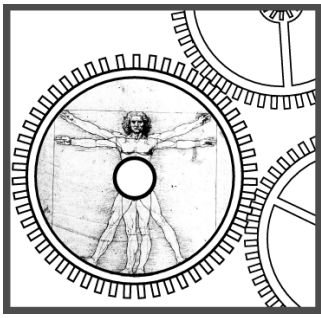

The Planning and Scheduling Machine

By Michael V. Brown, New Standard Institute

Get your organization focused on equipment condition and turn your maintenance effort into a planning and scheduling machine.

Maintenance workers are sometimes accused of taking too long or even stretching the time they take to perform maintenance tasks. However, the vast majority of maintenance workers would prefer to be gainfully employed when they come to work, but instead are interrupted or held up in the performance of their assigned duties. Interruptions to a typical maintenance job include:

- Trips to and from the storeroom for parts
- Trips to and from the shop for special tools
- Waiting for equipment availability (such as a fork truck, or crane)
- Waiting for another craft

Interruptions are not caused by laziness or lack of motivation, but rather by lack of adequate planning and scheduling techniques. A properly planned job will have the needed parts, equipment and tools identified, and the availability of these items will be confirmed prior to scheduling the job. The craft and labor hour requirements to complete the jobs will be known once the jobs are planned, so the correct personnel can be assigned at the proper time.

Unplanned jobs or jobs resulting from equipment breakdown still make up a large percentage of a maintenance worker's day. It is admittedly difficult to move away from the breakdown mode to a planned approach, but more and more companies are finding out that the status quo maintenance will not sustain them in the long run. There are four steps to achieving a planned approach to maintenance:

1. Identify and document the work that needs to be performed.
2. Develop a structured process to plan maintenance work.
3. Build a file of plans for future use.
4. Modify and expand on saved plans to fit new situations as they arise.

Identify and Document the Work

Early information is key to proper maintenance. Focus the eyes and ears of all facility personnel on equipment condition and you will get the information you seek. Equipment operators are one source (often under utilized) of this information. Operations personnel should be trained to detect equipment problems early on. An operator in a planning organization doesn't wait for the equipment to fail before contacting maintenance. Signs of beginning equipment problems, such as leaks, temperature anomalies, and odd sounds, are noted by an observant operator. No problem is too small to report. Even a false alarm can be turned into a training opportunity, which will help fine tune the operator's observation skills to discover beginning problems.

Preventive and predictive maintenance efforts provide a more structured approach to work identification. A robust preventive maintenance (PM) program would include cleaning, lubricating, adjusting, testing, calibrating, rebuilds, preemptive replacements, and inspections. The best

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programs include well written procedures with data entry forms and management spot checks. The success of a PM program is often measured by how many hours are logged or how many inspections are performed. A more definitive measure would be a count of corrective actions derived from PM activities. As rule of thumb, three corrective actions should be derived from every ten PM inspections.

A predictive maintenance (PDM) effort is also a major source of plannable work. A predictive approach can be applied to any equipment problem if, first, a physical parameter like vibration, temperature, pressure, voltage, current, or resistance can be measured. An engineering limit for the measured physical parameter must be, established so a problem can be detected during routine monitoring. The physical parameters are measured periodically (weekly, biweekly, monthly, etc.). If the measurement exceeds the established engineering limit, it must be analyzed further. Analysis can take many forms. For example, a vibration vs. frequency plot can be taken on rotating equipment. A trained analyst may review the plot for common problems, such as misalignment or imbalance, as well as for not-so-common problems, like resonance. Once the source of the problem is determined, the best repair activity can be chosen. If the engineering limit is set low enough, there will still be plenty of time to correct the problem before further damage occurs.

Develop a Structured Process to Plan Work

Work that is defined early can be planned. However the planning process needs to be nurtured and controlled. Organizations that have a structured approach to planning work seem to be the most successful. For years, aids have been developed to estimate construction jobs. The construction industry has compiled these estimates in publications available to all who work in that field. Maintenance work can have a similar structured approach. Plans can be developed for pending work, and stored for future use. The following example illustrates one maintenance plan structure.

An inspection of a V-belt drive indicated that the belts were cracked and worn. A corrective action work request to replace the belts was written by the inspector. The planner visited the job site and prepared the following planning sheet.

Planning Sheet

W/O #	Equip.	Seq.	Planner	Date
24585	West Dust Collector Blower		TMH	22 May 02

Job Title: Change V-belts. Cracked and worn.

