Packaging Preventive Maintenance Rationalization and Lean Pilot at a Pharmaceutical Company

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Abstract *— The downtime developed by the poor maintenance scheduling techniques used in a manufacturing plant produces a huge amount of loses, financially and timely speaking. This project looks to use DMAIC methodology to attack the problem, and eliminate the waste existing on the preventive maintenance itself. Using the mentioned aids, the planning and scheduling steps are clear and easy to follow. Several techniques (ex. routes) were applied to the maintenance to perform it in the least amount of time with greater results.*

Key Terms *— Lean, DMAIC, Preventive Maintenance*

RESEARCH OBJECTIVES

The main objective of this design project is to apply DMAIC Methodology to the schedule and execution process of the preventive maintenance in the packaging lines at a manufacturing plant.

The existing Work Orders schedule and execution process are not standardized, avoiding successful process flow. In addition, the excessive amount of Preventive Maintenance activities affects the controllable downtime, affecting the Overall Equipment Effectiveness (OEE), a very important tool in today's challenging environment when customers demand quality product at the best value [4].

RESEARCH BACKGROUND

This design project was conducted at a Pharmaceutical Company in Puerto Rico. The worked area was the packaging lines preventive maintenance work orders and scheduling. Each equipment in-line has a preventive maintenance work order and scheduled due date, independently of the other equipment in the same line.

DMAIC METHODOLOGY

As business competition gets tougher, there is much pressure on product development, manufacturing, and service organizations to become more productive and efficient [1]. Six Sigma methodologies improve any existing business process by constantly reviewing and re-tuning the process. To achieve this, Six Sigma uses a methodology known as DMAIC, the methodology used in the project [3]. The DMAIC methodology can be used when a product or process is in existence at your company but is not meeting customer specification or is otherwise not performing adequately [2]. The DMAIC methodology includes five steps; Define, Measure, Analyze, Improve, and Control.

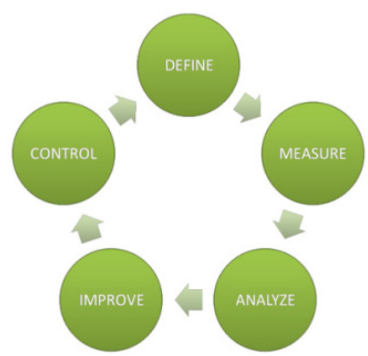


Figure 1
Six Sigma DMAIC Model

Define - Define is the first step in the process. In this step, it is important to define specific goals in achieving outcomes that are consistent with both your customer's demands and your own business's strategy. In essence, you are laying down a road map for accomplishment.

Measure - In order to determine whether or not defects have been reduced, you need a base measurement. In this step, accurate measurements must be made and relevant data must be collected so that future comparisons can be measured to determine whether or not defects have been reduced.

Analyze - Analysis is extremely important to determine relationships and the factors of causality. If you are trying to understand how to fix a problem, cause and effect is extremely necessary and must be considered.

Improve - Making improvements or optimizing your processes based on measurements and analysis can ensure that defects are lowered and processes are streamlined.

Control - This is the last step in the DMAIC methodology. Control ensures that any variances stand out and are corrected before they can influence a process negatively causing defects. Controls can be in the form of pilot runs to determine if the processes are capable and then once data is collected, a process can transition into standard production. However, continued measurement and analysis must ensue to keep processes on track and free of defects below the Six Sigma limit.

Research Methodology

As this project utilize a DMAIC model to resolve the problem, each step will be discussed.

DMAIC: Define Phase

A number of processes can be seen as an area of opportunities.

- The production window is controlled by the production scheduler and not available to the engineering scheduler.
- Few operator mechanics have access to the PM computer system to enter the data. The scheduler has to enter the data.
- Too many machines fail because of the poor maintenance due to line availability to perform the maintenance to each machine at different times of the year.

DMAIC: Measure Phase

Taking in consideration the current state data taken from the PM computer system, the important data can be measure as follow.

