

Engineering Management
Field Project

Early Equipment Management

By

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Executive Summary

ABC Company is a leading supplier and manufacturer of food ingredients, additives, functional chemicals, and specialty blending equipment.

ABC is a wholly owned subsidiary of XYZ, a Dutch based company. XYZ purchased Unilever's European Bakery supply division in 2000. Unilever had several plants heavily involved in the implementation of Total Productive Maintenance (TPM). XYZ became aware of the benefits first-hand after the acquisition and began executing the philosophy at several plants in the states. The benefits included plants that were more organized, had stronger maintenance departments, and a team-oriented, problem solving workforce.

The company chose their Kansas Avenue dry ingredient blending plant to implement TPM in July of 2003. The continuous improvement program was implemented in twelve steps because of its complexity. Early Equipment Management (EEM) is one of the eight pillars of TPM and is the eighth step in the implementation program. EEM is a structured process that evaluates the quality, flexibility, reliability, safety, and life-time cost of equipment. This paper will give an introduction to the basics of TPM, discuss the major parts of EEM, and evaluate the lessons learned from the team's first effort to execute the structured process on a major project.

Introduction

In today's competitive environment being innovative is more important than ever and often imperative for survival. Doing things the same way they have been done for the last thirty years is not looking as promising as it used to. Plants reducing their staff due to automation and products moving overseas are not uncommon headlines to be seen in trade magazines. In 2006's survey of the State of Food Manufacturing Study given by Food Engineering Magazine, all respondents stated their companies had a continuous improvement program in place. The top five issues facing food manufacturing companies included Continuous Improvement Programs. Only plant technology improvements and automation, consolidation, energy costs, and consumer demand for healthier and more nutritious products succeeded the improvement programs (Higgins, 66). Corporate executives are looking for programs that drive results and lead their organization towards the future.

Today's corporate executives are directing continuous improvement programs such as Six Sigma, Lean Manufacturing, Total Quality Management, and Total Productive Maintenance just to name a few. This paper will focus on the benefits of TPM. TPM brings together maintenance, quality, production, and engineering early in the design process to ensure everyone's needs are acknowledged and the best decisions for the company are made.

The goal of project management is to complete the project on time, within budget, at the desired performance level while using the resources allocated to the project. In a perfect world this would be achieved with every project.

Unfortunately, projects do not attain the desired results the majority of the time. TPM's Early Equipment Management Pillar uses good project management skills as the base of its knowledge. The most important part of EEM is the design phase of a project. The design phase is where the project team plans the project and incorporates ideas from maintenance, quality, production and engineering. Successful projects are completed efficiently and project teams receive buy-in from production and maintenance when all parties are involved from the beginning.

Literature Review

Introduction

A Literature Review was used to research Early Equipment Management (EEM) and Total Productive Maintenance (TPM) to determine the information available on these topics. There is a great deal of documentation about how to successfully implement TPM, failed implementations, and how to document and predict the plant's Overall Equipment Effectiveness (OEE). Unfortunately, there was neither a great deal of information about how to implement the EEM Pillar nor the importance of the human factor in designing equipment lines at a manufacturing plant.

The majority of the references are more than ten years old. This is because TPM in America was introduced to large companies at that time and has since lost its luster. Some of the U.S. companies who have received the TPM Excellence Award include Ford Motor Company, Harley-Davidson, Boeing, Procter & Gamble, and Unilever. According to the JIPM website, in 2006 no U.S. plant was recognized out of the ninety who received a TPM award. 2005 was almost as scarce with only one U.S. plant receiving an award. Today more U.S. companies are concentrating their efforts on continuous improvement programs such as Lean Manufacturing, Just-In-Time, and Six Sigma.

Background of TPM

"An enhanced approach for implementing total productive maintenance in the manufacturing environment", published in 1997 by Benjamin S. Blanchard was reviewed. The author gives an excellent overview of what TPM is and why

the philosophy is implemented in manufacturing organizations. The paper's concepts were combined from several previous papers on the same topic. It was concluded that although the TPM concept focuses on the OEE of plants and improving system maintenance where the focus should be is on the effectiveness of new equipment. The area of focus Blanchard highlights is Maintenance Prevention and Maintainability Improvement. These can be best accomplished through continuous improvement activities and design analysis of new equipment. Maintenance personnel, engineers, and production managers should be involved in the analysis of the both the system and each part of the process. This field project will discuss how these same concepts were used in the design of a manufacturing line.

The Japan Institute for Plant Maintenance published "TPM for Every Operator" in 1994. JIPM uses the various stages of maintenance to define how TPM evolved. Illustrations are used frequently to show what happens to machines over time without a strong TPM program in place. The perspective used is machines do not break themselves, operators' neglect does. TPM strongly supports operators are essential to the success or failure of a firm. In addition, the author pushes eliminating breakdowns to increase the machines OEE. Safety is also covered in great detail. Activity boards and training for new and existing equipment need to be active in the plant. The book's center of attention is on new equipment, not rebuilding old equipment which is the focus of this Field Project.

Basics of Early Equipment Management

“Equipment Planning for TPM” by Fumio Gotoh covers many facets of Early Equipment Management. The in-depth look into Early Equipment Management focuses on how to implement EEM as a combination of equipment design and product development. Several case studies and charts used to implement the program and are examined in the book. TPM is a data-driven concept and the author brings all of the concepts discussed in the book back to the importance of data collection. Another significant aspect of EEM is designing equipment that has non-defective conditions. In other words, the equipment must include devices that can be trusted not to produce defects. All of the TPM pillars are interrelated and this is where the EEM Pillar overlaps with the Quality Maintenance Pillar. In the Quality Maintenance Pillar this concept, called a Poka-yoke, originated from Shigeo Shingo which is loosely translated as mistake-proofing. Designing quality into the equipment early is important and is balanced using the life cycle cost methods. The methods are explained using thorough charts and figures. This field project will focus on the aspects of EEM that relate to equipment design.

“TPM in Process Industries”, published in 1994 by Tokutaro Suzuki presents a general overview of TPM. However, the author’s comprehensive process expands upon the need for early equipment management. This is completed by using Life Cycle Costing (LCC) and Maintenance Prevention Design or MP Design. These processes benefit new equipment projects in process plants. If the two are not incorporated in the planning portion of a project, operating and maintenance costs will be elevated over the life of the

project. Another important aspect of EEM is design reviews. Teams who conduct MP Design activities continue to do so during the entire length of the project from inception to completion. In addition, it is discussed how various stages of early equipment management evolve through a flow diagram. The flow diagram leads to the goal of EEM which is to achieve a vertical start-up when commissioning new equipment. This is defined as one that is fast, free of bugs, and right the first time. The book is well known in the industry and is recommended by JIPM for companies starting a TPM program.

The Human Factor

“Human Resource Management, Manufacturing Strategy, and Firm Performance”, published in 1996 in the Academy of Management Journal demonstrates a continuous improvement program such as TPM is beneficial to a company. A study conducted by the authors examined the human factor at ninety-seven plants. Before this study much of the scholarly information available was unreliable as what was taught did not match what was practiced in the real world. Several hypotheses were tested to determine if the human factor added value when adding capital improvements.

Best practices in Human Resources were compared to determine the relationship between them and manufacturing strategy and performance. A large number of the best practices mentioned in this paper are also part of TPM such as formal training, quality circles, production teams, information sharing, employee ownership, empowerment and problem-solving groups. Although the authors do not reference TPM, Total Quality Management is discussed and encouraged. The study found incorporating a continuous improvement program

that focuses on multi-functional teams improves employee productivity, machine efficiency, and customer satisfaction. The paper gives emphasis to the importance of incorporating operators and maintenance personnel to equipment design changes and purchases which is part of ABC Company's EEM program.

Because production operators are the heart of an organization, Kunio Shirose wrote "TPM Team Guide" in 1995. The book was written specifically for operators to read. TPM is an all inclusive program and relies on everyone for a successful implementation. One must not forget how important the operator is in a manufacturing environment and how they must know their equipment better than anyone else. The human factor is addressed strongly in the book. The basics of TPM and the importance of active involvement from operators to top management are strongly enforced. Great emphasis is placed upon how the teams' primary goal is to eliminate the six big losses. Some of the team-based concepts in the book are simple yet sometimes overlooked. Many of the theories and team-based concepts referenced in this book are incorporated into ABC's TPM program.

Continuous Improvement

Kevin Higgins, the author of "State of Food Manufacturing", published in 2006 drives the point that continuous improvement in food manufacturing today is extremely important for survival. The focus of the article is about the annual survey Food Engineering Magazine publishes. The survey questions engineers, operations managers and R & D personnel about continuous improvement programs and what percentages of their companies are implementing them.

Another topic discussed is the need for better maintenance management systems. Besides purchasing maintenance management software there is an ever pressing need for more training as companies are downsized. The author completes a brief overview of the food manufacturing market today. This article is one of the few recently published articles on continuous improvement that is relevant to the food industry. ABC Company implemented TPM as a continuous improvement program to help structure the plants to overcome some of the problems stated in this article.