Job Scope			Material, Tools & Equipment			
Job Steps	Crew	Est. Hours	Description	Qty	Stock #	Cost
	1 ME					
1. Lock out and tag motor starter		.5				
2. Remove belt guard, loosen, and jack the motor. Remove belts.		.25				
3. Check both sheaves for sidewall wear, radial runout and wobble. Runout and wobble should not be more than .4mm for the large sheave and .2mm for the small. Replace worn sheave or hubs if required.		.5	Dial indicator, mag base (tool crib)			
			Sheave gauge (tool crib)			If needed
			If sheaves are worn:			
			4MV5V150R sheave	1 ea	43-515-100	$173.00
			7/8" bore R1 bushing	1 ea	43-923-750	24.00
			4MV5V109R sheave	1 ea	43-510-100	124.00
			1 1/8" bore R1 bushing	1 ea	43-918-750	24.00
4. Install new belts, align sheaves, tighten motor bolts.		1.0	5V1120 belts	4 ea	06-510-112	53.00
			Belt laser alignment tool			
5. Tension belts using force deflection method, and recheck alignment.		.5	Belt tension gauge (tool crib)			
6. Re-install guard.		.25				
7. Remove locks, release to operations and clean up.		.5				
Drawings/Forms:	Total Hours	3.5	Total Labor Cost $130		Total Mat. Cost	$53.00
					Total Job Estimate	$183.00

Each step is written out along with an estimate of the time required to complete the work. Work standards (sheave run-out and wobble tolerances) are also noted. The formal definition of job steps also triggers a note for needed tools (dial indicator, belt tension gauge, etc.) or parts (5V1120 belts). On the day the job is executed, the mechanic can pull the belts out of the storeroom and withdraw the tools from the tool crib first thing. It is now more likely that the job goes as planned and is completed in the estimated time.

Build and Save Plans

The effectiveness of a planning effort is based on economics. It is assumed that the cost of the planner's time to review work ahead of time will be more than recovered in efficiencies derived from improved job performance. Equipment downtime and lost labor time can be reduced by ensuring that materials, tools and equipment are made available before the job starts, not during the job.

A common misconception presumes that jobs that occur frequently do not need to be planned at all. The conclusion is made that these jobs are performed so often that the maintenance worker should know what has to be done and what is needed to do the work. However, it is precisely these jobs that are frequently interrupted by trips from the job site to get a tool, or trips to and from a storeroom as additional materials and parts are required. A planned job would not only include a description of job steps and an estimate. The plan will include a list of parts and tools required for the job. This list can be improved and updated based on actual experience.

Modify and Expand on Saved Plans

Consider the previous job of changing V-belts on a small blower. The belts were 5V1120 in size, indicating a belt circumference of 2845 mm (112 inches). The motor size with 4 groove sheaves would probably not exceed 20 HP, and the shaft centers are not separated by much more than one meter. One mechanic can perform the job easily. Now consider another blower that is driven by a 150 HP motor and 8 groove sheaves employing 8V4500 belts. In this installation, the belt guard must be lifted by a crane or series of chain-falls and the whole job will now require at least two mechanics. However, most the job steps involved in changing these belts are the same as for the smaller motor. The resources needed will change, but these resources are much easier to identify and quantify when a list of job steps already exists. In other words, one plan can be used to build another more quickly as shown below.

Planning Sheet

W/O # 24678 | Equip. Bigger Blower | Seq. | Planner TMH | Date 22 May 02

Job Title: Change V-belts. Cracked and worn.

Job Scope			Material, Tools & Equipment			
Job Steps	Crew	Est. Hours	Description	Qty	Stock #	Cost
	2 ME					
1. Lock out and tag motor starter		.5				
2. Remove belt guard, loosen, and jack the motor. Remove belts.		.75	2 ea. 1-ton Chain-falls			
3. Check both sheaves for sidewall wear, radial runout and wobble. Runout and wobble should not be more than .5mm for the large and small sheave. Replace worn sheave or hubs if required.		.5	Dial indicator, mag base (tool crib)			
			Sheave gauge (tool crib)			If needed
			If sheaves are worn:			
			8MV8V2505 sheave	1 ea	43-515-230	245.00
			1 7/8" bore S bushing	1 ea	43-924-650	57.00
			8MV8V2075 sheave	1 ea	43-511-150	224.00
			2 3/8" bore S bushing	1 ea	43-919-100	65.00
4. Install new belts, align sheaves, tighten motor bolts.		1.5	8V4500 belts	8 ea	06-510-145	182.00
			Belt laser alignment tool			
5. Tension belts using force deflection method, and recheck alignment.		1.0	Belt tension gauge (tool crib)			
6. Re-install guard.		.75				
7. Remove locks, release to operations and clean up.		.5				
Drawings/Forms:	Total Hours	5.5	Total Labor Cost $410		Total Mat. Cost	$182.00
					Total Job Estimate	$592.00