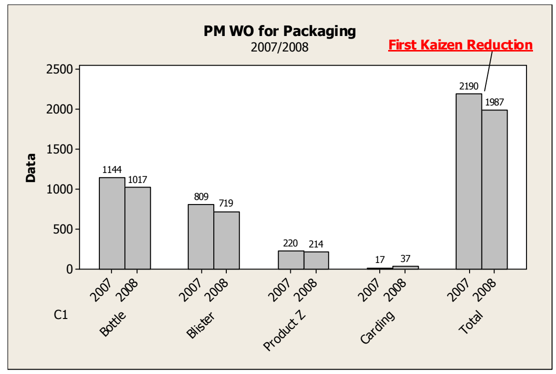


Figure 2
Preventive Maintenance Work Orders in 2008-2009

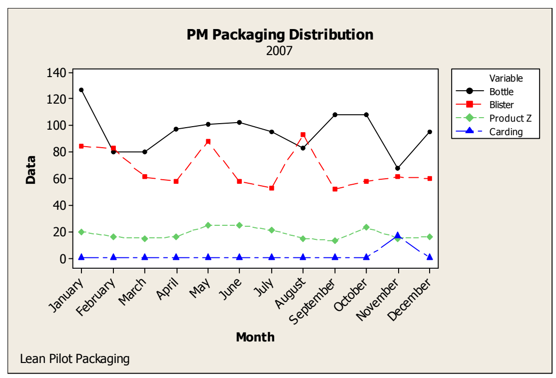


Figure 3
Preventive Maintenance Work Orders Distribution in 2007

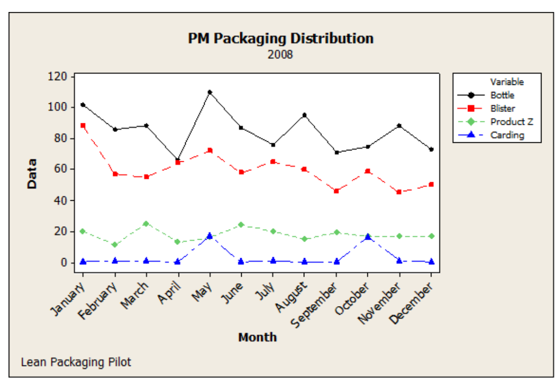


Figure 4
Preventive Maintenance Work Orders Distribution in 2008

DMAIC: Analyze Phase

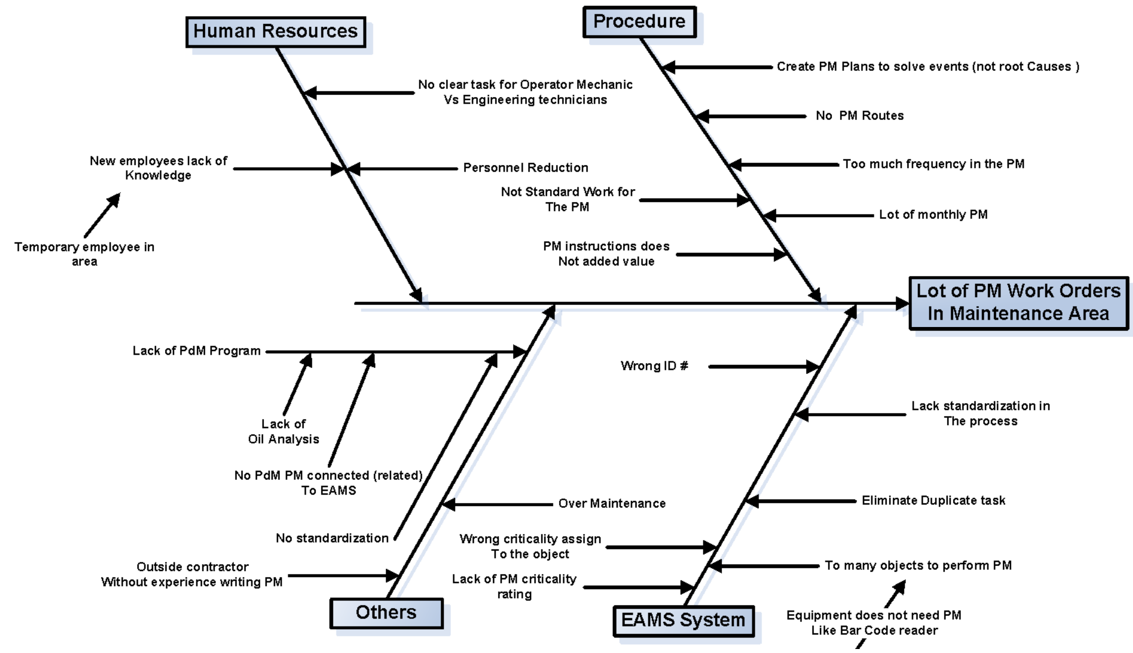


Figure 5
Fish Bone

Analyzing the data found on the PM computer system, other ideas were presented by a multidisciplinary group brainstorming the measurements.

