A CRANE AND HEAVY EQUIPMENT MAINTENANCE PLAN

FOR IMPROVING SAFETY AND EFFICIENCY

By

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ABSTRACT

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The goal of this study was to develop a crane and heavy equipment maintenance plan for improving safety and efficiency. XYZ Construction does not have a systematic method of maintaining its cranes and heavy equipment. Their approach to equipment maintenance could be creating risks to workers and property. This company realizes the potential for loss and believes improving their maintenance

plan will help mitigate this problem. In order to accomplish this, the paper used three steps to develop a maintenance plan for XYZ Construction, as follows:

1. Evaluated current maintenance practices used by XYZ Construction for deficiencies.
2. Evaluated currently available maintenance systems applicable to XYZ Construction’s needs through a review of maintenance systems and journal articles.
3. Developed the best plan suited for the corporate structure of XYZ Construction.

This plan is designed to add value to maintenance procedures and reduce the risks and exposures to loss the company is currently experiencing. Therefore, not only is the need improved maintenance performance addressed, but worker and property exposures are controlled as well.

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Chapter 1

Statement of the Problem

Introduction

The construction industry is classified as one of the largest industries in the nation. The construction chart-book reports that 3.8% of the gross national product is generated by the construction industry. The reported spending in the industry reached $452.1 billion during 1996. However, because of its' extreme competitiveness, this business is consistently fraught with failures. Construction businesses fail at the rate of 1.4 times the national average and 37% of these failures had been in business 10-yrs or more (CPWR, 1998).

The high failure rate and extreme competitiveness of the construction business demands that contractors continuously look for new ways to reduce costs. Many companies seek to gain competitive advantages by reducing labor and raw material costs or by increasing service and controlling losses. One way that companies in the industrial sector have found effective in increasing profit margins is by effective equipment maintenance.

DuPont, for example, reported cost savings of $200 million a year from improved maintenance practices

(Fredendall, 1997). Return on investment (ROI) rates of 500% has been documented through effective maintenance policies (Hartmann, 1992). This can be a real competitive advantage in controlling the losses associated with production downtime and emergency equipment repairs, with an added bonus of improved safety performance (Hartmann, 1992). Yet, extensive research cannot find these pro-active maintenance techniques currently being utilized in the construction industry.

Most construction companies tend to concentrate maintenance efforts on unscheduled breakdowns or emergency repairs. These tend to be the most costly in production losses, maintenance department overtime and in expediting parts for repairs. Typically, a construction company's largest assets are in the equipment it owns. By anticipating and preventing these unplanned events a company can protect its' equipment assets from production downtime, unscheduled loss or expensive failures, while improving safety factors.

The continual effort to improve safety performance in the face of this extreme competition has created the need for XYZ Construction to consider new methods to further augment their risk management program. There is a strong management suspicion that ineffective field maintenance of

their equipment is creating failures in their cranes and heavy equipment. This is generating significant safety issues. This suspicion has been created by three serious accidents and equipment losses occurring in less than three months.

These occurrences are summarized as follows:

1. June, Man-lift Failure, an all terrain man-lift failed during a wooden concrete form fire. Two employees were assembling wooden concrete forms at approximately 25-ft above the ground in the ABC man-lift. Another employee on the ground was preparing steel rebar on the ground with a torch when the forms caught on fire. In the ensuing fire, the man-lift failed, and both were burnt while stuck in the basket over the fire. One was burned on over 80% of his body. This piece of equipment had a history of maintenance problems relating to controls failure.
2. July, Crane failure, while hoisting a 1.5-yd concrete bucket the boom brake (which holds the boom erect) on an 85-ton crane failed, destroying a section of concrete formwork and narrowly missing several employees. The machine was repaired, and the very same thing occurred the next day when the machine was

operated. The maintenance mechanic called to repair the machine had performed improper maintenance and fixed the wrong brake.

3. August, Crane failure, a 150-ton crane was being assembled to work in a new location. After assembly, oil was discovered leaking from the machine. Inspection revealed the machine had been improperly maintained and operated without oil for several months. Complete disassembly is required for repairs; costs are expected to exceed $80,000 and result in two or three week's downtime.

