Click the video link below for an overview on the Maintenance Strategies Digital Report from Plant Engineering, Content Manager, Bob Vavra.

We talk a lot about the great new technologies in manufacturing—Industrial Internet of Things, Big Data, and collaborative manufacturing. At the end of the day, they all depend on one thing that has been around since Plant Engineering was launched almost 70 years ago – maintenance.

Plant maintenance is the offensive lineman of manufacturing – you never talk much about it until something goes wrong. And like the offensive line, your maintenance team is the foundation for your success. If it breaks down, you’re not going to succeed.

Everybody does maintenance of one kind of another, but great maintenance requires a real strategic approach.

Strategic maintenance means understanding all the parts of your plant, understand what needs attention and when, and above all, how to make sure you take the machine down for maintenance on YOUR time, rather then when the machine wants to take itself down. When a machine breaks, it almost always is expensive and wasteful, and can be dangerous as well.

That’s why a great deal of the focus of the Industrial Internet of Things, Big Data, and collaborative manufacturing revolves around maintenance. It’s why, more than ever, a sound maintenance strategy is important. As you see in Plant Engineering’s report, it requires time and effort, but it will pay off in the end.

Please enjoy this important digital report on Maintenance Strategies.
Manufacturers worldwide know that Lean maintenance practices cut costs and improve production by minimizing downtime. But the reality is that for many U.S. manufacturers, up to 90% of the maintenance they perform is conducted on a reactive rather than proactive basis. Some blame the age of their equipment, the absence of spare parts and the rapid pace of manufacturing.

But it is possible to implement production maintenance best practices, and doing so will save time and money while increasing production in the long run. Here are 10 steps you can follow to establish Lean maintenance best practices at your manufacturing operation:

**STEP 1: Gather data and calculate downtime costs.**
Before you can successfully transition to maintenance best practices, you’ll need to gather data to identify the scale of the challenge. Assemble information on machine downtime, meantime between machine failures, expenditures on parts, technology usage, technician response time and the percentage of on-time deliveries. This will enable you to calculate the average cost of one hour of downtime.

**STEP 2: Determine the dollar value of maintenance.**
With an average per-hour downtime cost estimate in hand, you can project how much money maintenance improvements would save. You can make reasonable assumptions by applying the per-hour cost of downtime to machine availability, determining how much value an increase in availability will add to the organization. You’ll likely find that even a small increase, such as 5%, translates into a huge improvement.

**STEP 3: Analyze operational variables.**
When determining projected productivity increases resulting from improved machine availability, it’s also important to factor in the savings your maintenance operation can realize.
by addressing operational variables. For example, take a look at how a better plan to handle critical spares, introduction of a work order system and faster technician response time could impact availability.

**STEP 4: Invest in a technology solution.**
As you’ll see in step 3, controlling variables adds significant value, and a technology solution can make it easy to improve the handling of variables across the board. A Computerized Maintenance Monitoring System (CMMS) provides work order information and improves technician response time, also lowering the mean time to repair and reducing downtime overall.

**STEP 5: Start scheduling preventive maintenance.**
With a CMMS that enables you to process work orders, you can easily monitor all manufacturing assets in your operation and track critical parts and spares. This means you’re ready to schedule preventive maintenance and generate checklists to manage maintenance tasks.

**STEP 6: Deploy a scheduler planning function.**
As you transition from reactive maintenance to a more proactive stance, you’ll need to schedule technicians’ time for preventive maintenance and ensure that the right parts are available when needed. A scheduler planning function is a critical tool for reducing downtime and maximizing the value of preventive maintenance.

**STEP 7: Introduce predictive tools.**
Preventive maintenance reduces downtime, and a predictive maintenance checklist can improve machine availability even more. The type of predictive tools you’ll need will depend on the equipment your team maintains. Electrical equipment can be hampered by overheating, so a thermography tool
can prevent trouble before it results in downtime. Rotating equipment requires vibration analysis, and aircraft need ultrasound scanning for leaks.

**STEP 8: Move toward Total Productive Maintenance (TPM).**
After the predictive maintenance plan is in place, the next step is to get operators involved in TPM. To leverage operators’ familiarity with manufacturing assets, find simple solutions that enlist operators in maintenance, such as keeping assets clean and freshly painted to aid in visual inspection or installing sight gauges that enable operators to monitor fluid levels.

**STEP 9: Implement a Reliability Centered Maintenance (RCM) strategy.**
Once you have practices, technology and monitoring tools in place, you can begin practicing RCM to drive downtime to even lower levels. With a clearer view of machine capabilities and status, you no longer have to take equipment offline for preventive maintenance until your data indicates imminent failure. You can maximize value with a cost-benefit analysis of maintenance vs. productivity needs.

**STEP 10: Bring in third-party technicians as needed.**
Achieving world-class maintenance involves a cultural transformation, and with a shortage of skilled technicians, it may be necessary to bring in third-party resources to establish metrics and define processes. If you are looking outside your company to achieve the cultural shift you require, make sure you get references from existing customers to ensure the right fit with your organization.