Literature Review Summary

In summary, TPM was introduced to the United States in the 1980's and was implemented at many plants in the 1990's. Because of this, most of the information available is over ten years old. One reason no one has written anything new about the subject might be the fact that there are many other improvement programs that are more popular to American industry today. The majority of the books discussed in the literature review were originally published in Japanese then translated to English. The translation is sometimes difficult as it is written from the theoretical Japanese manufacturing perspective and TPM is individual to every company and culture.

The books give a good overview of how TPM should work in a manufacturing organization but do not take into account the human factor. The topic of this paper was chosen to objectively review the EEM concept from a practical point of view. This paper will focus on the importance of a strong project management methodology using equipment reviews at five stages of the

equipment life cycle involving everyone in the plant from the top management to production floor employees.

Chapter 1: TPM and the Eight Pillars

History of TPM

The history of Total Productive Maintenance developed from various types of maintenance philosophies. In the 1950's, Japanese industries were introduced to the practical uses of Statistical Process Control by the teachings of Dr. Deming and the concepts of Preventive Maintenance, which are an important part of TPM today. In 1960, Nippondenso, a Japanese manufacturer of automotive components, first introduced plant-wide Preventive Maintenance (Robinson, 5). This program was initially introduced to support Total Quality Management. In 1964, a system for awarding Preventive Maintenance awards was launched (JIPM 2006). As Nippondenso became more automated, maintenance mechanics were needed more frequently. Thus, the company created the idea of autonomous maintenance where the operators maintain their equipment on a daily basis leaving maintenance personnel for difficult or emergency maintenance. Because the maintenance department had more time on their hands, the team was able to focus on improving equipment reliability or Maintenance Prevention. In 1971 Nippondenso was the first plant awarded the TPM Excellence Award by the Japanese Institute of Plant Maintenance (JIPM).

The credit to creating TPM was given to Seiichi Nakajima, an engineer from Japan. Seiichi is known today as the Father of TPM (Robinson, 1). Seiichi described his thoughts on equipment in the 1960's (Witt, 43) as the following:

The state of the equipment and processes that support the maintenance system in a facility are what need to be fixed, first, before

other process improvements can be undertaken. A large percentage of quality output is related to the condition of the equipment that builds the product.

“Total” in TPM came from total employee participation. Japanese plants began implementing TPM in the 1970’s (Wireman, 6). Nakajima wrote many books on TPM in the 1980’s. Volvo Europe began using the TPM philosophy in 1987 (Robinson, 7). The company achieved the honor of being the first company outside of Japan to achieve the TPM Achievement Award by JIPM. Since then, many companies in the United States and around the world have implemented TPM. TPM is difficult to put into practice because of the cultural change involved in the process of introducing the method of achieving operating excellence. Some of these companies include Unilever, Procter & Gamble, Harley-Davidson, and Ford Motor Company.

The definition of TPM according to JIPM (2004) includes the following five points:

1. TPM aims at building a corporate structure that thoroughly pursues production system efficiency improvement or OEE.
2. TPM constructs a system to prevent every kind of loss by promoting the concepts of zero accidents, zero defects and zero waste, based on Gemba (actual site) and Genbutsu (actual thing) over the entire life cycle of a production system.
3. TPM covers all departments including production, research and development, marketing and administration.

4. TPM requires involvement of the entire company from top management to production floor employees.
5. TPM achieves zero losses by overlapping small-group activities.

TPM Today

TPM is a Japanese approach to improve maintenance management in process industries. Most companies implement TPM or a similar continuous improvement program to enrich their company as a whole. With increased global competition many companies look to TPM to improve productivity and employee moral at the same time.

TPM is about communication. It mandates that operators, maintenance people and engineers collectively collaborate and understand each other's language (Witt, 45).

TPM is implemented by everyone in a company from the top management to equipment operators. The idea behind TPM is to maximize OEE using small teams that focus on the goal of zero defects (Productivity Press, 11). Most companies will concentrate on reducing the six major losses which are breakdowns, set up and adjustment losses, idling and minor stoppages, reduced speed, defects and rework, and startup and yield loss.

Many companies acquire the help of industry consultants when implementing the many facets of TPM. The Japan Institute of Plant Maintenance (JIPM) is one of the most well-known. JIPM defined the following five strategies for TPM as stated in TPM In Process Industries, 1994:

- Maximize overall equipment effectiveness

- Establish a comprehensive Preventive Maintenance (PM) system covering the life of the equipment
- Involve all departments that plan, use, and maintain equipment
- Involve all employees from top management to front-line workers
- Promote PM through motivation management

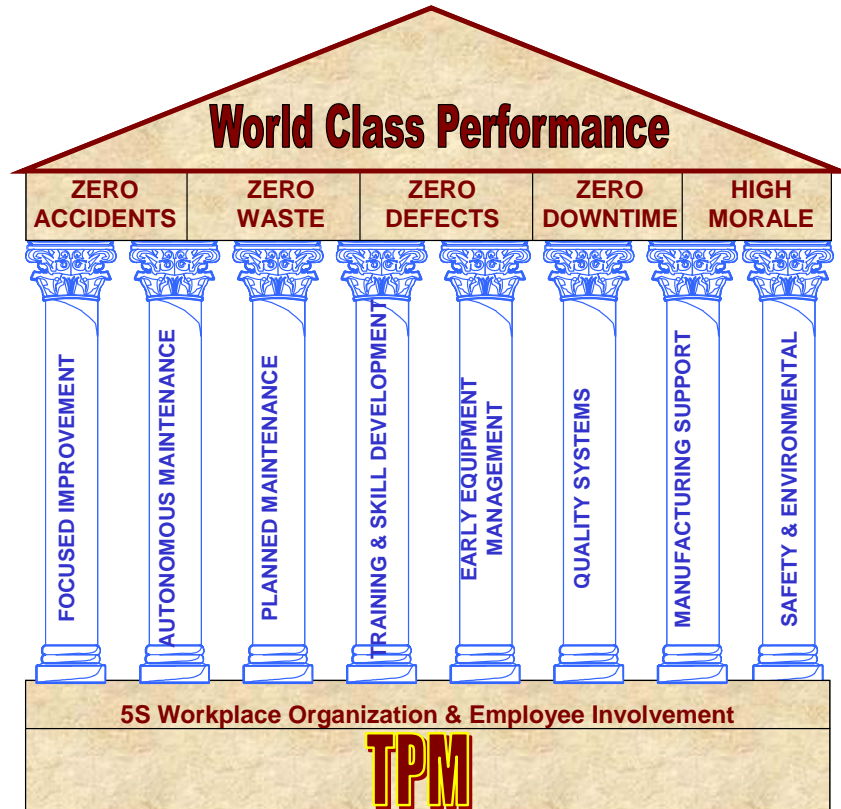


Exhibit 1: Eight Pillars of TPM

TPM introduces eight pillars to support its structure. The pillar champions are from various groups within the company and are appointed because of their expertise in the specific subject. The objectives of each pillar champion are listed below:

Pillar	Pillar Objectives
Focused Improvement	Eliminate all losses and demonstrate the ultimate state of production efficiency improvement.
Autonomous Maintenance	Educate operators in equipment operations and maintenance while teaching them to maintain their own equipment.
Planned Maintenance	To improve the efficiency of maintenance activities to prevent the seven major losses (failure, setup, replacement, start-up, minor stoppage, speed reduction, and defect).
Training	To improve the skill level and technical proficiency of all employees while improving their morale.
Early Equipment Management	Shorten the equipment development and product development cycle as well as perform vertical start-ups on equipment.
Quality Maintenance	Achieve zero defects by maintaining equipment condition.
Manufacturing Support	To achieve zero waste, zero downtime and improve the cleanliness of the facility.
Safety, Health and Environmental	To reduce the accident rate to zero and create a healthy place to work.

Exhibit 2: Objectives of Eight TPM Pillars (Ishibashi, 2004)

Although all pillars are indispensable to the TPM process, this paper concentrates on the fifth pillar, Early Equipment Management. The EEM pillar spearheads major projects to ensure the methodology is in place to achieve project success.

Chapter 2: Early Equipment Management

The basic concept of Early Equipment Management (EEM) is to design a system from inception to completion in the shortest amount of time that will produce quality products. EEM involves management, engineering, quality, maintenance, and production personnel to achieve the team's goals. Expanding plant flexibility and increasing the capacity of a plant are two ways EEM creates a more competitive plant. Some other benefits include improving the safety, reliability, maintainability, and operability of the equipment in the plant at the same time. EEM is a controlled method to design new and improve existing equipment.

Life Cycle Costs (LCC), MP Design, Vertical Startup, and Quality Assurance are the four main parts of EEM. Designing quality assurance into the system encompasses finding all possible defects that could affect the quality of the product and delay startup in the initial design phase of a project. Another important part of the initial design of a system is minimizing the life cycle cost of the equipment involved. This can be accomplished through four different methods. It depends on the industry and whether the cost of the initial investment is more important or the cost of maintenance over time is more important in which method is chosen. The four methods are Minimum Initial Cost Design (IC), Minimum Running Cost Design (RC), IC-RC Reduction Design, and LCC Design Under Uncertain Circumstances (Gotoh, 16).