This type of failure can be unacceptable with cranes and heavy equipment. It has potential to endanger workers and to create tremendous damages. These issues, along with the constant need to improve safety performance, provide sufficient reason to evaluate and apply effective equipment maintenance plans into this corporate structure.

Goals

Because this problem can create human endangerment and costly equipment damages this paper was written to accomplish the following goals:

1. Evaluated current maintenance practices used by XYZ Construction.

2. Evaluated currently available maintenance systems applicable to XYZ Construction’s needs through a review of maintenance systems and journal articles.
3. Developed the best plan suited for the corporate structure of XYZ Construction.

Background and Significance

XYZ Construction is a major bridge building company located in central Wisconsin. The nature of the business involves using heavy equipment and cranes for material handling and concrete placement. This company has an annual income of approximately $150 million a year, and has recently experienced several injuries, near misses and expensive equipment losses, believed to be caused by inadequate equipment maintenance in the field.

The logistics of this business can place their heavy equipment anywhere in the continental United States. Thus, necessitating the need for field maintenance. The company management realizes there are opportunities to increase profits by decreasing injuries, asset losses and maintenance expenses, and asked for help in remedying these problems.

Limitations of the Study

Because the logistics and work parameters on a construction site change constantly, studies similar to those conducted in industrial settings are not possible. This study is directed towards setting up and establishing methods for managing XYZ Constructions' cranes and heavy equipment maintenance to improve safety and maximize efficiency. Because this is the first implementation of this plan, there will not be sufficient response data to conduct performance evaluations.

Definitions

Corrective maintenance: A reactive maintenance system, characterized by run-to-failure breakdowns and repairs after the breakdown occurs.

Preventative maintenance (PM): A maintenance system that uses a procedural approach with schedules and guidelines that attempts to prevent breakdowns with maintenance procedures.

Productive maintenance: A maintenance system that strives to predict breakdowns through analysis of historical data.

Total Productive Maintenance (TPM): A maintenance system developed in Japan about 30-years ago similar to Total Quality Manufacturing (TQM).

Summary

The need to improve safety records and the extreme competitiveness of the construction business demands that contractors continuously look for new ways to improve safety and reduce costs. Companies in the industrial sector have found effective equipment maintenance increases profits and improves safety performance. This paper attempts to apply these techniques to the construction industry.

Chapter II

Review of Literature

A Brief Overview of the Problem

The purpose of this study was to develop a maintenance plan for cranes and heavy equipment that improves safety and efficiency. XYZ Construction is experiencing problems with its' cranes and heavy equipment that are creating risks to humans and property. These problems are costing the company money. It is suspected that these problems are related the improper maintenance of their cranes and heavy equipment. XYZ believes that improving their equipment maintenance procedures will improve these conditions.

However, there was very little information found in the search for a construction equipment maintenance program. A comprehensive search was conducted through articles and books with no results. An electronic database and World Wide Web search yielded similar results. Electronic (e-mail) polling of the major construction contractors, equipment manufacturers and crane certification organizations produced only maintenance manuals for specific machines. There were no comprehensive maintenance plans available for contractors in the construction business.

This necessitates formulating a plan by focusing on successful safety and maintenance plans used in industrial settings. The construction industry is usually slow to adopt new management techniques, with many contractors being entrepreneurial in nature and priding ability to scramble through a myriad of adversities and risks (Palmer, 1996). These construction industry leaders realize the need to extract maximum efficiency from their company's assets. In the industrial sector, notably on the overhead cranes used in the paper industry, proactive maintenance techniques have been developed that have dramatically improved safety and efficiency in their overhead cranes. Along with these improvements, they have been able to reduce expenses, and create value added improvements in their equipment for every maintenance dollar spent (Sothard, 1996).

Today's optimal maintenance program must not only remediate risk factors but also demonstrate a measurable return on capital invested (Sothard, 1996). By identifying significant risk factors, problem areas can be revealed and construction contractors can take suitable action. By using accepted techniques of both safety or risk management and maintenance management, performance in both areas can be improved. Effective maintenance programs have been

proven to enhance both safety performance (Hartmann, 1992), and decrease maintenance costs (Fredendall, 1997). In addition, by using proactive maintenance techniques companies can legitimately expect to achieve value added results form their maintenance department expenditures (Tajiri, 1992).