- Eliminate the electrical PMs, creating electrical routes per packaging line.
    - PLC batteries route
    - DC motor brushes route
    - Electrical panels route
    - Ultrasound route
- Transfer the verification of the emergency stop and guards to the mechanical PM.
- Eliminate the challenge of the sensors; this verification is done as part of every batch record.
- Extend the PM frequency based on the equipment technical evaluation and history.
- Remove the lubrication instructions for the mechanical PM and create three lubrication routes, 3, 6, and 12 months.
- Lubrication assessment; identify the lubrication points, the correct lubricant and frequency.
- Harmonize the lubricants/grease.
- Segregate the PM task between engineering and mechanical operators.
- Integration of equipment (ex. Capper elevator and Capper machine)
- Verification of the current packaging equipment and the object ID versus the data in the PM computer system.

DMAIC: Improve Phase

After the approval and implementation of all new PM Task, two measurements can be done to look for the immediate results of the project.

- From a total of 112 PM Task activated in 2008, only 74 PM Task will be activated after the project.
- From a total of 1,987 PM Work Orders done in 2008, only 426 PM Work Orders will be done after the project.

As a result of the Lean event, 34% of the PM Task and 79% of PM work orders were reduced.

Table 1
Preventive Maintenance Task Reduction

PM Task Reduction in Packaging			
2008 PM Task	2009/2010 Total PM Task	% Reduction	Total PM Task Reduction
112	74	34%	38

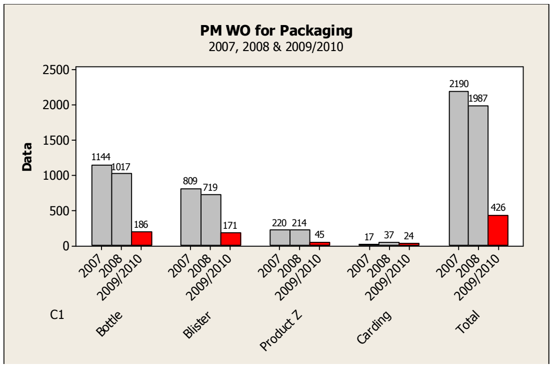


Figure 6
Preventive Maintenance Work Orders Comparison

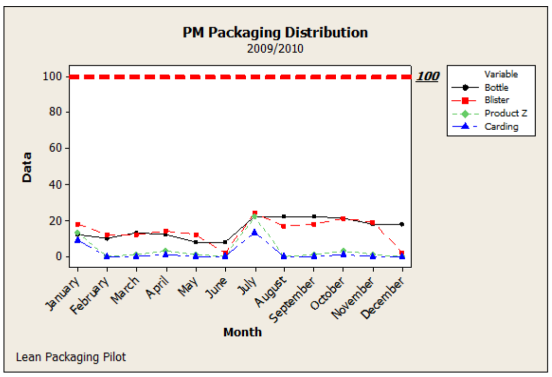


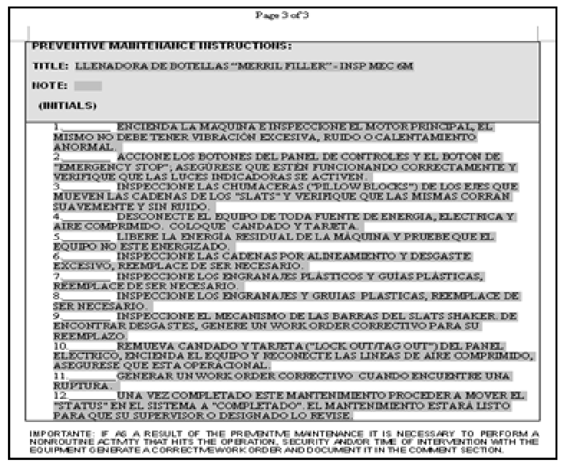
Figure 7
Preventive Maintenance Work Orders Distribution after Lean Project

Benefits of the data shown are:

- Increase available time for packaging to operate the lines.
- Reduce the labor time in non-value added activities.
- Reduce controllable downtime.
- Reduce or eliminate the PM Alerts due to PM work orders that remains open due to unavailability of the line.
- Reduce the amount of documentation and data entry.
- To save energy cost, an ultrasonic route was established for each line to avoid compress air leaks.
- A lubrication route for each line was created to go with more specific instructions for it.
- Lubricants were standardized.
- Include lubrication points that were not cover in the old PMs.
- Include important maintenance instructions that were not included in the old PMs.

DMAIC: Control Phase

For the control phase of our Lean event we choose to do Visual Aids for the lubrication routes specific to each line, the PM schedule of a year in advanced to facilitate the availability of each line and the communication between packaging and engineering departments, and implement a regional SOP to standardize the PM Task template for all Puerto Rico locations.