Deploying Lean maintenance practices takes analysis, planning and skill. Above all, it requires a commitment to move from a reactive to a proactive state of mind. By following these 10 steps, you can implement world-class maintenance practices at your manufacturing operation and significantly improve productivity.

*Jeff Owens is president of Advanced Technology Services (ATS), www.advancedtech.com.*
As a maintenance planning and scheduling professional, I am often asked how to schedule maintenance activities when production is 24/7 or 24/6. An important question is whether the 24/7 operation is driven in part by a lack of reliability or if the organization is proactive and actually capacity constrained. In either case, the challenge is finding windows for work with the equipment stopped or shutdown.

What I often find are the following opportunities:

1. **FAILURE TO IDENTIFY SMALLER WINDOWS FOR WORK SUCH AS PRODUCT FLAVOR OR SIZE CHANGES.**
   In these cases, the sections of process are shut down for allergen cleaning, clean-in-place processes, or physical product size change as examples. These are often difficult to schedule since operations is running a lot size or specific amount of production. Depending on how they run, they may shorten or extend beyond the anticipated time of the downtime window. To do the work requires a level of resource scheduling flexibility.

2. **GIVE WORK TO OPERATORS.**
   Following on the item above, when flavor changes or cleaning occur, we find maintenance technicians performing operations tasks that should be performed by trained operators. This in turn frees up the maintenance personnel to do maintenance during those windows. This item and the one above are reflections of the item below.

3. **LACK OF PARTNERSHIP BETWEEN THE OPERATIONS AND MAINTENANCE GROUP.**
   I like to say that operations should own the equipment and maintenance owns the capacity of the equipment. If operations expects to meet their requirements with any level of reliability, then maintenance must be allowed time to ensure that capacity. In a true partnership, operations should do everything possible to meet their production schedule downtime windows so that maintenance can
do the work. Operations personnel also have to operate the equipment properly based on standardized work practices. Without the partnership, operations and maintenance are often working with different goals and measures.

4. GET THE WORK DONE RIGHT.
The maintenance function has the responsibility to ensure the work they do is to a specification or with precision. Shame on us if we work on an asset and once returned to operations, it fails shortly after being placed back into service because of a behavior. We also have the responsibility to do the work in the most efficient and effective manner possible which means properly planned and scheduled, with realistic durations, parts kitted, and the resources standing there at the machine to do the work when it goes down.

5. MAKE RESOURCES AVAILABLE.
In the case of a 24/6 window, I often find that ample maintenance resources are not available for scheduling on the down day simply due to shift schedules. It’s not unusual to see maintenance working 10-hour shifts Monday thru Thursday and then have overtime required to get them in for work on Saturday and Sunday. While I realize that everyone wants to be home on Saturday and Sunday with the family when they are not in school and so on, unfortunately the maintenance job really requires a different schedule. The challenge for the organization is to provide for the business needs and maintain a work/life balance for the employees.

6. THE RIGHT FOCUS ON PREVENTIVE MAINTENANCE (PM).
In addition, maintenance has the obligation to ensure that we don’t take down the equipment unnecessarily for PM work. More than 40% of the PM tasks performed add no value and fail to address any likely failure modes of the assets. The majority of PM tasks should be inspections, looking to find the equipment in the act of failing, not failed.
7. IDENTIFY FAILURE.
Everyone—engineering, maintenance, operations, and quality—has the responsibility to identify what indicates failure. In many cases, we are shutting down equipment to look for potential failures (the P on the P-F Curve) or failures (the F), when other techniques could determine the potential for failure without shutting the asset down. In addition to predictive technologies such as vibration and infrared analysis, include SCADA system parameters like flow, pressure, temperature, and statistical process charts from the Quality group. Don’t forget about the human senses either. There are many more people qualified to use those senses than people qualified to do vibration analysis. The senses include feeling temperature differences, hearing noise, and detecting vibrations as examples.

8. ACT, DON’T REACT.
In a number of cases where the operation is 24/7, we find high levels of reactivity driven by the need to make production targets which in turn drives lack of access for maintenance. In those situations, we find the maintenance personnel literally waiting on the next reactive failure. If that is the case, shame on us. There are so many opportunities for improvement (defect elimination, PM optimization, parts kitting, CMMS Bill of Material improvement, and lower priority maintenance work such as rebuilds). The challenge we have is to use all of the labor effectively and that means everyone gets scheduled work. This is why I prefer to break out planned work into different levels within the Priority system (high, medium, and low).

9. DON’T DEFER PM TASKS.
When a downtime window appears, there is often temptation to schedule corrective and project work, while deferring proactive PM tasks. While you may get away with this for a short period, it will come back to bite you in the rear end. It’s the PM tasks that prevent the reactive cycle of chaos. This is assuming that we are doing the right work from a PM perspective, referring back to Items 6 and 7 above.
10. FAILURE TO TAKE ADVANTAGE OF UNPLANNED DOWNTIME FOR PROACTIVE WORK.
When a line or process suddenly stops, there should be schedule ready work (planned, parts kitted, only waiting for downtime and the resources to do the work). It should be the responsibility of the maintenance Supervisor to have a schedule ready job listing literally in their back pocket. When downtime appears, send a couple of responders if required, and then, focus the rest of the group on those schedule ready jobs of less or equal duration.