Because of today's market and extreme global competition, flexibility can be considered one of the most important attributes in a production line.

EEM Strategy

It is not uncommon to hear that the plant engineer does not have any common sense. This is because many engineers design their equipment or processes based on a mathematical calculation or how the process theoretically should work and not how the process actually will work. EEM uses everyone's eyes and ears from all departments when making changes to a facility.

The core of EEM's spirit is Maintenance Prevention (MP) Design. JIPM defines maintenance prevention as the use of the latest maintenance data and technology when planning or building new equipment to promote greater reliability, maintainability, economy, operability, and safety, while minimizing maintenance costs and deterioration-related loss (Gotoh, 72). In general, MP Design concentrates on minimizing operational problems in equipment by making it defect-free equipment from the start. Design reviews are completed at every stage of the equipment's life cycle that concentrates on the safety, ease of quality assurance, reliability, maintainability, and operability of the equipment. When an engineering team is deciding what equipment to purchase for the project the team looks at equipment available in the market, the throughput or capacity, equipment specifications, ongoing costs (labor, raw material yields, maintenance costs and energy costs), and the budget. It is important to have a MP Design checklist to go through when designing or purchasing new equipment. Some points of interest might be if there are hard to inspect or lubricate places, easily accessible filters, and centralized greasing points that are easy to reach. Many of these maintenance burdens can be simplified if the engineering group works with the equipment manufacturer to engineer out these design flaws.

MP Design needs a strong Computerized Maintenance Management System (CMMS) to understand where the bulk of the maintenance costs for the equipment are. If the equipment up for discussion is in house the engineering team can consult the maintenance software.

The equipment life cycle model begins with evaluating the equipment need. This is where the bulk of the debugging activities will take place. The easiest place to catch design flaws is in the initial phase before the equipment is purchased and shop drawings have been signed. When a company is evaluating the need for a certain piece of equipment it is important to understand both the sales/marketing plan as well as the production requirements for this particular machine. One place some companies overlook is maximizing the plant's capacity before purchasing new equipment. Even though the old equipment does not look as nice as new equipment it might be debottlenecking material.

Safety is high on a plant's list of priorities and is normally number one. EEM uses intrinsic safety design focusing on creating an accident-free environment. Engineers need to look at the design of new equipment and discuss ways they could get hurt using the equipment. The engineers could then take the list and begin designing out these potential problems starting with the ones that could cause the most human harm. This is also an excellent time to discuss all the lockout/tagout points on the machine, determine how much safety training is necessary and if there are enough warning stickers. The idea is to make the machine "fool proof".

The vertical startup of a system is also extremely important in EEM. When starting a piece of equipment or a complete system it is important to have the shortest startup that is right the first time. In order to accomplish the challenging task, the project team must have completed a few vital steps. At ABC Company, the steps consist of design reviews during the first three stages of the equipment life cycle process, equipment test runs, operator and maintenance training and production acceptance of the equipment. Below is an example of a vertical startup diagram developed by Mark Whitman, XYZ's TPM Internal Consultant.

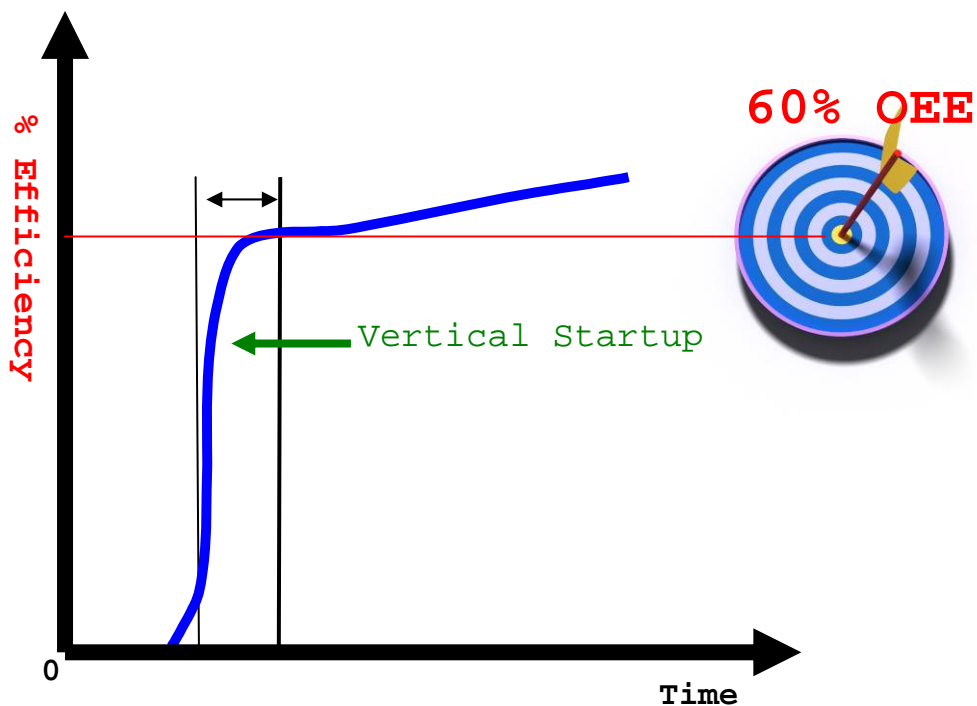


Exhibit 3: Example of how time relates to the equipment's OEE in a vertical start-up

Early Equipment Management and Project Management

Early Equipment Management is similar to a strong project management skill set. The project manager is the Pillar Champion who leads the team to success. The project team is the EEM steering committee which includes groups outside of engineering such as quality, production, and maintenance. The project sponsor is the TPM Coordinator. The relationship between all the players and the project stages is seen below in Exhibit 4.

Project Management	Early Equipment Management	Who's Involved	Pillar Champions
Concept Phase	Evaluate Equipment Need	sales, marketing, upper management, project sponsor	EEM
Definition Phase	Design/Modify & Purchase Equipment	maintenance, production, engineering, vendors	EEM, PM, AM, QM
Production Phase	Build, Install & Startup	maintenance, production, engineering, vendors, contractors	EEM, PM, AM, QM, T, MS
N/A	Operations & Support	maintenance, production	EEM, PM, AM, QM, T, MS, FI
N/A	Decommission	maintenance, production	EEM

EEM = Early Equipment Management

PM = Planned Maintenance

AM = Autonomous Maintenance

QM = Quality Maintenance

T = Training

MS = Manufacturing Support

SHE = Safety, Health and Environmental

FI = Focused Improvement

Exhibit 4: Relationship between Project Management and EEM

EEM as it relates to project management focuses on the Equipment Life Cycle (ELC). The life cycle has five stages which includes design reviews at each major step of the equipment from inception until their timely decommission. On the other hand, the project management methodology focuses more on the front end or planning of a project.