Basic Safety and Risk Management Principles

In what is considered one of the most effective safety and risk management programs ever developed, Proctor and Gamble's Key Elements, has been able to achieve significant improvements in both health and safety. This remarkable association validates the key element approach, which are listed as follows:

1. Organizational Planning and Support.
    a. Clear expectations.
    b. Management and employee involvement.
    c. Goal setting and action planning.
2. Standards and Practices
    a. Standard implementation.
    b. Safe Practices.
    c. Planning for safe conditions.
3. Training
    a. Site training systems.
    b. Qualification of safety risk management resources.
4. Accountability and Performance Feedback.
    a. Safety Sampling.

b. Behavior feedback.

c. Performance tracking (Olson, 1999).

Because this system effectively integrates risk management into the corporate fabric, it affirms that accidents cannot be simply dismissed as events that do not involve the management system.

In addition to using Proctor and Gamble's Key element methods, management must realize reacting after the accident or event cannot accomplish effective risk control. In essence, reactive safety management focuses on the symptoms rather than the root causes while a proactive safety management approach searches for ways to measure systems that produce results (Earnest, 1997). As illustrated in the following literature review, successful industrial maintenance programs also rely heavily on root cause analysis and measurement of results to achieve continuous improvement. This literature review will show how proactive management of both maintenance and safety risk produces similar positive results.

Effective Maintenance Systems

Maintenance activities are linked with keeping a facility's systems and machinery in working order (Sheu, 1994). These activities unarguably cost companies a lot of

time and money, but are a necessary business expense. In the industrial sector, with maintenance expenses running 15-40% of production costs, smart management has realized that maintenance, with its high cost and low efficiency, is one of the last cost saving frontiers (Löfsten, 1999). Furthermore, the most successful systems seek to assimilate it into the corporate fabric and save the company time and money.

Construction industry leaders realize the need to squeeze maximum efficiency from their company's assets. One of the primary objectives of Productive Maintenance is to assist managers in selecting the least cost corrective maintenance policy, one that reduces the severity of equipment failures (Sheu, 1994). In addition the optimal maintenance program prescribes not only when to repair but also when to inspect (Hontlez, 1996). Ideally, the goal of Productive Maintenance is to maximize asset utilization and minimize loss from unproductive maintenance.

History of Productive Maintenance

The traditional management concept considers equipment maintenance unavoidable. This system is characterized by run-to-failure breakdowns and is called corrective or

reactive maintenance. It strives to reduce the severity of equipment failures once they occur. This tactic attempts to restore equipment productivity in the least possible time. These companies tend to retain standby machines, large spare parts inventories, and use worker re-assignments during breakdowns (Sheu, 1994).

Progressive companies, on the other hand, have come to embrace preventative maintenance or PM systems, which strive to reduce the frequency of failures once they occur. They seek to build a system that finds potential failures and seeks remediation to prevent these failures. This technique uses a structured, procedural approach and sets up formal guidelines and time schedules for maintenance tasks (Sheu, 1994).

Increasingly, in the past decade, world-class organizations have come to realize maintenance is not an independent corporate entity that makes repairs as needed. They have come to consider maintenance as a strategic partner in striving to achieve a company’s corporate goals (Fredendall, 1997). These companies consider proactive maintenance techniques a tool to gain competitive advantage. One particularly effective proactive maintenance technique, called Total Productive Maintenance or TPM, and was developed in Japan about 30 years ago.

Components of Productive Maintenance

TPM or Productive Maintenance requires corporate management and employee involvement in a unified effort to recognize equipment deficiencies. It substantiates that successful industrial maintenance programs rely heavily on root cause analysis and measurement of results (Hartmann, 1992). Beyond the need for management's, acknowledgement and commitment, successful productive maintenance programs contain several other components closely resembling the key elements of Risk Control as follows:

1. Develop the data needed to make decisions and set priorities, set operating expectancies.
2. Analyze the equipment losses.
3. Develop (and rank) improvement needs and opportunities.
4. Execute improvements as planned and scheduled.
5. Check results and continue with improvements as required (Hartmann, 1992).