11. MANAGE THE BACKLOG.
With a very limited opportunity to perform maintenance work, there has to be a laser focus on the actual work to be planned and scheduled. Therefore, trim the backlog of non-essential “nice to haves” that may end up diverting the resources into less important activities given the critical nature of the downtime windows.

12. LACK OF EFFECTIVE COORDINATION BETWEEN THE CRAFTS.
Rather than maintenance planning and scheduling, people should view it was maintenance planning, scheduling, and coordination. With short windows to work, it’s critical that the work be well coordinated to ensure effective execution. Think about scaffolding, insulation, mechanical, electrical, painting, and so on.

These 12 items are some of the most common opportunities that I see in planning, scheduling, and coordinating organizations that operate on a 24/7 or 24/6 schedule. Mahatma Gandhi said “The future depends on what you do today.” In the end, the challenge is look beyond the normal approaches for the opportunity to optimize and perform maintenance work. What can you anticipate?

Jeff Shiver CMRP, CPMM, CRL is a certified RCM2 Practitioner with The Aladon Network and Managing Principal with People and Processes, Inc.
More than ever, manufacturers must focus on establishing preventive maintenance programs as a base to build upon their competitive strategy within the market. After all, premium performance of production equipment drives profitability and can transform an organization’s operational success.

To ensure high performance, manufacturers should focus on implementing a world-class preventive maintenance program, which occurs when organizations spend 90% or more of their time on preventive maintenance without requiring the machinery to be taken offline.

A focus on preventive maintenance benefits the organization in a number of ways. First, it significantly reduces the costs associated with maintenance. Breakdown maintenance costs can be as much as five times higher than the same activity done in a planned fashion, and that doesn’t even take into account the revenue loss from decreased product inventories.

Second, preventive maintenance allows the maintenance organization to focus on high-level priorities. Elevating your planning from a tactical approach to strategic can help extend the life of essential assets. Additionally, the maintenance team can become a key proponent for larger strategic decisions within the organization, such as capital planning.

Consider these five strategies to help your team establish a world-class preventive maintenance program and experience the resulting operational gains.

1. **Conduct a Review**
   Prior to beginning any preventive maintenance procedures, especially if there aren’t any already in place, conduct a review and understand what assets and programs currently exist. Without insight into current activities, it can be impossible to understand key gaps and areas for improvement.
The review should capture:

- **Assets.** Without a strong understanding of owned assets and their associated conditions, you can’t put a solid preventive maintenance program in place.

- **Procedures.** Understanding the organization’s current library of procedures can help you quickly identify any gaps that may exist in the processes. It can also provide context to where your team’s priorities already lie.

- **People.** Knowing how the maintenance team spends their days can help organizations realize better ways to leverage their talent. While the activity can be time-intensive, it also can be the most fruitful as employees will often share where they see key gaps in current processes and procedures that may not be otherwise obvious.

**2. ESTABLISH STANDARDIZED OPERATING PROCEDURES FOR REACTIVE AND PREVENTIVE MAINTENANCE**

As organizations grow larger, either by adding more shifts or locations, doing things the way they’ve always been done won’t necessarily work anymore. A U.S.-based metal manufacturing organization that was quickly growing learned this the hard way. After adding two additional facilities with the same equipment, they noticed one plant had significantly more downtime than the other.

The engineers and technicians were conducting preventive maintenance on a regular basis, and were also diligent in responding to reactive maintenance requests quickly and efficiently. Even so, the unprecedented downtime for the new location was so high it was impacting its profitability.

The organization compared preventive maintenance procedures that had been conducted on the equipment in the past month and found they were incomparable to each other. Because they didn’t have standardized operating procedures in place, the staff at each facility had to navigate the wa-
Dude Solutions is driven by optimizing the uptime and efficiency of our clients in manufacturing. Our simple, cloud-based software solutions give you greater insight into your maintenance operations so equipment can be serviced before problems happen — and your team can respond quickly when they do. That means your machines can stay up and running through all three shifts, so you don’t have to.

1. CREATE A RELIABILITY AND MAINTENANCE POLICY WITH AN IMPROVEMENT PLAN
Planning sits at the center of becoming more cost-effective with your maintenance activities. To prevent failure, establish a sound reliability and maintenance policy that incorporates an improvement plan. Industry experts recommend that the improvement plan outlines documentation for a 3- and 5-yr timeline.

2. INVEST IN THE RIGHT TOOLS
The best tools do not solve all problems, but they can solve many. In many instances, the problem is not the tool, but how the tools are used. Just as a poorly trained mechanic can harm your equipment, a well-trained mechanic with the right tool set can solve problems quickly and effectively.