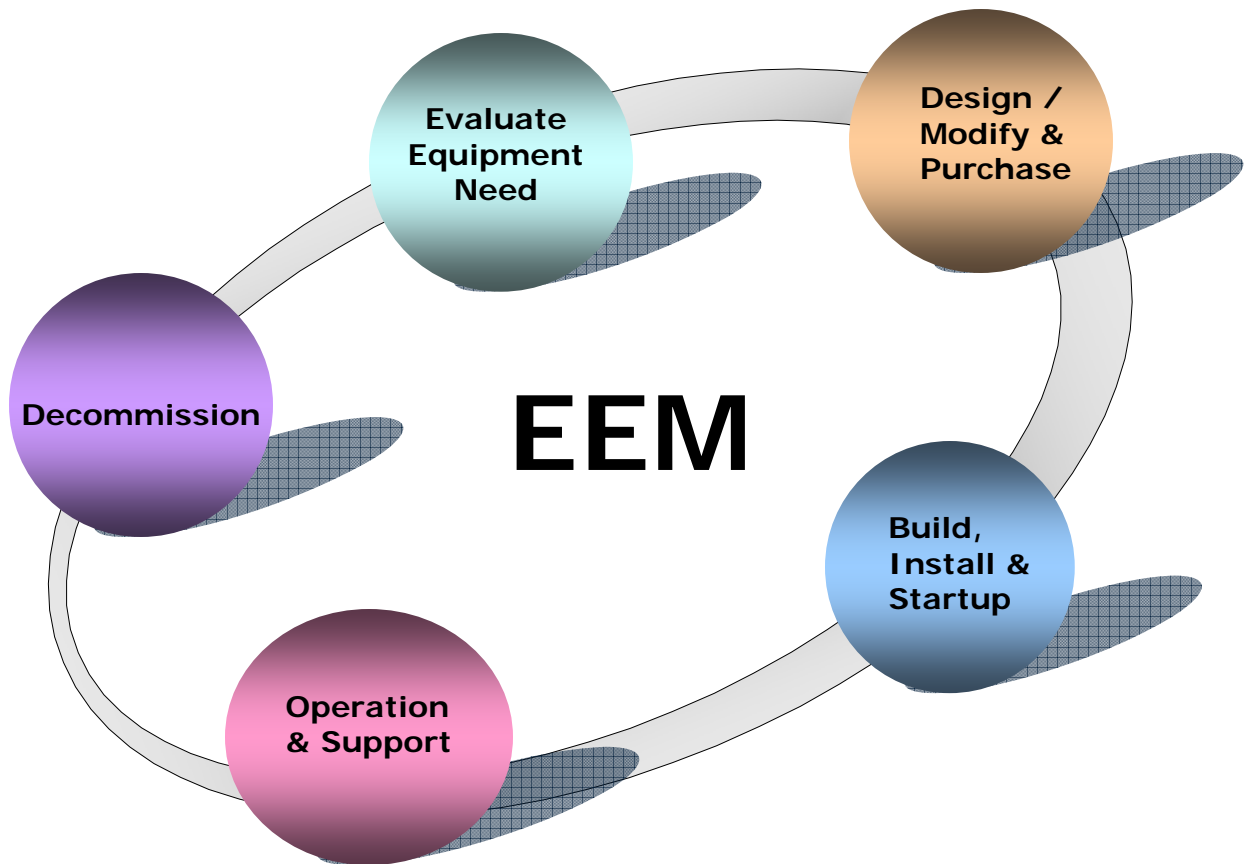


Exhibit 5: Equipment Life Cycle and Methodology used at ABC Company

Evaluate Equipment Need

The first stage Evaluate Equipment Need, is similar to the project Concept Phase in project planning. This is the most important stage in the ELC. In this stage the EEM steering committee determines whether or not a new piece of equipment or production line is necessary. To accomplish this, the team must talk with sales, marketing, and upper management to see what is required for the equipment both today and in the future. After researching the equipment necessary, it is important for the team to look at the equipment in the plant. Can the equipment be retrofitted or debottlenecked to meet their specifications? The critical decision factors when purchasing new or upgrading old equipment includes specifications such as line speed, number of SKU's, as well as types

and variety of products produced. If it is determined that new equipment is the answer, the Project Manager must research and offer alternatives to the EEM steering committee at the first design review. At this review, a rough timeline and estimated costs will be presented with each alternative. After the Capital Project Request is approved, the team can move to Stage II, Design, Modify, and Purchase New Equipment.

Design/Modify and Purchase Equipment

The second stage of the ELC is similar to the Definition Phase of project planning. This stage is extremely critical because risk is evaluated, project costs are determined, and the project plan is finalized. The Life Cycle Cost (LCC) of the equipment is the sum of the acquisition cost of the equipment and the on-going costs. Some examples are listed below.

- Design
- Installation
- Start-Up
- Downtime
- Programming
- Spare Parts
- Training
- Preventive Maintenance
- Emergency Maintenance

In order to complete a thorough analysis of the maintenance piece of the ELC, a company must have a good equipment maintenance tracking program in place. In addition to maintenance costs, the steering committee must also look at any Maintenance Prevention (MP) Design sheets that have been completed on similar equipment in the plant. If the equipment is new technology for the plant, it is essential that the Project Manager tests the equipment to ensure the equipment is able to produce the company's products at their desired rates.

After all of the important information has been collected, the group meets in a second design meeting to discuss what changes need to be made to the equipment the plant is planning to purchase. Maintenance and Production personnel must be present for an effective meeting. The group looks at several factors in the meeting including equipment reliability, maintainability, flexibility, availability, safety, and economy. At this point in time it is good to complete a risk analysis and HACCP review on the equipment.

The Project Manager combines all the information to create an equipment specification for each vendor. This includes the equipment rate, detailed vendor and engineering specifications, required ship date, training, and start-up if necessary. When the vendor agrees to the equipment specifications, the Project Manager can sign the purchase order for the equipment.

Build, Install and Startup Equipment

The third stage of the ELC is to Build, Install, and Start-Up the equipment which is analogous to the Production Phase in project planning. Depending on the costs of the equipment the Project Manager should visit the vendor several times to guarantee the engineering specifications are met and any potential mistakes are fixed before shipment. Delays in shipment can push the critical path of a project. Maintenance is heavily involved during this stage and works with engineering to complete the PM sheets, order spare parts, and complete training manuals.

After the equipment arrives at the plant, the installation is as important as the equipment itself. Design reviews for each piece of equipment should take

place at this time to determine the Autonomous Maintenance procedures needed. One-point lessons should be completed on all inspection, lubrication, and lockout/tagout points. Equipment labels should be created at this time including lockout/tagout and predetermined set-points.

The key to a successful EEM program is achieving vertical start-up. The EEM steering committee needs to work with engineering to certify all equipment has completed an I/O and motor rotation check and all manuals have been written or handed over to maintenance and production. The ideal vertical start-up would be completed in the shortest amount of time running at full production rates without any modifications to the equipment.

Operation & Support and Equipment Decommission

Operations and Support is the fourth stage of the ELC. Most engineers and project managers do not assist with this stage because the equipment is now under the umbrella of production and maintenance. The Planned Maintenance (PM), Autonomous Maintenance (AM), and EEM pillar champions work together during this stage. The three pillar champions certify preventive maintenance work orders are being completed, operators are trained and performing AM on the equipment, and the failures are being documented properly. Documenting failures is vital because TPM is data driven and if bad data is inserted into the system, the system will not perform to specifications.

The entire plant is involved during the Operations and Support Stage through focused improvement teams. These teams look at opportunities found by operators who use the equipment daily. The opportunities improve the

system as a whole and are documented on MP Design sheets for future projects. The final stage is decommissioning of the equipment. This includes selling or scrapping the equipment and cleaning up the area to look new again.

What does EEM do for ABC Company?

A corporate objective brought TPM to ABC Company. The company has used this philosophy to create a stronger, more creative project environment.

ABC Company's Mission is to be the leader in the finest quality baking and food ingredients.

Delivering:

- *Innovative solutions*
- *Technical expertise*
- *Endless customer service*

In order to accomplish the company's mission, EEM must be an intricate part of every day business. EEM involves maintenance, quality, and production in addition to engineering to design safe, reliable, and maintainable systems. EEM involves all departments through a structured process to ensure a vertical start-up, one which is capable of a one-shot startup and therefore requires only a short commissioning period (Suzuki, 218). EEM emphasizes a strong project management approach which directly improves a plant's OEE.

The objective of EEM at ABC Company is to embrace the TPM philosophy to improve project management. The engineering group uses design reviews to pool ideas from groups outside of engineering to improve equipment designs based on what actually works on the production floor. The EEM team has

addressed concerns from maintenance and production by modifying equipment at the manufacturer. In addition, ABC Company has introduced MP Design sheets to track changes to existing equipment. The EEM pillar champion works closely with the Preventive Maintenance, Autonomous Maintenance, and Quality Maintenance pillar champions to continually improve the process.

Chapter 3: Kansas Avenue Phase III Case Study

Introduction

XYZ, ABC's parent company, purchased Unilever's European Bakery supply division in 2000. Unilever has many plants heavily involved in the implementation of TPM. XYZ became aware of the benefits first-hand after the acquisition and began executing the philosophy at several plants in the states. The benefits included plants that were more organized, had stronger maintenance departments, and a team-oriented problem solving workforce.

In July of 2003, ABC Company made the decision to introduce TPM at the Kansas Avenue plant. The newly hired TPM Coordinator, eight pillar champions, and three production workers were trained for three weeks in Kansas City on TPM basics. The team selected a pilot line to kick off TPM. The team completed an initial cleaning of the line, generated one-point lessons, and created safety tags. After a few months they added a second production line. At the time, JMAC was hired to prepare the plant for the TPM Pillar I award but not audit their progress along the way. JMA Consultants Inc. (JMAC) is a group of consultants that started as an independent entity in the consulting department of Japan Management Association in 1980. The consultants visited the plant monthly.

In the spring of 2004, JIPM visited the plant for the first time to determine the plant's progress towards the Pillar I award. They critiqued the pillar champions and the plant in general on what they were doing well and what they could do better. After the TPM Coordinator did not receive the buy-in necessary for a successful TPM program, he left the company in May 2004.

In July of 2004, a new TPM Coordinator was hired who had excellent people skills and was excited to lead the group into the world of TPM. At this point in time there was a complete turnover in management and new pillar champions were announced. The TPM leaders and three production employees (one from each shift) were trained for three weeks in Kansas City through JMAC.

By this point in time, two new production lines had been installed replacing unreliable equipment and the building had been upgraded. One of the new production lines was appointed the new TPM pilot line. About a month later an initial cleaning and TPM kickoff commenced. A new vision was in place and the pillar champions were considered “internal consultants”, available to answer questions from other plant employees whom were not familiar with the benefits of TPM.

One key to success is identifying and measuring the right factors. TPM thrives on Safety, Morale, Quality, Cost, Delivery, and Production deliverables. In January of 2005, Autonomous Maintenance standards and policies were introduced to support the deliverables. Key Performance Indicators or KPI's were also established to show employees what should be measured and why. This reinforced the importance of the plant's OEE which is crucial to the success of a TPM plant.