With the addition of site, training needs and qualification of service providers this proactive maintenance closely mirrors the Key Element approach to safety.

Analysis of Productive Maintenance Programs

Productive maintenance is a system driven by facts and statistics. The importance of developing a good equipment history is crucial for management, equipment maintenance and improvement. Equipment histories can help develop a good approach to proactive equipment maintenance efforts. This is the instrument used to locate financial drains or repetitive repairs, and computer databases or Computerized Maintenance Management Systems (CMMS) are to primary tool used to aid this analysis process (Hartmann, 1992).

To initiate this program, the current conditions of the company's equipment must be established. This means assessing the condition of all equipment currently in operation. Inspections are done to determine the exact condition of the equipment and the data is recorded. This provides the initial data to establish equipment histories.

In "Countermeasures to Achieve Zero Breakdowns," Tajiri (p. 29) advises, establishing basic equipment conditions and recording data as the first steps to establishing effective equipment maintenance programs (Tajiri, 1992). Hartmann illustrates the importance of maintaining a good equipment history as follows:

> A good equipment history is vital for equipment management, maintenance and improvement.

> Unfortunately, only a few companies maintain and use good equipment histories. Without it, you will not be able to pinpoint repetitive failures or establish total repairs costs as compared to replacement costs. Equipment histories also help you to adjust your PM (preventative maintenance) efforts and to develop a good approach for equipment improvement. (p. 105)

He goes on to illustrate how a large steel manufacturer set up equipment histories for 5,000 pieces of mobile equipment. They discovered certain pieces of equipment were costing up to three times their replacement costs in maintenance expenses (Hartmann, 1992). This is like spending $3,000 a year to keep your $1,000 car running.

Cleaning before inspection is one of the most powerful tools in achieving effective maintenance and zero breakdowns. The importance of cleaning develops more than just an aesthetic importance when inspecting machinery and equipment. It plays a key part in exposing deficiencies. “In other words, the hidden defects can be exposed” (p. 31, Tajiri). Cleaning has also been proven effective against slips and other safety hazards. This is especially a key component involving older equipment.

As companies strive to increase the service life of aged equipment, inspections and establishing equipment

histories become especially important. With increasing age, the equipment becomes more and more expensive to operate. The deterioration rate directly relates to the working conditions in which the machine operates. Equipment life varies with how the equipment is used, and various equipments each can be expected to have different productive lives (Turco, 1984).

Additionally, failures do not occur suddenly. Equipment undergoes a gradual deterioration process that can be detected only through appropriate controls. Once the threshold of failure is achieved, deterioration can be quite rapid (Turco, 1984). This illustrates what every old car owner already knows: with age and hard use, the possibility of failure increases. With cranes and heavy equipment, these failures are unacceptable because of human endangerment or high costs of failure.

Not only has equipment operating conditions already been proven to affect equipment's useful life (Turco, 1984). It is legally mandated that crane owners comply with the manufacturer specifications and limitations in the operation of all cranes (OSHA, 1986). Equipment owners must maintain equipment according to manufacturers' specifications. Simply put, a prudent car owner must

repair failed brakes to manufacturers' specifications even if the car is old.

Recognizing when equipment will fail is achievable, but only with acquisition of appropriate data (Steinbacker, 1993). Unplanned repairs are the biggest single problem facing maintenance managers today. This indicates they have not determined when or where the breakdowns will occur (Sothard, 1996). Assimilation of this information is the first priority for data collection.

The next information needed is data on components that fail repeatedly. By examining component life cycles, pro-active maintenance management reduces downtime and saves the company money by anticipating critical component failures. Also noted are safety related repairs, for meeting OSHA requirements and helping to reduce liability risk exposures (Sothard, 1996).