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4. FOCUS ON COST-EFFECTIVE MAINTENANCE
Focusing on cost-effective maintenance requires a comprehensive strategy that takes into account all aspects of the operation. This includes identifying the most cost-effective solutions for each maintenance task, considering the cost of downtime, and evaluating the long-term benefits of different maintenance strategies.

5. ENSURE A Robust Maintenance Program
A robust maintenance program is essential for ensuring the longevity and performance of your equipment. This includes regular inspections, timely repairs, and proactive maintenance actions that prevent problems before they occur. With a well-planned maintenance program, you can minimize downtime and maintenance costs while maximizing equipment performance.

6. INVEST IN TRAINING
Investing in training for your maintenance staff is crucial for ensuring they have the skills and knowledge needed to perform their jobs effectively. This includes both technical training in specific maintenance tasks and soft skills training in areas like communication and teamwork.

7. FOCUS ON PREVENTIVE MAINTENANCE
Preventive maintenance is a proactive approach that focuses on identifying potential problems before they become critical. This includes regular inspections, predictive maintenance, and condition-based maintenance strategies that allow you to address issues before they cause downtime or equipment failures.

8. DEVELOP AN EMERGENCY RESPONSE PLAN
Developing an emergency response plan is essential for ensuring you can quickly and effectively respond to unexpected equipment failures. This includes identifying critical equipment, determining how to isolate problems to minimize downtime, and designating roles and responsibilities for different tasks in the event of an emergency.

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The policy itself should establish objectives, goals, and key responsibilities for the team. Other essential elements in the document include:

- Current state versus future goals
- Key performance indicators (KPIs)
- Importance of KPIs and organizational value
- Importance of reliability to the entire organization
- Internal recognition for reaching goals
- How maintenance feeds into plant competitiveness
- How employees can submit comments and feedback.

Once you’ve determined your policy and improvement plans, think about how you will store it and how employees will access it. By leveraging a technology solution, like a computerized maintenance management system (CMMS), ensure that it’s readily at the hands of everyone to review and access at any time.

4. LEVERAGE TECHNOLOGY TO ADVANCE YOUR PREVENTIVE MAINTENANCE PROGRAM

For decades, plant automation has helped optimize plant equipment. To this day, it has helped manufacturing organizations significantly reduce costs, both from a production and people standpoint.

So, where does preventive maintenance technology fit in? In leveraging CMMS solutions, there’s the opportunity to use the data you gain in plant automation to take your preventive maintenance up a notch.

Using manual processes, such as spreadsheets or even paper documents, to manage your preventive maintenance schedules consumes time, promotes redundancies,
and drains resources. A CMMS solution allows all data to be automatically updated on a regular schedule and include the exact information that is necessary to complete the PM request.

For an engineer or technician working out in the field, they can use their mobile device to pull up all the information they need—the specific request, procedure information, and inspection details—and record their work and findings as they go.

In addition, a CMMS solution can track how teams are spending time on a daily basis to help departments plan more effectively in the future. Leveraging business intelligence and reporting capabilities offer maintenance departments the opportunity to showcase activities and how they are obtaining key performance indicators.

5. **SECURE 100% EXECUTION OF PREVENTIVE MAINTENANCE IN LINE WITH THE 10% RULE**

Oftentimes, organizations will assign a 10-day or even a 30-day deadline for monthly preventive maintenance procedures to give technicians the time they need to execute tasks. When this occurs, it’s likely your preventive maintenance procedures are being completed sporadically, which can limit their effectiveness.

For instance, a monthly preventive maintenance task comes up at the beginning of July, but due to vacations and other issues within the plant, it’s delayed until the end of the month. It’s still considered as completed on time and, thus, in compliance.

In August, the technician has enough time to complete preventive maintenance on the second day of the month. September comes along and has many of the same problems as July, so it’s not completed until the end of the month.
Lack of consistency within these months makes it difficult for preventive maintenance, which needs to be done on a regular and consistent schedule, to work for your organization. Because of this, it’s important to focus on the 10% rule of preventive maintenance: the task must be executed within a 10% variation of the time frequency of the request. In the case of a 30-day preventive maintenance activity, it must be completed within 1.5 days on either side of the due date to be compliant.

Aiming for 100% compliance in line with the 10% rule can significantly improve your preventive maintenance outcomes, as it will optimize reliability of equipment and reduce equipment failures, propelling you into a world-class preventive maintenance organization.

Whether an organization manages preventive maintenance activities manually or via an extensive asset lifecycle management program, there is always room for improvement—even when there’s zero-reactive maintenance.

Once a reliability and maintenance policy and associated improvement plans are in place, it requires constant refining to ensure it meets the dynamic demands of the industry and organization. In fact, organizations with world-class preventive maintenance programs spend time each quarter to assess the current state of the program and how it can be improved. Once established, however, it opens doors to extend your maintenance program beyond that by integrating predictive maintenance techniques and technologies.