By the spring, most of the pillar champions were substituted out because of changes in roles. TPM was rolled out for the north end of the building which included three production centers. Autonomous Maintenance teams were formed to begin the initial cleaning of all first floor equipment. In March, JIPM

visited the plant again to record the progress. JIPM assigned tasks for each of the pillar champions to achieve before the next visit. By September it was time to reorganize a few of the pillar champions because of changes in management. Most pillar champions had switched three times by this point in time. The change in pillar champions really dampened the progress of two very important pillars: Autonomous Maintenance and Preventive Maintenance.

In 2006, new KPI's were introduced to focus everyone on what was best for the company using TPM measures. The KPI's focused on OEE, defect free production, inventory control, and cost/pound. The year started out to be a successful year with a week of training in January. Pillar champions from several plants across ABC's parent company XYZ attended the Atlanta training and a second training was held in Kansas City in June. JIPM visited Kansas Avenue twice in 2006, both times with excellent remarks and looking forward to the future.

The goal for any company operating under the TPM Philosophy is to achieve the TPM Excellence Award. The target set by ABC Company to achieve this award is 2008. The plant has seen a great deal of turnover in key roles. The TPM Coordinator's job is no easy task to keep the pillar champions on point while managing change. In addition, the company has merged with a sister company and acquired another company since the last JIPM audit. In order to ride the giant wave to shore instead of being taken down by the undertow, the team must bond together now to achieve their combined goal of a TPM Excellence Award.

EEM Methodology at Kansas Avenue

Obviously, TPM had a rough start at the Kansas Avenue facility. This is not unusual as TPM is difficult to implement and there are many documented failures. In the second quarter of 2005, the first project EEM was introduced into was the Phase III project. This included installing two new production lines to produce enrichment blends for the flour industry as well as dry blends and concentrated bakery ingredients for manufacturers of consumer food goods.

When the project began a new EEM Pillar Champion was in charge of the project. At that point in time the person had little to no training on EEM. Nine months after the project began all pillars were trained on the many facets of TPM. EEM was only discussed for thirty minutes during the six days of TPM training.

The EEM steering committee focused on design reviews at three phases of the ELC during the project. Every major piece of equipment went through a Pillar V review or a design review of the equipment to decide if it was the best choice for the application. If the equipment was new to ABC Company, the team traveled to the vendor's site to test the equipment. This was especially important if the equipment was considered essential to the quality and integrity of the product. Most of the equipment chosen was based on equipment already installed in the plant and was the engineering standard.

The second Pillar V review included looking at all the design changes made in house, assessing the engineering standards, and a plant walk-through that included production, maintenance, and engineering. If the equipment was not in house and non-standard the Project Manager would visit the manufacturer

and possibly a plant where the equipment was installed. The equipment would then be evaluated and necessary changes would be addressed. The equipment design changes would be presented to the manufacturer to make certain the design changes would be implemented.

The EEM Pillar V review team would gather often to double-check all design changes were included and approve the engineering drawings. On all major pieces of equipment, equipment that costs more than \$50,000, the project manager visited the vendor for final approval before shipment. After the equipment arrived at the plant a Pillar V review was conducted to confirm the equipment would be installed safely and contractors understood installation specifications. In addition, maintenance and operator training documentation, one-point lessons, and equipment labels were assigned to be completed before start-up.

After the equipment was installed the EEM steering committee would complete a plant walk-through to compile a punch list. The punch list would be in Microsoft Powerpoint format including pictures and descriptions of what needed to be completed on the equipment.

6th Floor-Liquid Addition

- All totes need to be closed with lid and clamp
- Tote and stand need to be labeled
- VFD needs to be added to mixer motors to reduce vibration
- Install heat blankets on totes that need to be kept at a certain temperature





Exhibit 6: Punch list example

An example of a slide is seen in Exhibit 6. The two production lines were started up at different times due to delays in equipment arrivals. The first line was the most complicated and therefore the most troublesome. The second line started up with little problems.

Equipment Problems

Kansas Avenue's Pillar Champion chose to concentrate on equipment problems that had been identified and design them out of the equipment by working with equipment vendors. This was completed through word of mouth from maintenance, production, and engineering. There was no formal documentation system set up during the project duration to record MP Design changes or a solid record of PM and breakdowns. The main focus was to involve as many people as possible to obtain the most input in order to make the best decision. By the end of the project an MP Design Process was designed. An example of an MP Design sheet is below in Exhibit 7.

Link to MP Design Sheet Cover Page: #List of MP Designs!A1									
MP Record of Improvement									
TITLE: KS - Guages - Entire plant								M-P # 2006-006	
Background: Gauages were installed but no one knows how to use them.									
Originator: KS Ave. Pillar V Improvement Team								Date: 9/20/2006	
Equipment #					Equipment Vendor:				
Attribute Type:	Food Safety	Reliable	Operable	Maintainable	Economy	Flexible	Other: Easy to know if you are operating at the right pressure.		
		Operators Troubleshoot							
PROBLEM: The current bag dump station had unnecessary surface area, there are wires hanging down, painted motors, base and actuators.									
Existing Condition: Gauge is not marked so operator does not know if the pressure is in spec or not.					Corrective Action: Add a green, yellow and red area so the operator can identify if the pressure is within the right range. If not, they can contact maintenance.				
Picture/Sketch:					Picture/Sketch:				
									
Date:									
Area									
Operators									
Verify									

- Negative Aspect
- Positive Aspect

Exhibit 7: Maintenance Prevention Design Record of Improvement

Design Reviews

Design reviews were completed at least three times for each major piece of equipment ordered. The design reviews included the engineering team, the operations manager or team leader, maintenance supervisor, along with a few operators who were knowledgeable with the piece of equipment being purchased. If the equipment was in house, the team reviewed a checklist that asked questions about the safety, ergonomics, etc. The original Pillar V checklist is located in Appendix A of this Field Project. If the machine was not in house the Pillar Champion gave a presentation about the pros and cons of the machine including many pictures. A short presentation can be found in the Appendix D to show what the EEM team decided should be improved on the Accurate Feeder. Next, the EEM team would discuss essential design changes.

The team should have used different checklists for the various phases in the ELC instead of using the same one over and over again. Each design review is at a different stage in the ELC, therefore the team should have lists that refer specifically to that stage. After the conclusion of the project the EEM team redesigned the EEM process and checklist. A flow chart, multiple-stage design review questionnaire, and engineering drawing sign-off sheet can be found in the Appendix of this document.

Training

The first item on the EEM Pillar Champion's mind should have been training. The only persons trained on EEM are the eight Pillar Champions and members of the EEM steering committee. The entire maintenance staff should be trained at the very minimum because the maintenance staff must understand why it is important to fill out MP Design sheets properly. Secondly, the EEM Pillar Board is difficult to understand if a person hasn't received any training. An explanation next to each of the topics would clarify what the board means so that anyone in the plant that reads the information would understand.

Liquid Addition

The liquid addition clean area was designed from a team brainstorming activity on how to increase the safety and cleanliness of the area. The team focused on reducing product spills and transferring product safely. The new design used a tote transfer system where incoming totes would be placed in one of two pallet locations. This eliminated operators from raising totes up to gravity feed liquids from incoming totes to the stationary product totes. Lifting totes into

the air is dangerous for several reasons. First, the product could be hot or acidic and burn an employee. Secondly, the tote could fall on someone. A tote transfer system also reduced the amount of product spilled because it was a closed system. The stationary totes were



Exhibit 8: Liquid Addition Clean Area

also made 20% larger than the incoming totes so product could be transferred as soon as the tote was below a certain level instead of waiting until the tote was completely empty.

There were several design reviews covering the new liquid addition area. During the first couple of reviews the team improved the design by adding a location for agitation on each mixer in addition to the large man-way for inspection. The team also added agitators with VFDs to five of the six liquid totes. The totes had excessive vibrations when the agitators were run at full speed. In addition, a few of the incoming totes need to be agitated before the product is transferred to a stationary product tote. The team has been unsuccessful in designing a feature that is spill-proof because the agitator motor and shaft assembly is heavy and must be lifted out of the tote completely.

Fourth Floor Layout

Midway through the design phase of the project the EEM team observed



Exhibit 9: Full-scale Wood Hopper and Dump Station

the operators were not involved in the design meetings. Operators must be involved in the design process because they are the ones who understand their workstation better than anyone else in the company. Many operators can not read engineering drawings. In order to

compensate for this the team gave the operators a full-scale look at their

potential workstation. As you can see in the

above picture the EEM team designed a full-

scale wood mockup of a bag dump station and

a 120 cubic foot hopper. The cardboard laying

on the floor represents the top of the mixer

which is located on the floor below. The

operators moved the bulk hopper and hand

dump station to the location that would allow

them to be efficient at their job. The operators

felt a sense of ownership and appreciated that

management wanted their opinions.

the operators were not involved in the design meetings.

Operators must be involved in

the design process because

they are the ones who

understand their workstation

better than anyone else in the



Exhibit 10: Hopper and Dump Station Installed

In order to improve this idea for future use the team should leave an easel and markers to allow operators to make comments on the layout concerning what they like or dislike about the equipment.

CIP System

The Clean In Place system (CIP) was designed to reduce cleaning from 8-12 hours down to under an hour. The team had a company with CIP experience to devise and fabricate the system. The system was built on a skid with a gas-fired instant water heater, 500 gallon tank and a caustic metering pump. The team had been told to design a closed system because the company had plans to tear out the boiler and therefore could not be designed into the system.