With the identification of repeatedly malfunctioning parts, we can prioritize replacement of components whose wear patterns have safety or production consequences (Sothard, 1996). We can determine how frequently the repairs are repeated, and examine if root-cause failure analysis is needed (Katzel, 1996). This eliminates spending money on the same repairs over and over again.

With any business, the measurement of success depends on the bottom line, the profits or the money it makes. The addition of maintenance expenses and financial reports of associated costs like equipment downtime, make the determination of where monetary losses are occurring possible. After all, we obviously want to avoid situations like spending money on repeated repairs or Rent-A-Cars while trying to keep our $1,000 car operating.

To develop the equipment histories an information management system is needed. Fortunately, there are many Computerized Maintenance Management Systems (CMMS) on the market. These systems are available for a variety of PC operating platforms, use graphical user interface (GUI), and appear relatively easy to use. They all allow data retrieval in a variety of formats. The decision on which program to select depends largely on which operating platform the company uses, and the end user. Several vendors were contacted and the software companies willing to provide trial copies of their product are listed in appendix A.

With the acquisition of these facts, the identification of equipment problems and critical issues is possible. Some problems will be obvious. Others may not be apparent until equipment history, maintenance logs, and

other pertinent information reviewed. Possibly, root-cause failure analysis may need completed. Weighting problems must be executed in a Pareto or 80/20-type fashion. This is done by examining your statistics and placing emphasis on solutions that need immediate remediation, by choosing the problems that will offer lasting resolutions, or selecting the ones contributing the most significant return on investments (Katzel, 1996). This allows management to develop and rank improvement needs and opportunities according to risk management and monetary considerations (Hartmann, 1992). Basically, you want to get the best Return on Investment (ROI) possible, when selecting problem remedies, in both maintenance and risk management programs.

Additionally, in both Productive Maintenance and Safety Risk Management programs, it is not an exaggerated attempt to state that the success of either depends on the commitment of top management. To be successful they require visible support and active participation (Hartmann, 1992), (Peterson, 1989). Active participation in all levels of management must be responsible for planning, organizing and leading the way in the Productive Maintenance effort (Steinbacher, 1993). These are the leaders who have to set goals, provided the guiding effort, and reap the benefits from favorable results (Fredendall,

1997). They set impetus management and measurement. After all, smart managers realize that, “effort will be put forth in the area in which the boss is measuring” (Peterson, 1989).

Most importantly, periodic auditing of improved maintenance activities is imperative. This is the reason for establishing initial equipment conditions and standards. Proactive Maintenance is a dynamic system that responds to the changing conditions of the equipment. Active feedback is needed from maintenance and the operators to monitor for weaknesses and measure improvements or non-improvements in performance (Hartmann, 1992).

All Productive Maintenance and Safety Risk Management programs stress training and education as one of the primary tools used to accomplish improvements. This tool is recognized in both safety risk management (Peterson, 1989), and productive maintenance programs (Hartmann, 1992), (Tajiri, 1993). These are dynamic systems and workers, operators and managers need to be trained how to use them. (Fredendall, 1997). In the old car analogy, drivers’ education is an important safety requirement in most states, no matter how old and decrepit your car is.

Finally, one of the added benefits of an effective maintenance program is improved safety performance. Tennessee Eastman, a large chemical company, reports that with an effective maintenance program they have achieved vast improvements in their safety record. They reported only three minor injuries in over a million maintenance tasks (Hartmann, 1992). This was a vast improvement in their safety statistics.

Summary

XYZ Bridge construction has no standardized maintenance plan for maintaining its cranes and heavy equipment. This could be creating risks to workers and property. Research on this issue yielded a nominal amount of information. Basically, there were no comprehensive plans designed specifically for construction equipment.

Effective maintenance programs have been designed for industrial settings. These programs were found to enhance productivity, efficiency, and safety. The application of these techniques can add value and longevity to the company’s equipment as well as to ensure safe operations. Through root cause analysis, companies utilizing these techniques have achieved substantial economic gains. However, successful implementation of these programs requires management buy in.