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PREVENTIVE MAINTENANCE INSTRUCTIONS:

TITLE: LLENADORA DE BOTELLAS "MERRIL FILLER" - INSP MEC 6M

NOTE:

(INITIALS)

1.________ ENCIENDA LA MAQUINA E INSPECCIONE EL MOTOR PRINCIPAL, EL MISMO NO DEBE TENER VIBRACIÓN EXCESIVA, RUIDO O CALENTAMIENTO ANORMAL.
2.________ ACCIONE LOS BOTONES DEL PANEL DE CONTROLES Y EL BOTON DE "EMERGENCY STOP"; ASEGÚRESE QUE ESTÉN FUNCIONANDO CORRECTAMENTE Y VERIFIQUE QUE LAS LUCES INDICADORAS SE ACTIVEN.
3.________ INSPECCIONE LAS CHUMACERAS ("PILLOW BLOCKS") DE LOS EJES QUE MUEVEN LAS CADENAS DE LOS "SLATS" Y VERIFIQUE QUE LAS MISMAS CORRAN SUAVEMENTE Y SIN RUIDO.
4.________ DESCONECTE EL EQUIPO DE TODA FUENTE DE ENERGIA, ELECTRICA Y AIRE COMPRIMIDO. COLOQUE CANDADO Y TARJETA.
5.________ LIBERE LA ENERGÍA RESIDUAL DE LA MÁQUINA Y PRUEBE QUE EL EQUIPO NO ESTE ENERGIZADO.
6.________ INSPECCIONE LAS CADENAS POR ALINEAMIENTO Y DESGASTE EXCESIVO, REEMPLACE DE SER NECESARIO.
7.________ INSPECCIONE LOS ENGRANAJES PLÁSTICOS Y GUÍAS PLÁSTICAS, REEMPLACE DE SER NECESARIO.
8.________ INSPECCIONE LOS ENGRANAJES Y GRUIAS PLASTICAS, REEMPLACE DE SER NECESARIO.
9.________ INSPECCIONE EL MECANISMO DE LAS BARRAS DEL SLATS SHAKER. DE ENCONTRAR DESGASTES, GENERE UN WORK ORDER CORRECTIVO PARA SU REEMPLAZO.
10.________ REMUEVA CANDADO Y TARJETA ("LOCK OUT/TAG OUT") DEL PANEL ELECTRICO, ENCIENDA EL EQUIPO Y RECONECTE LAS LINEAS DE AIRE COMPRIMIDO, ASEGURESE QUE ESTA OPERACIONAL.
11.________ GENERAR UN WORK ORDER CORRECTIVO CUANDO ENCUENTRE UNA RUPTURA.
12.________ UNA VEZ COMPLETADO ESTE MANTENIMIENTO PROCEDER A MOVER EL "STATUS" EN EL SISTEMA A "COMPLETADO". EL MANTENIMIENTO ESTARÁ LISTO PARA QUE SU SUPERVISOR O DESIGNADO LO REVISE.

IMPORTANTE: IF AS A RESULT OF THE PREVENTIVE MAINTENANCE IT IS NECESSARY TO PERFORM A NONROUTINE ACTIVITY THAT HITS THE OPERATION, SECURITY AND/OR TIME OF INTERVENTION WITH THE EQUIPMENT GENERATE A CORRECTIVE WORK ORDER AND DOCUMENT IT IN THE COMMENT SECTION.

Figure 8
PM Task Template

Other controls implemented in the project include:

- All changes were approved by a multidisciplinary team.
- Colleagues were properly trained to know all changes applied during the project.
- Acronyms for PM task IDs, equipment IDs, and route IDs were standardized (guide was created).
- New scheduling groups were created in accordance with the current necessities.