When the engineering team brought in the technician from the gas-fired water heating company it was pointed out that the gas-fired water heater needed 3 lbs. of gas pressure and the plant was set up for 2 lbs. The entire plant had to be regulated at the higher pressure which cost additional funds and time.

Dry Ingredients Feeder

The engineering team had rented a small dry ingredients feeder for their in-house test from Accurate. When it was decided the project would move forward the EEM team asked Accurate to make some changes to the design of their feeder to meet the company's engineering standards. Accurate refused to comply and the engineering team found a new feeder supplier. K-Tron met all design specifications requested and offered some additional ideas. One included creating an agitator out of round tubing instead of flat bar.

The feeder was installed and a few days later the continuous mixer was receiving surges of dry material. The feeder had a manway door which revealed the agitator bent like a pretzel. Engineering responded immediately, requesting the company send the standard flat-bar agitator as this one was not engineered strong enough for the application. Engineering



Exhibit 11: 400 Gallon Tank and K-Tron Feeder

went over the design specs necessary for this application to insure the new agitator would meet the company's needs. The feeding company took two weeks to decide what was appropriate. One week later a flat bar agitator was installed. ABC Company had to pay contractors to install the agitator as K-Tron would only pay to make the new agitator. The second agitator failed only two weeks later. Again the company went back to K-Tron for a redesign and they informed the engineering group that it would be at least five weeks before they would have a new agitator to them.

K-Tron's insensitivity to the fact that a production line can not be down for five weeks forced the engineering group to have a local machine shop build a more robust version of the second agitator. The machine shop delivered the third agitator 3 days later while K-Tron shipped their third agitator seven weeks later. All of these delays in finding the right agitator cost ABC Company thousands of dollars in downtime and contractor time. This could have been

prevented if K-Tron and ABC Company had a stronger supplier/vendor relationship where they could analyze the situation and guarantee a fail-proof agitator.

First Floor Layout

The EEM team wanted to show the production floor how much room a new equipment line would take on the first floor. A local furniture store donated



Exhibit 12: Cardboard Box Layout of First Floor Equipment

cardboard boxes and the team made a full-scale model of all the packaging equipment. The operators changed the side they wanted to work on from the north side with the equipment operating from their left side to their right side to the south side with the equipment operating in the opposite direction.

This gave them more room to move around the equipment and allowed them to look towards the rest of the production area instead of at a blank wall. Job satisfaction is observed in various ways. The operators chose the best seat in the house.

Continuous Mixer

Moving a production line from a batch process to a continuous process is a huge step for any plant. The engineering group at the plant understood this and tested the mixer twice at the vendor before renting a



Exhibit 13: Continuous Mixer

full-scale production unit to run extended test runs at the plant.

The EEM team chose five products whose physical characteristics were the most diverse of all products run on the production line. All of the products ran well and passed quality control. The problem the plant faced after the equipment was installed is the team changed the discharge gate to a 4" triclamp gate for ease of cleaning and connecting to the CIP (Clean In Place) system. The change was never tested because it was a custom job and unfortunately caused product variation and production downtime.

Gantry Palletizer

The original scope of the project included a single station gantry-style palletizer. After the engineering group looked at the limits of the robot it was determined the gantry palletizer would need to include at least three stations to accommodate another line with double the rate of the original line. The gantry was chosen because of its simple design and the programming was easy to understand.

Before the order was placed for the gantry palletizer, three persons from the EEM team went to GE's light bulb plant in St. Louis where two eight-station



gantry palletizers were recently installed.

This gave the team members a chance to look first hand at the gantry running boxes and determine what could have been done better by talking with operators and fork truck drivers. When the gantry palletizer

Exhibit 14: Gantry Palletizer

was installed at Kansas Avenue a maintenance technician was assigned to work with the palletizer crew chief. The EEM team decided this would be an excellent way to get maintenance involved from the very beginning. Unfortunately, the idea backfired because the maintenance mechanic quit two weeks after installation. Even though this idea backfired, the idea will be applied in future projects.

What did ABC Company Learn from this Experience?

ABC Company took away many important observations from this process. First, the process was not perfect. In order to improve upon all the design issues that surfaced during the start-up of the equipment, the group gathered to make a list of questions that would have caught these problems earlier in the design process. This new process is located in Appendix C of this Field Project. Second, equipment changes asked of vendors must be extremely specific and documented. In the future, the group will take pictures and sit down with the manufacturer's representative to make sure they understand what is required of them. Third, operators and maintenance input is essential to the design process. Without the practical knowledge of these key individuals a system can not be designed for a vertical start-up. Finally, always test new equipment. It is difficult to determine how the large variety of materials will flow through the system without proper testing. Testing can lengthen the system design and customizing any piece of equipment can be both risky and rewarding. In summary, creating a strong vendor-customer bond will enhance the equipment buying experience.

Chapter 4: Summary

Early Equipment Management addressed some of the potential issues the engineering team would see during the installation and start-up of the two production lines. As EEM becomes part of engineering's every day life the benefits will be more prevalent. This project also included a lot of "news" which is usually deemed as not productive for a project. Some of the "news" on this project included the following:

- A new Project Manager to the company
- The project was planned by someone different then the Project Manager
- Change in the process from batch to continuous mixing
- Equipment "News"
 - CIP System
 - Continuous Mixer
 - Beta Machine-Bag Uncuffer / Sealer
 - Gantry-style palletizer

The Project Manager was new to the company and this project was the first one to attempt to implement EEM. The Project Manager had not had any formal project management or TPM training at the beginning of the project. The project was planned by another Project Manager who was transferred to another plant when the new person was hired. The third "new" was moving the process from batch to continuous mixing and came with a lot of anxiety from upper management. The project could be on the verge of the newest mixing technologies for the company or fail miserably. Because of the change in

process and the desire to change how “things had always been done” the EEM team purchased a lot of new equipment. In order to clean the continuous mixer, a CIP system was purchased. This would take the equipment changeover time from twelve hours down to less than one hour.

On the packaging floor there were three pieces of new equipment involved in the design of the new continuous system. First, the continuous mixer was new to everyone at the company. To overcome the anxiety of the mixer the EEM team took two trips to test the equipment at the manufacturer and completed a full-scale in house test running at full production rates of several key products. The second piece of new equipment on the packaging floor was the uncuffer/sealer. The vendor was the same for this uncuffer/sealer as it had been for the other two in house. The vendor redesigned this piece of equipment based on many customer problems including input from ABC Company.

The last new piece of equipment on the packaging floor is the gantry-style palletizer. In the past the plant had either used a Fanuc robot to stack the finished goods or hand stacked the pallets. The gantry-style palletizer was easier to use than the robot but it was still different than what operators and maintenance personnel were used to.

The project evaluated at Kansas Avenue cost \$3.4M to install two new equipment lines with an annual return of \$1.16M. At this point it is difficult to determine how much more the project will save over the lifetime of the equipment. Past preventive maintenance, emergency maintenance, and

equipment parts were not allocated to each individual piece of equipment through a sophisticated CMMS program.

In the future the EEM team will be able to extract data from CMMS to determine the cost savings for each piece of equipment. This will be accomplished by evaluating the Life Cycle Cost (LCC) of the equipment by spending more money up front. This will enable the company to buy equipment that is the best overall value. Design reviews completed at every stage of the equipment's life cycle concentrating on the safety, quality, reliability, maintainability, and operability of the equipment will guarantee success.

Lessons Learned

Every project close leaves the EEM team with the ability to learn from their oversights or missed opportunities. The EEM methodology is based on continuous improvement. The following opportunities for improvement are the lessons learned on the Phase III project at Kansas Avenue:

- In order to plan the project in the first stage of the ELC, front load the project with an assistant project manager.
- Test the equipment until the team is positive it will meet the needs of the company.
- Always have a vendor's technician on-site when starting up equipment that is new to production and maintenance personnel.
- Travel to vendor's site to sign off on engineering drawings if many changes have been made, or if the vendor is new to the company.

- Visit vendor 6 weeks before scheduled shipment to ensure all specifications are met.
- Complete a systems check before equipment ships from the vendor's location.

In addition to improvement opportunities, the EEM team also found events that worked well for the team and should apply to future projects. These include the following:

- Continue design review meetings at each step of the ELC.
- Bring new technology in house for extended testing to receive feedback from production and maintenance.
- Build full-scale equipment models for operators to design their workspace.
- Have maintenance personnel help with the start-up of equipment to give them hands-on experience of potential problems in a short period of time.
- Travel to other companies' plants to see equipment installed. Example: Trip to GE light bulb plant to observe gantry palletizer in action.
- Don't settle for the standard equipment model.

Clearly, the Phase III project combined the EEM methodology into the standard project management style used at ABC Company. The team did a good job of involving production and maintenance observations. In the past, only engineers with some upper management influence determined the equipment installed at the plant. Where the team could have been stronger is vendor management. The team should have been specific as to what they needed in the vendor-customer relationship. The team relied on emails and trips to the

vendor to ensure all changes were completed. This process would be more efficient if everything was documented up front and signed by both parties.