Chapter III

Methodology

Introduction

The purpose of this study was to formulate a crane and heavy equipment maintenance plan for XYZ Construction that can help improve safety and efficiency. The company is experiencing maintenance related failures in their cranes and heavy equipment. This is unacceptable because it is creating human endangerment and possible high damage costs. A maintenance plan is needed and an existing equipment maintenance system could not be found for XYZ Construction to use. This chapter outlines the methods used to conduct this research and address these issues.

Research Design

A descriptive research design was used. First, this research project engaged a review of the maintenance procedures used by XYZ Construction in order to determine its maintenance needs and establish baseline equipment conditions. Secondly, the company considered it imperative to integrate risk management principles when controlling these shortcomings. Therefore, a review of basic risk management principles was done in order to integrate these into the plan. Finally, a review of literature on preventative maintenance programs was done to isolate the

components of an effective maintenance system. It was discovered that uniformly, world-class corporations in the industrial sector use proactive systems in both maintenance and risk management. Throughout these systems, Key Elements are present. These uniform Key Elements allowed selection of the ones relevant to the company's current risk management philosophy. The most applicable of these components were then developed into the maintenance plan for XYZ Construction.

Method of Analysis

First, the author reviewed current maintenance procedures for the cranes and heavy equipment. This was accomplished from notes taken during the course of a summer internship and field experience. During that time, a basic overview of the maintenance procedures, the age, and the condition of the equipment in use by XYZ Construction were noted.

Then, a literature review was done on categories of interest related to the study. The search engines used were Pubcat, Ebsco, FirstSearch, and Carl. Keywords like equipment safety, maintenance management, crane, equipment, and industrial maintenance were used. These articles were retrieved and assessed for content. The history and evolution of effective maintenance systems were examined

and the most effective maintenance systems were documented. The key components of safe and effective maintenance plans were identified and organized following the key elements of safety.

Finally, a plan was developed for improving safety and efficiency for cranes and heavy equipment through proactive maintenance from the research. The Key Elements of safety was used as a guide for incorporating these proactive maintenance techniques.

Chapter IV

The Study

Introduction

The purpose of this study was to develop a crane and heavy equipment maintenance plan to improve safety and efficiency. XYZ Construction does not have a systematic method of maintaining their cranes and heavy equipment. Their approach to equipment maintenance could be creating risks to workers and property. The company realizes the potential for loss and believes that improving their maintenance procedures will help mitigate these conditions.

A descriptive research design was used that engaged a review of the current maintenance policies used by XYZ Construction. Then, a literature review on maintenance systems and their history enabled a greater understanding of the processes involved. It was discovered that, uniformly, world-class corporations in the industrial sector use proactive systems in maintenance management. These proactive maintenance systems improve efficiency with the added bonus of improving safety performance as well.

This company realizes the potential for loss and wants to mitigate this problem with a maintenance plan. In order to accomplish this, the paper used three steps to complete its' goals:

1. Evaluated current field maintenance practices used by XYZ Construction.
2. Evaluated currently available maintenance systems applicable to XYZ Construction's needs through a review of maintenance systems and journal articles.
3. Developed the best plan suited for the corporate structure of XYZ Construction.

Current Field Maintenance Practices

Although this company spends over three-quarter of a million dollars a year on equipment maintenance, there are no comprehensive loss or maintenance histories on the cranes or heavy equipment. The small but dedicated maintenance staff maintains fifty-five cranes, along with assorted other heavy equipment that has a mean age of about twenty-five years. Although the equipment manager can identify specific high cost and expensive breakdown or repair items, comprehensive loss trends are not available. The maintenance plan is generally reactive maintenance, which is characterized by run to failure breakdowns.

The equipment's operators normally do field maintenance and repairs. Because this equipment is heavy and awkward, other workers on the job-site assist the operator when upkeep is needed. When the repairs exceed the scope or abilities of the job-site personnel,

independent repair mechanics are contacted to perform needed machine care. They are selected on a least cost basis.

Field conditions are usually dusty and rugged, and maintenance facilities do not exist. On some jobs, the equipment operators may run several pieces of equipment during the workday. Daily equipment maintenance may or may not happen, depending upon production schedules. On other jobs, the same operator may be assigned one piece of equipment for several months. Equipment condition varies widely, depending on the operators' assignment length. Machines with one assigned operator are always in better condition. Additionally, several of the cranes were noted without proper lubricants or daily maintenance supplies on hand.