*Lora Mays is a product marketing manager at Accruent, which provides real estate and facilities management solutions to more than 4,000 customers in 120 countries.*
Click the video link below to view a video provided by Dude Solutions
Hart Industries manufactures food contact packaging materials in Owings Mills, Maryland. FDA guidelines, as well as vendor specific guidelines, are continuously expanding and evolving making it important for manufacturers to stay up-to-date in order to pass critical inspections. We sat down with TJ Hart, Quality and Regulatory Compliance Officer at Hart Industries to see how this affects them:

“You can’t sell your products in certain stores if you aren’t up to vendor qualifications, which are defined by the Food Safety Modernization Act. Food contact materials can be considered an ingredient in certain products, so we need to follow the strict guidelines that other food companies do.

Knowing that, I decided we needed a system to help keep everything straight. I started looking at maintenance-based applications since that was an area we were struggling with. We needed to be able to show records of when equipment was worked on, when it was inspected before putting it back into operation, and a way to give supervisors appropriate notice. A lot of that is hard to manage without any kind of system in place. There are actual quality management tools out there but a lot of them don’t have the flexibility to touch on everything. They will either be maintenance and training based or they might be quality control based — but none are all in one.

After coming across FacilityDude, we realized that we can do a lot more with MaintenanceEdge than just maintenance as we progressed and learned more about the system.
“Being a web-based system made it very easy to implement. We got our login info on a Friday and had it working on Monday.”

It looked so easy to develop and implement. It was basic, but at the same time very adjustable and open so we could really make it our own. Being able to put multiple tasks into routine schedules is what made us move forward with FacilityDude. MaintenanceEdge gives us ability to have our inspections in the system with multiple different tasks listed within in them, with working instructions attached, and we are able to take photos and attach them as well—all of that is so important to us. Also, being a web-based system made it very easy to implement. We got our login info on a Friday and had it working on Monday.

After we got going with FacilityDude, we were focused on our SQF III Certification. That meant we needed to start documenting in more detail and have preventive programs in place that would verify that things are being done, and being done on time. All of those new changes had to be implemented very quickly since a lot of our customers require these audits. What SQF provides is a comprehensive quality and food safety system that meets or exceeds all the standards put forth by the FDA and by our customers. Therefore, when we have the certification it is a very easy approval process for vendors to work with us.

We actually got a perfect 100 our first time being audited and we might be one of the only packaging companies to ever do that! Our auditors were shocked at the robust attention to detail in all of our records and FacilityDude played a huge part in that.

MaintenanceEdge is usable to manage everything from training to sanitation, and inspections to internal auditing of programs. Basically everything can be incorporated into the FacilityDude system, and we are always finding new ways to use it. It has really become an excellent tool to manage all aspects of our operations.”
Click the video link below to view a video provided by TPC Trainco
Traditionally, availability forecasts and remaining useful life (RUL) estimations have been based on expert assessments of technical risks and a certain degree of intuition from personal experience with assets. This inside understanding is invaluable. Yet, especially in industries in which downtime is extremely costly new solutions are demanded to assess future risks. Most assets have data readily available - why not using this data to objectively support an expert’s experience?

Predictive maintenance solutions offer an excellent starting point to use the data and move towards a data-driven maintenance strategy: based on data analysis it informs in advance that certain equipment will run into trouble soon. Prognostic solutions even go a step further by informing when the equipment will likely run into trouble. Prognostics -- using data analytics to foster expert’s assessment of future availability and Remaining Useful Life (RUL) of assets -- provides help to maintenance engineers in their daily working routine. Operations and asset managers also can make use of Prognostics for a proactive and efficient organization.

The following seven steps are necessary to turn your prognostic data analysis effort into a success:

**1. IDENTIFICATION OF ASSETS TO BE MONITORED**
Choose assets that are critical to continuous operation or those that would generate considerable costs or maintenance effort in the case of failure.

**2. IDENTIFICATION OF KEY MALFUNCTIONS**
List those malfunctions that reduce efficiency or reliability over time and shorten asset RUL. There is no need for a malfunction history - also malfunctions that have never been observed before for the equipment at hand can be listed.
3. DATA REVIEW
Visualize the historical condition and process data from the equipment at hand in order to detect trends. Filter out downtime, startup, and shutdown and graph historical condition and process data for each component.

4. FORMULATION OF PARAMETERS
Determine what data relates to which malfunctions and the type of the relationship (e.g. correlation or causation). Afterwards, create parameters involving arithmetic or logical functions and dependencies. Finally, check the data patterns for malfunction indicators or explanations.

5. RUL COMPUTATION
Feed the condition and process data as well as malfunction and parameter specifications into a stochastic model. Project the asset’s condition over an explicit time horizon, apply diagnostic rules at various future time stages, and infer malfunction likelihoods. After obtaining malfunction-specific RUL distributions, total RUL distributions for each asset can be formed.