In the end, the project was an excellent learning experience for future projects. The team updated the EEM process and added a more thorough checklist as seen in Appendices B and C. The next step is to apply the lessons learned from this project to another major project. Before the project begins, the project team should review the opportunities for improvement from the Phase III project. Next, the team should set goals based on the lessons learned in order to not repeat some of the same dilemmas. If the team is able to overcome some of the previous challenges, the next startup will be vertical.

In today's competitive environment being innovative is more important than ever and often imperative for survival. ABC Company strives to succeed and is determined to be the leader in the finest quality baking and food ingredients. Part of success requires using a world-class method of achieving operating excellence. This paper covered the basics of TPM, discussed the major parts of EEM and evaluated the team's first effort to execute EEM on ABC Company's Phase III project.

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A. Original Design Review Document for Pillar V Process

Phase III – ABC Kansas Avenue Plant

TPM Pillar 5 Final Review of [APS Batch Mixers for PC-7 and PC-20](#)

Scope: To ensure that every piece of equipment purchased for Phase III meets or exceeds ABC's Engineering Standards and is essential for the future expansion and success of our business.

GENERAL

- What do you like most about this piece of equipment?
- What would you like to change about piece of equipment?
- If we have this piece of equipment in house, what have we changed on it since it has been in the plant?

FUTURE CAPACITY

- What is the maximum capacity for this piece of equipment?
- What would it take to increase the capacity for the future?

CONTROLS

- Do the operators find the PLC operator interface easy to use?
- What type of controls does the machine use?
- What do the screen print-outs look like?
- How does this piece of equipment fit in with the rest of the process flow?

CLEANING

- Does this piece of equipment meet our standards for ease of clean ability?
- How long will it take to clean this machine? How often?
- Does the equipment have spaces where dust or product would accumulate?
- What are your safety concerns about this piece of equipment?

MAINTNEANCE

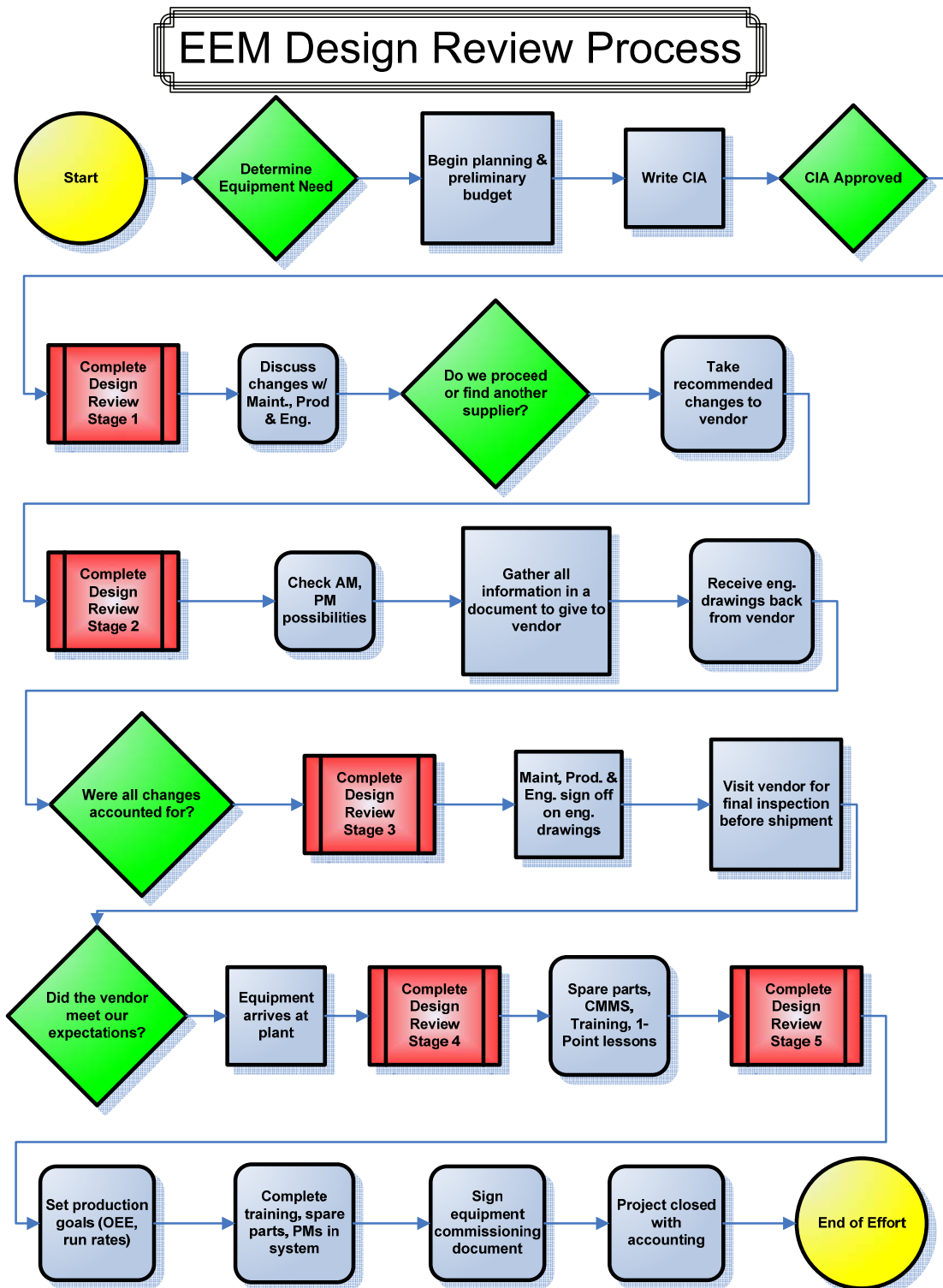
- Did we special order any part(s) on this machine? If so, will we have a spare part or how long will it take to get a replacement part on average?
- Will we be able to perform autonomous maintenance on this piece of equipment?

Additional Comments:

Changes that need to be made to complete Pillar 5 Review:

Date: _____
PC: _____
Author: _____

B. EEM Design Review Process Flow Chart



What are your safety concerns about this piece of equipment?

DESIGN REVIEW STAGE 1:

Note: This is completed before we have decided what equipment to purchase.

How good is the service from this company? If we currently own their equipment in the plant are they willing and ready to visit when we are having problems?

Will they include a start-up visit to ensure the equipment is working properly if we buy from them?

What visual controls are necessary? Can they make adjustments easier for operators? Can maintenance easily reach the lubrication points? Can they read the air pressure standing outside the machine without having to search the gauge?

Are they willing to label the equipment properly including any lockout/tagout points? Will they label lubrication points, air pressures, proximity switches, etc?

We must send the vendor pictures to show them how we would like this to look.

If the equipment is not in-house call three companies on their reference list to determine potential problems.

Consult the engineering specifications book to determine if there are any non-standard motors, belts, valves, etc used on this piece of equipment.

Receive spare parts list and review it with maintenance.

Request a spare parts list and see if the vendor will give some freebies to close the sale.

What is the availability of spare parts? Are they setting on a shelf in St. Louis or are they made to order from Germany?

Ask them if they are willing to sign a change order request. This will be the document that lists all changes made to the equipment with the agreed price.

Check with other XYZ sister companies to determine if they have worked with this vendor before and their experience.

Determine if we need to test the equipment before purchasing as this will need to be budgeted in for both time and money.

DESIGN REVIEW STAGE 2:

Note: These are all the items we need to look into or request changes in standard design from the vendor before engineering drawings are started.

Check through all the questions in Design Review Stage 1.

Receive a list of PM's required on the equipment.

What AM possibilities are there? Are the tools standard or can the equipment be modified so they only need their hands?

In order to set up the machine or changeover products an operator must complete certain tasks. Are these tasks operator-friendly? Can they be pre-determined before the machine arrives at the plant?

Pull maintenance records from the CMMS system if the equipment is in house to see where the problems are and fix them.

Is there any information in the MP Design sheets on this piece of equipment? Do the operators and maintenance personnel have any information on past changes?

How many products will be made on this machine? What types of products? Test the equipment if necessary.

Build a mock-up of the equipment to determine space allocation if necessary.

What is the material used for the equipment? 304SS, 316SS, etc. Is the motor stainless steel?

What are the disconnects/safety switches made out of?

Do the electrical boxes have cooling? Are they dust-proof? Simplify the wires, air hoses, etc. inside and around the machine. Ask the vendor to use larger conduit or make a plug-n-play design.

DESIGN REVIEW STAGE 3:

Note: This design review takes place when engineering drawings are ready to be signed off. If for any reason the engineering drawing does not meet our specifications do not sign.

Check through all the questions in Design Review Stage 1 and 2.

Double check all changes were made on the engineering drawing. Follow a checklist created in stages 1 and 2.

Standardize! Check motors, parts, tools, etc.

Visit another manufacturing site that is running this piece of equipment if we do not have it in house. Talk to their operators and maintenance personnel to see what they like/dislike.

Revisit engineering standards to make sure the machine is in compliance.

Determine where to store spare parts, manuals and drawings that come in with the equipment.

