WIP (Work in Progress), and other concepts.

By March 2017, the team was ready to revisit its basic system for managing maintenance work. The maintenance process is shown in Figure 1:

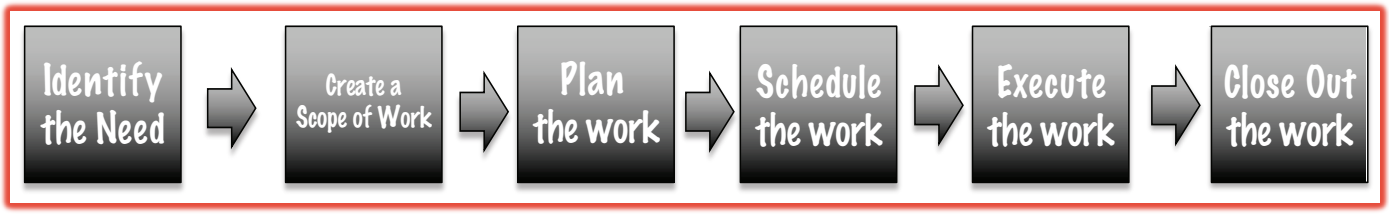


Figure 2: Maintenance Work Flow Process

Like most work processes, maintenance was initially set up as a 'Push' system. There was no capacity constraint on the system. As a result, operations personnel would push work to scoping, which would then push work to planning, who would then push work to scheduling, which would only then try to schedule.

Figure 3: Push to Pull Vision from Leadership

As with any push system, a hiccup in the flow caused the work to "stack up" in front of that step, creating WIP (Work in Process). When the front-end of the system can push at a faster rate that the field can execute, WIP builds with predictable consequences. As WIP builds, priorities become less clear and cycle times stretch out. As cycle times extend, well intentioned mechanics and technicians start spending valuable time reprioritizing work in the hope of doing the most important jobs first. As reprioritization grows, the ability to focus and progress work declines, ultimately resulting in an inefficient system. The growth in WIP was further exacerbated as it became easier to enter a new work order than to find an existing work order in the computer system.

Operations Manager:

"I am getting more work done for 30% less cost. My backlog and average work have dropped by 40% by changing the way we work without having to add resources."

Reliability Center Coordinator:

"The new Pull workflow helps improve work order prioritization, expedite planning/scheduling, and reduce maintenance spending. Prior to pull workflow, the RCC's and planners spent time scoping and planning as many work orders as possible, which generated a distracting RDY backlog of lower priority work orders that prevented timely execution of the RC's top priorities."

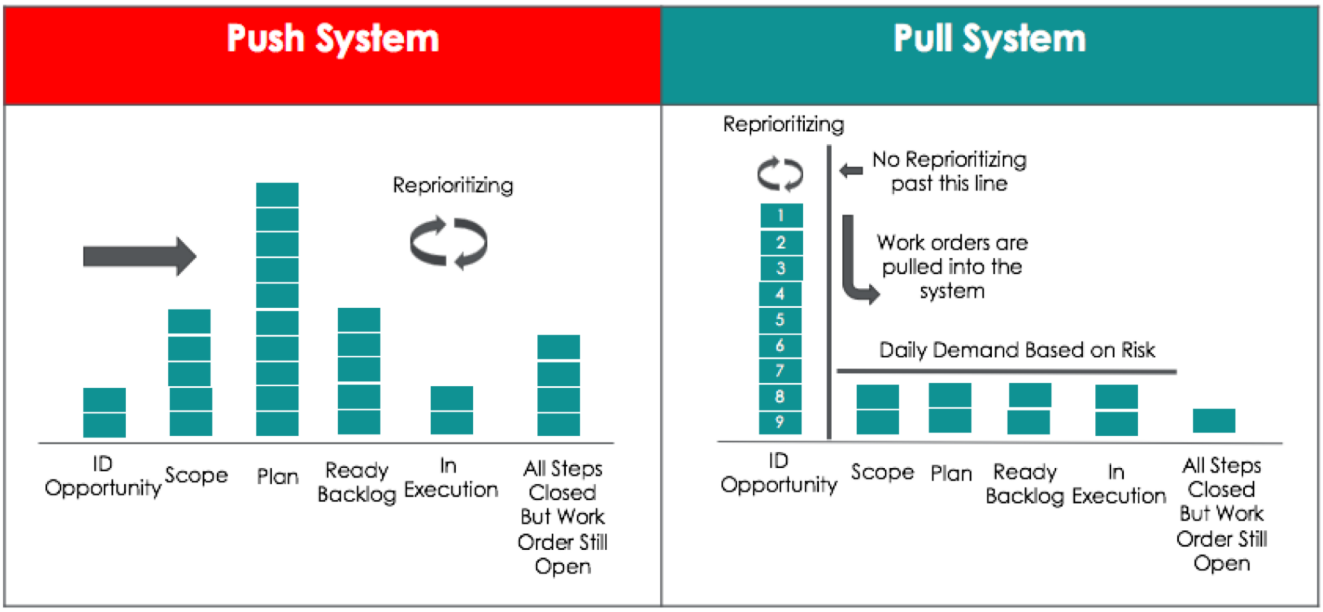
Leadership Challenge: Transition to "Pull" and Cut WIP by 40%!