6. RESULT VALIDATION
Now that the bulk of the work is done, it is time to ask yourself: “Are these results plausible given what we assume or know now? How early can we make a reliable or useful prediction?” This is to check whether the results are plausible and the time frames used are appropriate for conclusive forecasting.
7. BENEFIT REALIZATION
Now you are ready to reap the benefits that are outlined above. You know now how prognostic data analysis works and how you can use it intelligently to improve your maintenance strategy.

Moritz von Plate is the CEO of Cassantec, a company specialized in prognostic Maintenance. Prior to assuming this role, Moritz was CFO and managing director of an EPC contractor specializing in concentrated solar-thermal power plants. Julia Heggemann is the marketing manager of Cassantec. Her responsibilities include marketing, communication and sales. This article is contributed by SMRP, a CFE Media content partner.
Every facility, whether domestic or abroad, runs on information. But too often the information that a workforce needs to operate and maintain the equipment in their facilities is severely outdated, missing, or difficult to utilize in the field. Hadeed Saudi Iron & Steel Company came to TPC Training Systems with similar issues – inadequate distribution of machine-specific knowledge was bogging down their steel manufacturing workforce with unnecessary downtime and high overtime hours. Hadeed’s over-utilized veteran technicians and operators were simply spread too thin, managing novice workers while trying to maintain a high standard of quality that Hadeed demands.

TPC sent on-site teams to conduct a detailed review of the actual processes and equipment involved in Hadeed’s production and maintenance. Saudi Arabia’s largest steel manufacturer produces 5.5 million metric tons of a combined steel rebar, wire rod, hot rolled coils, cold rolled coils, galvanized coil, and other flat steel products annually using highly customized and specialized equipment. The information collected at Hadeed’s steel facilities pointed to low standardization of information, stunted information distribution processes, and large knowledge gaps between veterans and new hires. TPC’s review suggested a tailored, integrated workforce development plan that focused on producing digital materials in order to provide effective training and responsive maintenance support.
The integrated workforce plan would employ different components of TPC’s portfolio of solutions, with each piece focusing on key areas that are critical to each job requirement. The resultant operator and technician training program would aim to:

1. Drive efficiency in senior technician utilization.
2. Enhance new hire fundamental knowledge and troubleshooting techniques.
3. Capture critical machine documentation and troubleshooting information.
4. Assess technical and safety knowledge throughout the workforce.
5. Stress correct safety procedures for each technician and operator.

At the core of TPC Training Systems’ services is an industry-leading earning management system (LMS), TPC Online™. With the most comprehensive industrial training catalog in the industry, TPC Online™ provides Hadeed with interactive tools to develop a detailed training regimen that addresses key competency areas within their workforce. Assessment is fundamental to maintaining a standard of quality throughout a workforce. Hadeed’s customized training plan focuses on finding gaps in defined key knowledge areas. TPC Online’s core knowledge questions and client-specific subjects give training administrators a benchmark to measure training effectiveness across the entire company. TPC Online™ makes it easy for Hadeed to then follow-up with training courses that fill their technical and safety requirements.

In addition to training Hadeed’s workforce to a common set of standards, TPC Training Systems provided a unique solution to the challenge of knowledge gaps in machine-specific operations.
TPC’s patented iSchematic process mapping platform provided the means to upgrade troubleshooting processes with ongoing job support and advanced training utilities. The role of iSchematic is to map complex system and process events in an easy-to-use mobile format, placing every operation, task, and machine event at the fingertips of every worker. The custom-built, interactive schematic modules empower Hadeed’s maintenance technicians with detailed process and component-level information directly in the field. Its patented process converts static documentation into modules that allow workers to interact with the components that make up their hydraulic machine processes – shortening downtime while performing maintenance procedures. The machine-specific information, detailed descriptions, animations, and images give trainers a platform to teach procedures in the classroom using up-to-date schematics of the actual processes running in their facilities.

“The large quantity of machine documentation that Hadeed employs called for a centralized, simpler system for accessing and searching for relevant process information,” said Tim McDaniel, EVP TPC iSchematic. “TPC iSchematic is the only maintenance solution that cuts through the clutter and places essential, job-relevant information directly within each machine process.”

The detailed training schedule combines three training activities where new hires receive instruction in the classroom, job-relevant exercises, and integrated site visits. Each worker completes a five-day schedule, using TPC Online™, learning the basics of hydraulics, to working with servo valves and specific hydraulic pumps. Day five is dedicated to troubleshooting and fault-finding using TPC iSchematic. After implementing the full-scale training program, Hadeed has seen immediate results. Since implementation Hadeed’s workers have improved their average test scores by 60% in core competency
areas. This achievement provides the foundational knowledge necessary to effectively troubleshoot the machine systems in their facilities.

Hadeed is now able to efficiently use their veteran technicians across their facilities because critical system information is readily available to all technicians using iSchematic. Their veterans, who are the expert source for procedural information, can now focus on critical areas while lowering the amount of overtime needed to operate the plant. Additionally, Hadeed’s workforce can now train on over 1,000 course hours of technical and safety subjects and has already seen workers achieve large gains in assessment scores on core knowledge areas.