Attach the engineering sign-off sheet to the drawing kept in the project file.

DESIGN REVIEW STAGE 4:

Note: This design review takes place after the equipment has arrived and before it is installed in the plant.

Review engineering drawing and checklist to ensure everything that was agreed upon between ABC Company and the vendor were completed.

Create 1-point lessons and equipment labels.

Begin writing up training manuals and determine training schedule.

Place spare parts, manuals and drawings in designated area.

Determine which maintenance personnel will help with the installation if necessary.

Begin CMMS asset management.

DESIGN REVIEW STAGE 5:

Note: Complete this design review before the equipment is commissioned.

Complete training for all maintenance and production personnel.

Set goals for production which may include OEE, equipment parameters and key products produced to set a clear hand-off between engineering and production.

Ensure maintenance has ordered all the spare parts.

Are all the cleaning material staged by the equipment?

Equipment Checklist:

Note: List all equipment changes that need to be completed on this piece of equipment.

1.

All of the above changes have been made to the equipment. We approve the engineering drawings.

	Name	Signature	Date
Maintenance			
Production			
Engineering			

D. EEM Pillar V Design Review Example

Figures 1 – 4: EEM Pillar V Meeting on Accurate Feeder

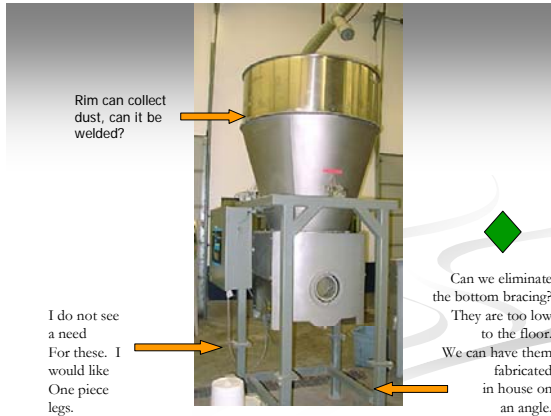


Figure 1: Front View

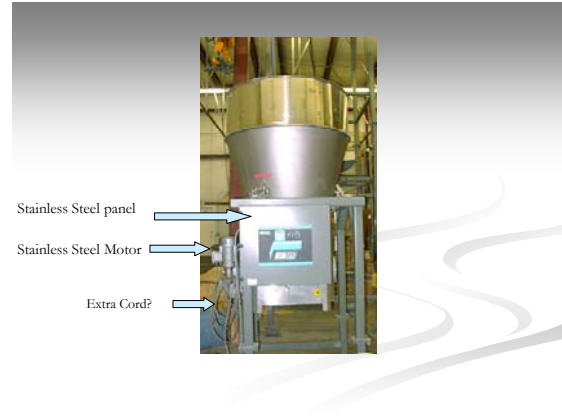


Figure 2: Side View

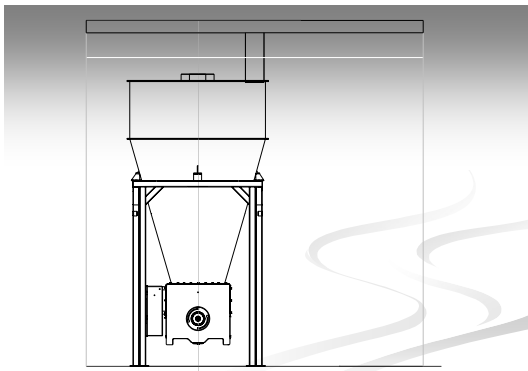


Figure 3: Engineering Drawing

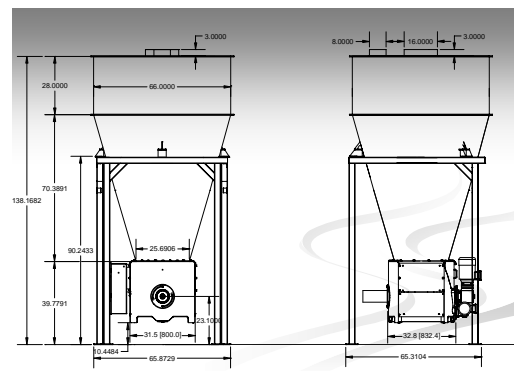


Figure 4: Feeder Dimensions

E. Microsoft Project Plan for EEM in 2007

Microsoft Project Plan for Early Equipment Management in 2007

ID	Task Name	Duration	% Complete	Start	Finish	% Complete	2007									
							Half 1, 2007	Half 2, 2007								
							F	M	A	M	J	J	A	S	O	N
1	Early Equipment Management Master Plan	515 days?	29%	Tue 3/14/06	Mon 3/3/08	29%										
2	Pillar Organization	1 day	100%	Tue 3/14/06	Tue 3/14/06	100%										
3	5 Phases of EEM	515 days	21%	Tue 3/14/06	Mon 3/3/08	21%										
4	Gather information about the 5 phases	30 days	100%	Tue 3/14/06	Mon 4/24/06	100%										
5	Understand the 5 phases of EEM	15 days	100%	Tue 4/25/06	Mon 5/15/06	100%										
6	Find out where we are today	30 days	100%	Tue 5/16/06	Mon 6/26/06	100%										
7	Determine how to document LCCs	90 days	0%	Mon 1/29/07	Fri 6/1/07	0%										
8	Maintenance to gather qualifying data	90 days	0%	Mon 6/4/07	Fri 10/5/07	0%										
9	Design a way to incorporate LCCs into new projects	60 days	0%	Mon 10/8/07	Fri 12/28/07	0%										
10	Train engineers in LCCs	45 days	0%	Mon 12/31/07	Fri 2/29/08	0%										
11	End of effort for EEM	1 day	0%	Mon 3/3/08	Mon 3/3/08	0%										
12	Vertical Start-UP	465 days	31%	Tue 3/14/06	Mon 12/24/07	31%										
13	Where we are today	15 days	100%	Tue 3/14/06	Mon 4/3/06	100%										
14	Design process for Phase III	30 days	100%	Tue 4/4/06	Mon 5/15/06	100%										
15	Document Phase III VSU	60 days	100%	Mon 9/4/06	Fri 11/24/06	100%										
16	Evaluate Phase III VSU	20 days	0%	Mon 1/29/07	Fri 2/23/07	0%										
17	Report Lessons Learned for VSU	10 days	0%	Mon 2/26/07	Fri 3/9/07	0%										
18	Design improved VSU for future projects	20 days	0%	Mon 3/12/07	Fri 4/6/07	0%										
19	Meet with all engineering to finalize VSU design	15 days	0%	Mon 4/9/07	Fri 4/27/07	0%										
20	Test VSU on upcoming project	90 days	0%	Mon 4/30/07	Fri 8/31/07	0%										
21	Report Lessons Learned and create new/improved VSU	20 days	0%	Mon 9/3/07	Fri 9/28/07	0%										
22	Train TLs, Maintenance and Engineers on VSU	30 days	0%	Mon 10/1/07	Fri 11/9/07	0%										
23	Implement VSU for all future engineering projects	30 days	0%	Mon 11/12/07	Fri 12/21/07	0%										
24	End of effort for Vertical Start Up	1 day	0%	Mon 12/24/07	Mon 12/24/07	0%										
25	Vision	30 days	100%	Tue 3/14/06	Mon 4/24/06	100%										
27	Plant Capacity-on going activities	5 days	100%	Mon 11/6/06	Fri 11/10/06	100%										
29	Maintenance Prevention (MP)	345 days?	34%	Tue 3/14/06	Mon 7/9/07	34%										
30	Revise MP design checklist	45 days	100%	Mon 9/4/06	Fri 11/3/06	100%										
31	Create folder to keep all MP documents for projects	30 days	100%	Mon 11/6/06	Fri 12/15/06	100%										
32	Train engineering group to use MP checklist	30 days	0%	Mon 1/29/07	Fri 3/9/07	0%										
33	Design easy to use work order to improve MP info with Maint.	40 days	0%	Mon 3/12/07	Fri 5/4/07	0%										
34	Train Maintenance how to use MP design sheets	1 day?	0%	Mon 5/7/07	Mon 5/7/07	0%										
35	Design information feedback system	45 days	0%	Tue 5/8/07	Mon 7/9/07	0%										
36	begin using small groups (P, M, E, O) for MP meetings	30 days	0%	Tue 3/14/06	Mon 4/24/06	0%										
37	End of effort for MP implementation	1 day	0%	Tue 4/25/06	Tue 4/25/06	0%										
38	General	394 days?	25%	Tue 3/14/06	Fri 9/14/07	25%										
46	EEM Pillar Checklists	17 days	0%	Thu 1/25/07	Fri 2/16/07	0%										
50	EEM Projects	386 days?	0%	Tue 2/28/06	Tue 8/21/07	0%										
51	Change out conveyor motors	180 days	0%	Wed 12/13/06	Tue 8/21/07	0%										
52	Readco continuous mixer	261 days	0%	Tue 2/28/06	Tue 2/27/07	0%										
58	K-Tron agitator	123 days?	0%	Wed 8/30/06	Fri 2/16/07	0%										