Recognizing the problems with their existing approach, the site leadership set out two goals for the maintenance process in 2017:
Transition to using "Pull" in the maintenance process.
Cut WIP in the work order system by 40%.

While the pull concept has been applied in the manufacturing of discrete products as one aspect of the application of Just in Time (JIT) manufacturing, it required a few modifications for use off the shop floor. Most significantly, "pull' works in a factory by providing simply visual cues to allocating effort– if my "pull" box is empty I work, if it's full I move to another area. Non-production work like maintenance is more difficult to manage because you can't easily see the amount of WIP. To adapt "pull" for maintenance, the team created a simple method for visualizing the maintenance process. Using some open wall space in the break room, they created a series of "boards," with each one representing a key step in the maintenance process (see figure 1).

Maintenance jobs then went on Post-It notes so that the team could see them "moving" through the system. A simple color scheme was used to capture jobs that were falling behind or otherwise stuck. With this system in place, anybody could assess the state of the maintenance system in just a few minutes.

This transition to "Pull" was piloted in two of seven operating areas. In a maintenance system, operations is the customer. A work order represents a "purchase order" to be filled, and the closing and execution of the maintenance work represents the "product delivered" to the customer.

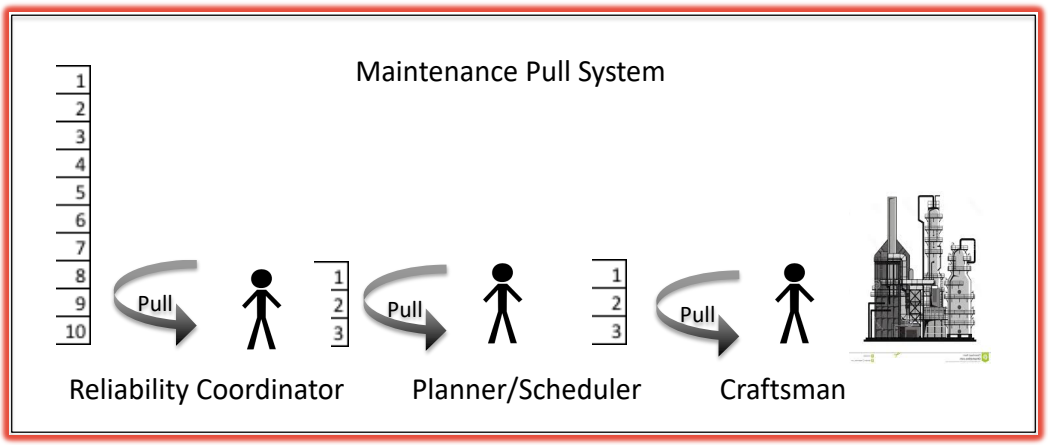


Implementing a "pull" system also required changing the rules. The customer or operations can continue to prioritize the work, however, they can't "push" work into the maintenance organization. Operations can only make a particular work order the top priority and wait for the maintenance to "pull" it into their system.

Work in progress limits were established for each step in the process so that the next step in the maintenance process could only 'pull' the work if it had an open slot within their work process. Once work entered the system, it could not be reprioritized, thus allowing the maintenance organization to focus, and move work through the system.

A common challenge when making this transition is figuring out how to get all of the existing WIP out of the system. Do you curtail the front-end? Expand the back-end? Cancel work? The answer is "all of the above."

Figure 4: Maintenance Pull System after implementation.



The team had "backlog clean-up parties" prior to transitioning to pull. Cross- functional groups acted to close work that had already been done, closed work orders that were no longer needed, and unstuck work orders that were waiting on management decisions. Leadership made themselves available to make the risk call when a work order was in the system that required them to give a thumbs-up or thumbs-down call.

Operations pulls work orders from queue that they will be ready to support.	Maintenance leaders pull critical must do work and fill in with work they can do (easy PM's and related work) to meet customer demand.
	

Plant wide Operations and Maintenance pulling work orders the day before to coordinate what maintenance WILL be completed tomorrow. 27% Increase in productivity by enabling supervisors to lead.

Results:

The results were astounding. As a benchmark, in May of 2015, the average **cycle time** for a priority 2 work order was 300 days, almost a year! The average cycle time in November of 2017 for a priority 2 work order was 37 days. New Priority 2 work orders average 10 days.

Throughput: In the spring of 2015, only 212 work orders were getting completed each week versus 328 work orders getting entered and approved. They were losing ground to the backlog each week. Today they are completing 311 work orders versus their current target of 250 per week.

Backlog: The backlog has gone from 11,700 work orders in May of 2015 to 4,075 in July of 2017.

Productivity: Productivity has increased by 300% by eliminating the waste, sharing resources, and reversing the death spiral.

Resources: In May of 2015 there were 400 contractors supporting the base maintenance organization. By November 2017, that number had dropped to less than 140.

People: The best part was the individuals in the organization were in the drivers seat-they designed and implemented the changes with coaching provided by ARGO. "Pull" takes the noise out of a system and allows people to focus. Because you "pull" work to you, you have more autonomy, and control of your own destiny. This feeling of "being in control" and able to contribute brings about a sense of fulfillment.

Summary:

In short, applying lean concepts, and specifically "Pull" don't "Push" allowed this processing plant to dramatically lower backlog, cycle time and costs, while reducing risk and improved fulfillment - simultaneously. So, remember, for lean maintenance success, "Pull" don't "Push."

About the authors:

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