“In the past, it was difficult to obtain information on a component’s functional details or learn the skills of troubleshooting and repair,” said Saad Al Jeri, Senior Hydraulic Specialist. “Now, with the development of educational materials and experienced staff, learning has become easier to gain the knowledge and necessary skills for individual development.”

The digital availability of TPC’s training solutions makes its integration into workforce processes seamless. Workforces are able to efficiently train on critical knowledge areas, assess workforce progress, document procedures and processes, and safely and accurately troubleshoot the critical systems running their facilities. TPC’s ability to identify training needs, combine customized solutions, and assess the outcomes makes TPC Training Systems is the total training solution.
Maintenance strategy doesn’t enter our non-technical brains unless it directly affects our productivity and well-being. You change the oil in your car’s engine (that’s preventive maintenance) to keep it running so the engine doesn’t seize and you’re not late for work. However, if you’ve ignored your car’s transmission and it drops out on the way to a new business presentation, you have no choice but to stop at a garage for some reactive maintenance. (The other ‘reaction’ will be losing that new business opportunity, but I digress.)

Maintenance professionals who have hundreds of millions of dollars riding on consistent production and on-time delivery know there is much more to the story. The maintenance strategy they choose can have significant financial consequences.

**FIVE METHODS, VARIOUS USES**
Each of the five basic maintenance strategies — preventive (aka planned), reactive, predictive, condition based, and reliability based — has its own distinguishing features and optimal applications.

- **Preventive (aka Planned) Maintenance (PM).**
  This is maintenance activity that takes place before something breaks so you don’t incur equipment downtime or lost product. It is almost always cheaper to do this than to wait for failure.

- **Reactive Maintenance.**
  Just as it sounds, this is maintenance activity that reacts to equipment failure after it occurs. However, sometimes waiting for equipment to fail is the best thing to do, as I’ll explain below.
• Predictive Maintenance (PdM).  
Maintenance based on specific information about the equipment that is a reliable predictor of imminent failure. Examples include oil analysis, vibration analysis, and thermal analysis.

• Condition Based Maintenance (CBM).  
This is often used synonymously with predictive maintenance. The distinction? CBM is driven from real-time data gathered from sensors and other devices that measure specific conditions against known parameters of failure so that action can be taken in advance.

• Reliability Centered Maintenance (RCM).  
has a much broader scope, often incorporating all of the other strategies. RCM has been referred to as a process to establish the safe minimum levels of maintenance. RCM begins with answering seven questions about the equipment:

1. What are the functions and associated performance standards of the asset in its present operating context?  
2. In what ways does it fail to fulfill its functions?  
3. What causes each functional failure?  
4. What happens when each failure occurs?  
5. In what way does each failure matter?  
6. What can be done to prevent each failure?
7. What should be done if a suitable preventive task cannot be found?

RCM is a complete engineering approach designed to do whatever it takes to promote the greatest level of equipment reliability with the least investment of maintenance cost.

**DECISIONS, DECISIONS.**

*Some general guidelines for choosing a maintenance strategy:*

**Preventive Maintenance (PM).**
You’ll need to develop detailed job plans that spell out the maintenance tasks and the time intervals for each to keep the equipment up and running. You also should have a means to capture the conditions found at each inspection. This is usually done with a PM work order and captured by the computerized maintenance management system (CMMS) for later analysis.

**Reactive Maintenance (RM).**
Only works if the equipment cannot be easily / cheaply repaired. If it is cheaper to replace than to repair, use reactive maintenance and then make sure you have a ready supply available. A common example is an electrical motor rated at 5hp or less.

**Predictive Maintenance (PdM).**
Requires an investment either in analytical equipment and user training or contractors to do the analysis. The decision depends on your specific situation.

**Condition Based Maintenance (CBM).**
Considered a good strategy overall (again, depending on your type of equipment) but it is also good way to minimize energy expense. CBM usually requires an investment in a remote data gathering system and user training.
Reliability Centered Maintenance (RCM).
A great maintenance strategy and considered the most cost effective overall. As we mentioned, RCM may encompass all of the other strategies depending on the equipment component and the available resources.

*Plant Engineering* recently gathered a lot of information about how maintenance professionals feel about these strategies. Take look at the Plant Engineering 2014 Maintenance Report to see what your peers have to say.

How have you resolved the issue of which maintenance strategy to employ in one or more scenarios at your facility? Please share your insights and experience, and thanks for visiting!

*Steve Mueller is Director of Commercial Operations for Daniel Penn Associates. As such he is responsible for project development, management and the delivery of results for our private sector clients. Steve has over 30 years consulting experience.*
Asset utilization, also called Overall Equipment Effectiveness (OEE) or equipment capacity, is not just the responsibility of one department. It is the responsibility of the entire company. It has the focus of ensuring that nowhere in the world does another company have the same assets or produces greater capacity from those assets. It means being the best at getting the most out of the assets by measuring and managing availability, performance efficiency, and quality rate, according to Terry Wireman’s book Zero Breakdown Strategies.