Product Z Line - Preventive Maintenance Schedule 2010 - 2011

Equipment	TASK	FREQ	2010 JUL (hrs)	2010 AUG (hrs)	2010 SEP (hrs)	2010 OCT (hrs)	2010 NOV (hrs)	2010 DEC (hrs)	2011 JAN (hrs)	2011 FEB (hrs)	2011 MAR (hrs)	2011 APR (hrs)	2011 MAY (hrs)	2011 JUN (hrs)
Bottle Unscrambler (UB02001)	BWR005M1	MECH (12M)				0.50								
Powder Filler (FP11001)	PFI001M1	MECH (3M)	0.50			0.50			0.50			0.50		
Capper (CF01005)	CAM008M1	MECH (2M)		0.50		0.50		0.50		0.50		0.50		0.50
	CAM003M1	MECH (6M)				1.50						1.50		
Detector de Metales (DM13001)	MTD004M1	MECH (12M)				0.75								
Rotary Labeler (LS11005)	LRM007M1	MECH (6M)				1.00						1.00		
Checkweigher (CW32001)	CWM001M1	MECH (12M)				0.50								
Case Packer Skinetta (SC61003)	EMP025M1	MECH (6M)				1.00						1.00		
Pallet Lifter (PLL009)	PLL001M1	MECH (12M)				0.50								
Ruta PLC	PLC001E1	ELEC (12M)				4.00								
Ruta Motores	DCM001E1	ELEC (12M)				9.00								
Ruta Ultrasonido	ULT001M3	MECH (12M)				5.00								
Ruta Panel de Control	ELP001E1	ELEC (12M)				8.00								
Ruta Lubricación	LUB001M2	MECH (3M)	3.00						3.00					
	LUB002M2	MECH (6M)										12.00		
	LUB003M2	MECH (12M)				16.00								
Total de horas			3.50	0.50		48.75		0.50	3.50	0.50		16.50		0.50
Turnos de trabajo en la línea														
Aprobado Por :									Fecha:					

- Se entrará iniciales, fecha en el espacio correspondiente luego de realizar el mantenimiento preventivo.

Figure 9
Packaging Line PM Schedule Example

The PM schedule was very helpful for everyone involved with the packaging equipment maintenance. The schedule includes:

- Each equipment will show the corresponding Task, the type of PM (Mechanical or Electrical), and the estimate time.
- Each PM frequency will have a unique color: red – 2 months, blue – 3 months, yellow – 6 months, and green – 12 months.
- Each month provide how much time the PM activities will take in total.

PM Task #: RTE 1 Rev 0.0 "Ruta 3 Meses de Lubricación para linea 7 "

TERMOFORMER UPS - 4 Machine parts Lub.	Local lubricant used	Stock Part No.	Lubricated Method
Forming stasion (bearings)	Bel Ray no tox HD # 2 (62280)	20958	gun grease
Forming St.(post guide way / nipple)	Bel Ray no tox HD # 2 (62280)	20958	gun grease
Single-stroke index after forming (engranaje de piñones)	Bel Ray no tox HD # 2 (62280)	20958	brush
Single-stroke after forming (bearings/ nipple)	Bel Ray no tox HD # 2 (62280)	20958	gun grease
Sealing station (bearing / nipple)	Bel Ray no tox HD # 2 (62280)	20958	gun grease
Sealing station (post guide way / nipple)	Bel Ray no tox HD # 2 (62280)	20958	gun grease
Single-stroke idex after sealing			
Single-stroke idex after sealing (Bearing / nipple)	Bel Ray no tox HD # 2 (62280)	20958	gun grease
Punching station (connecting rod) *detail A	Bel Ray no tox HD # 2 (62280)	20958	gun grease
GOTTCHO INK PRINTER			
1. Gear and Rack	Oil ,castorl tribol 878 - 150 (H1)	11225	brush
2. Bushing and Rods	Bel ray no tox AL lube, (62050) mineral oil	24279	oil can
Preparado por:	Fecha:		
Aprobado por:	Fecha:		

Figure 10
Lubrication Visual Aid Example

For the safety part of the PM Task, the Environmental, Health & Safety (EHS) department standardize the safety instructions. The assessment was completed with a table dividing the instructions by PM types mechanical, electrical with LOTO, and electrical with energized system. More specific safety instructions can be added but none of the included in the table can be taken off.

CONCLUSION

The work done in this project is considered one of the most beneficial and profitable projects done in the plant. With this Lean event the reduction of documentation was evident, with 79% of reduction compared to 2008. Reducing the packaging PM Tasks by 34%, eliminates the need to work in the same machine more than once.

Also, the PM distribution in the year was excellent for the packaging and engineering department, to know in advance what line will be affected by scheduled maintenance; and planning around the schedule to finish the packaging process before the maintenance. The downtime on packaging lines was successfully reduced with the new schedule. Finally, we eliminate the need of a pile of PM alerts each month because of PM work orders not finished on time.

REFERENCES

[1] Breyfogle III, F.W. Implementing Six Sigma: Smarter Solutions Using Statistical Methods, 2nd Ed., John Wiley and Sons, 2003.

[2] Montgomery, D. Introduction to Statistical Quality Control, 3rd Ed., Willey & Sons, 1997.

[3] *What is Six Sigma?*, Six Sigma Tutorial 2005, sixsigmatutorial.com/six-sigma-tutorial/7/.

[4] Hansen, R.C. Overall Equipment Effectiveness: A Powerful Production/Maintenance Tool for Increased Profits, 1st Ed., Industrial Press Inc., 2001.