Job plans generated for generic maintenance work can also be used to plan out work that may involve some unusual aspects. A job plan developed for changing out a 50 HP motor located at ground level with easy access, could also be used as a basis for a plan to change out a motor located down in a pit. The job steps remain relatively unchanged. The resources required to accomplish many of the steps *will* probably change. For example, the initial step of gaining physical access to the motor will involve more than a lock-out procedure. Now a confined space entry procedure will also be needed and a safety watch individual may have to be added to the crew.

Contrary to numerous advertising campaigns, most things are not "maintenance free". Owners have a choice. Equipment or facilities are either allowed to fail in service or are refurbished in advance of failure.

Scheduling the Work

Truly only planned work can be scheduled. We have to know the resources required (people, equipment, tools and parts) and must have an estimate of the job duration before the work can be scheduled. A schedule without planned jobs is just a "wish list". An example of a schedule for a typical week is shown below.

Schedule for the Week Beginning 7 Sept. 02				
Area: D		**Available Hours:** 180 hours + 52 PM hours = 232 hours		
W/O#	**Equip #**	**Description**	**Est Hrs**	**S/D Date**
P14315	26C420	PM – Compressor quarterly	4	9 Sep
P14318	GEN	PM – Greasing route D4	11	
P14321	GEN	PM – Oil route D5	16	
P14322	MOB23	PM – Pickup truck safety check	2	
P14324	GEN	PDM – Vibration monitoring – Week 27	7	
P14326	37T910	PM – E13D transmitter calibration	4	11 Sep
P14327	47R100	PM – Perform leak test on reactor	8	
03426	47R200	Repair minor leak at reactor seal	14	
03357	37R907	Remove knock-out pot	8	
03398	37R907	Replace rupture disc. with lower pressure	7	11 Sep
03402	05P201	Repair stuck drawer	2	
03364	05BLDG	Annual shop floor treatment	16	
03369	05T905	Replace frayed hose	6	
03414	26B501	Increase fan speed, change sheave & motor	11	9 Sep
03415	10B501	Replace fan bearings – per vibration analysis	9	8 Sep
03450	37C031	Balance compressor lobes – per vib. analysis	4	11 Sep
03430	10M210	Replace worn mixer blades	11	8 Sep
03339	14PK205	Fabricate and install new bagger guide	15	
03447	26G204	Change oil in gearbox – per lube analysis	5	9 Sep
03458	37P303B	Cut down impeller size	6	
03351	05V108	Paint vessel and piping	14	
03372	26T200	Replace T-200 modify pipe	6	9 Sep
03454	37P201	Replace guard and nipple	25	
03353	26T607	Weld tank crack	6	9 Sep
03465	37T973	Relocate level controls and dipleg	15	
		Total	232	

The schedule was developed on the Friday before (4 September) with the intention to provide a week's worth of work for each employee in Area B. Some equipment in the plant may have to be scheduled down by operations. The S/D Date column indicates the best day in the week to perform some jobs. Operations should get a copy of the weekly schedule to help arrange equipment shutdowns and other coordination with the maintenance work force.

Some planner/schedulers simply turn over the weekly schedule to the maintenance supervisor and wash their hands of what happens from day to day. In these cases the maintenance supervisor or team leader must determine which jobs should be worked each day and must also coordinate equipment availability with operations. This can add a burden that is really unnecessary.

Many planner/schedulers develop a daily schedule to free the supervisor or team leader from some of the coordination requirements. The form shown below is typical of a daily schedule used at many facilities.

Daily Schedule

Area: D | Day: Tuesday | Date: 7 Sept 02

W/O #	Equip. #	Description	D. Huff	R. Smith	J. Stallcup	J. Bartlett	A. Meyers	A. Hanson	Days on Sched.	Orig. Est. Hours	Compl. Hours	Act. Hours Today
03415	10B501	Replace fan bearings			4.5		4.5		2	9	0	(9)
03430	10M210	Replace worn mixer blades		5.5		5.5			0	11	0	(11)
P14321	PLANT	PM - Oiling route D5		2.5		2.5			1	16	11	(5)
03465	37T973	Relocate level controls			3.5		3.5		1	15	8	(7)
P14318	PLANT	PM - Greasing route D4	X						1	11	0	0
P14322	M0B23	PM - Pickup truck safety check				X			0	2	0	0
03454	37P101	Replace guard and nipple				6			4	25	8	6
03481	35P201	EMERGENCY - Replace pump seal	10									(10)
03480	37M120	EMERGENCY - Replace sample valve				2						(2)
		Straight Time	8	8	8	8	8	8				
		Overtime	2	0	0	0	0	0				