Overall equipment effectiveness (OEE). Total productive maintenance (TPM). Reliability Centered Maintenance (RCM). The guidelines are not new. But for companies that truly want to maximize their equipment uptime, productivity and quality, a disciplined approach is critical. So is creating a culture where everyone understands and carries out their role in the maintenance continuum.

**SITUATION 1:**
A machine shop decided to adopt the TPM approach to proactively care for their large machines. They trained the maintenance team to implement the program for key equipment. The team developed a “war wagon” with all the tools, critical parts and chemicals to perform scheduled maintenance and emergency repairs on machines throughout the facility.

However, the wagon wasn’t maintained, so when mechanics went on a call, components hadn’t been restocked. Tooling was missing. Chemical supplies dropped to low levels or were completely exhausted. Because the maintenance store was disorganized, restocking the wagon took longer. Frustrated, the maintenance team took matters into their own hands, dedicating one wagon to unplanned machine stoppages and another to planned maintenance efforts.

**SITUATION 2:**
A chemical processing facility had more motors in their maintenance stock room than the plant had in service. More than half of the motors and several electronic control components in stock
were for equipment the company no longer owned. And because the right spares for current equipment were not on hand, unscheduled downtime stretched into weeks.

Certainly, maintenance priorities in a heavy machining plant will be different from an assembly plant or a chemical processing plant. Regardless, these practices can be applied across most production facilities:

1. **Borrow from successful Lean production techniques and process map your maintenance workflow.** It’s recommended to begin the mapping effort at the very beginning of the maintenance process and the flow of the process from one step to the next. Once the map is done, it eliminate as many of these extra maintenance steps as possible.

2. **When the facility is organized, it’s easier to see areas for improvement.** Depending on the facility, industry and specific needs, the use of 5S techniques can be an important tool to identify problems in the maintenance process.

3. **Depending on the industry and facility needs, consider Single Minute Exchange of Dies (SMED) strategies to reduce machine changeover times, reduce labor and meet just-in-time production goals.**

4. **Give machine operators process ownership.** A number of real-time digital condition monitoring and reporting systems now support the positive trend to operator-driven reliability (ODR). The Total Productive Maintenance (TPM) approach shifts basic maintenance work (and problem notification) to machine operators, freeing up maintenance personnel to
work on planned maintenance. The idea is to give workers ownership of their machine and the process, maximize equipment effectiveness, increase employees’ skills and reduce manufacturing costs through continuous monitoring. For their part, the maintenance team should respond to requests within a pre-determined time window.

5. **Schedule your facility’s planned maintenance program far in advance**, just as any other operation, to maximize productivity and meet order deadlines. Annual checks are going to be more comprehensive than a monthly or quarterly check, meaning the machine will be down for longer, so make sure they synch with your production commitments.

6. **Use ERP system to plan for downtime, just as it does for jobs.** The ERP ties in with the procurement function, and if properly described with consumption amounts and order lead times, maintenance parts will have been ordered in advance and arrive at your plant in time for the machine to be serviced. Use your ERP or CMMS system to specify the maintenance mechanic who will work on the machine, and to specify the parts and chemicals needed to complete the maintenance activity.

7. **Schedule more frequent checks for older equipment.** As equipment ages, parts and components will start to wear out sooner, and the maintenance window narrows. What were annual checks when the equipment was new may move to semi-annual or even monthly. The service parts required will have to be ordered more often. However, the planned downtime will affect production schedules less than a breakdown.

8. **Engineer machine improvements for maintainability and operability.** Windows cut into guarding to give easier viewing of gauges will make the daily checks easier to perform and more likely to be completed. Access doors installed on equipment will allow for easier periodic maintenance. Consolidation of lubrication points into a single manifold also contributes to more consistently performed maintenance.
9. **Conduct daily operator walk-arounds to pinpoint issues and opportunities for improvement.** Whether it’s a check sheet, whiteboard, or in some cases, a bar-coded activity, the operator’s checks are the essential element of a TPM-oriented operation.

10. **Address operator alerts immediately.** Beyond the operator and the proper performance of the checks, the maintenance organization must be ready to respond immediately to an abnormality that’s been raised as part of the operator checks. Nothing will take the energy of TPM efforts faster than operators raising issues that aren’t addressed immediately.

11. **Continually review spare part requirements.** Remove any spare parts from stock as equipment and machines are retired.

12. **Document and continually re-visit your operation’s maintenance history,** including how critical items have addressed. **Develop and regularly review metrics** that correlate equipment up and down time with production volume, quality and delivery.

Whether using a computer-based maintenance system, or relying on a card file, or having a white board in the maintenance area, the strategies, opportunities and approaches remain the same. Once implemented, the entire workforce – from senior management all the way down to the last mechanic hired, must adhere to the basic tenet: minimize unplanned downtime through proper preventive maintenance.

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