NOTE: Circle Act. Hours for Completed Jobs

The schedule is developed for the next workday (Tuesday) and for a specific area (Area D). Operations should review the schedule to determine which equipment must be shut down for maintenance. The first two jobs on the schedule require a shutdown discussed with operations the week before. Permitting and lockout requirements can also be discussed at this time.

In the example, an effort was made by the planner/scheduler to provide a day's work for each maintenance employee in the area. The normal staff was listed along the top of the schedule. Some information has been added to the schedule to help anyone who might want to audit it later. Using the computerized maintenance management system, the planner/scheduler has listed the number of times each job has been placed on a schedule. The original estimate (Orig. Est. Hours) and the hours already charged to the job (Compl. Hours) are also listed.

It is usually the responsibility of the team leader or maintenance supervisor to assign the right person or persons to each job. The team leader or maintenance supervisor also has the responsibility to make every effort to start each job on the schedule. The jobs that were not completed may be put on the schedule for the next day or left for another day during the week.

Auditing a Completed Daily Schedule

A daily schedule can provide very good control over weekly schedule activity. Jobs on a weekly schedule are easily ignored in lieu of, so called, emergencies. Maintenance supervisors and team leaders are often persuaded to perform "added jobs" which were not discussed with the planner/scheduler.

A completed daily schedule tells all. If a scheduled job has not been performed a maintenance manager can ask some key questions. The maintenance managers should ask **questions** like:

"Why wasn't this job started today?"

or

"Why wasn't this job completed today?"

The **answers** will often resemble these.

"The parts and materials were not available."
"Operations didn't shut down the equipment."
"An emergency job came up."
"The estimate was too low for the work involved."

These answers should evoke more questions, this time directed toward the responsible individuals. The maintenance manager may ask the planner/scheduler why parts were not available for a job on the schedule. The planner/scheduler should also be asked if they had arranged to have the necessary equipment shut down with operations. The operations department should be questioned as to the validity of an emergency job and why it was necessary to displace a scheduled job if it was not an emergency.

The maintenance manager may also ask about the progress of longer jobs that were not completed. Jobs that have been on the daily schedule a number of times and not completed should also be scrutinized. The maintenance supervisor may put off some jobs because they wrongly feel they are not as important as others. This happens more often when the daily schedule includes many more jobs than can be completed within a normal workday.

If the actual time spent on a long job exceeds the estimate, the maintenance manager should determine the reason why. Both the planner/scheduler and the maintenance supervisor should be included in a discussion to determine if the problem is with the job performance or the estimate.

On the other hand, the maintenance manager should also ask questions if all the scheduled jobs were completed within the estimate. This is especially questionable if added jobs or emergencies were also completed during the day. The job estimates may be too high when this occurs.

The maintenance manager should correct this situation because questionable estimates call all other components of a scheduling effort into question. High backlogs that seem to indicate the need for a larger work force are suspect. Operations may disbelieve the time estimates for downtime required on certain jobs. If this situation persists, weekly schedules and daily schedules will also be considered invalid by facility personnel.

The Payoff

When PM, PDM and planned work makes up the large majority of the workday:

1. The planner's work is already completed, and the planner can concentrate on developing solid work plans for the remaining corrective type work orders.
2. Breakdowns and unscheduled downtime are dramatically reduced.
3. Stores inventory can be minimized because supplies and materials required for PM and planned jobs are defined ahead of time. Much of the maintenance can be purchased just prior to the scheduling of the work.
4. Work can be completed more efficiently without interruption, which means the same workforce can complete even more work.
5. The working climate of maintenance is improved and the morale of the work force is boosted. (No one really likes working a world of constant breakdowns and emergencies.)
6. The budgeting process is streamlined when PM and PDM makes up the most of the work performed. The manager knows what the labor requirements are as well as materials and supplies needed.

This article was written by a consultant from **New Standard Institute**, Inc. For other articles on Maintenance-related subjects, view our website at http://www.newstandardinstitute.com or contact us via email at nsi@newstandardinstitute.com or call **(203) 783-1582** to discuss the subject with one of our consultants.

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