In short, there are no equipment histories or loss trends kept on the equipment. There are a variety of rugged field conditions and no standardized maintenance practices. The equipment's condition varies widely and there are many personnel with maintenance responsibilities.

A Review of Currently Available Maintenance Systems

A literature review on maintenance systems and their history was conducted to enable a better understanding of the processes involved so the best plan could be chosen.

The search initially concentrated on maintenance systems for cranes and heavy equipment, but none could be found. This necessitated focusing on successful maintenance plans found in the industrial sector, such as those used in the auto, chemical and paper producing industries.

Historically, it was found that there are three basic types of maintenance systems: corrective, preventative and productive maintenance. Corrective maintenance is a reactive maintenance system, characterized by run-to-failure breakdowns, and repairs after the breakdown occur. Second, Preventative Maintenance or PM, is a maintenance system that uses a procedural approach with maintenance schedules and guidelines that attempts to prevent breakdowns with procedures. Finally, there is productive maintenance, which is a maintenance system that strives to predict breakdowns through analysis of historical data. In addition, several of the systems examined revealed that productive equipment maintenance systems could augment safety as well as enhance profits.

In this study, one Key Element was evident in every maintenance system and journal article reviewed, successful implementation of effective maintenance plans require management buy in. To be successful, productive maintenance requires active participation across all strata

of management corporate management in a unified effort to recognize and correct equipment deficiencies.

To initiate the Productive Maintenance process, the current conditions of the company's equipment must be established. Accurate data on the age, condition and notable alterations are needed to establish baseline equipment histories. Then, loss histories, which are then developed, are maintained on all equipment. This gives the company management the ability to prioritize risks, losses, and rank equipment improvement needs based on statistical data and facts. The logistics of the construction business mandate recording job location also.

Annual analysis of the accrued data will have to be done to identify critical issues and equipment problems. This provides the company's management information to avoid spending money on the same equipment or repairs repeatedly. This also allows time to pre-plan corrective repairs when construction equipment is more likely to be idle, during the off-season or winter months. Additionally, this is the time to evaluate the plan for effectiveness and deficiencies.

All Productive Maintenance programs stress training and education as one of the primary tools used to accomplish improvements. The sequence is as follows:

1.) Train personnel how to maintain the equipment, 2.) Provide the supplies, 3.) Certify the person doing the repairs. All are listed as being significant in proactive maintenance systems. Also imperative, is making sure the supplies for lubrication of the equipment are on hand at all field locations.

Finally, auditing equipment conditions and back-charging damages to the appropriate jobsite gives each manager a financial incentive in the maintenance of the equipment. After all, the bottom line is profit, and maintenance related equipment damages could affect profits significantly.

A Crane and Heavy Equipment Maintenance Plan

The crane and heavy equipment maintenance plan for XYZ Construction was developed using Proctor and Gamble's Key Elements of Safety as a general guide. The company currently utilizes these Key Elements of Safety as the philosophy in their loss management and risk control department. Therefore, integration of this philosophy when managing risk in the maintenance department was considered essential.

By incorporating these elements into proactive maintenance techniques, a proactive maintenance plan is developed to mitigate the human exposures and equipment

losses the company is currently experiencing. This plan is designed to add value to maintenance procedures, and reduce the risks and exposures to losing valuable human and economic assets. Therefore, not only is the need for improved maintenance addressed, but also worker and property exposures due to equipment failures could be controlled as well.

XYZ Construction's Key Element Equipment Maintenance Plan

1. Organizational Planning and Support.
    a. Clear expectations, set operating expectancies.
    b. Management and employee involvement.
    c. Develop (and rank) improvement needs and opportunities through loss histories.
2. Standards and Practices.
    a. Implement maintenance standards.
    b. Follow manufacturer's recommended maintenance practices at recommended intervals.
    c. Plan for maintenance needs and supplies.
3. Training.
    a. Site training systems for all personnel involved with equipment maintenance.
    b. Establish certification of repair personnel.
4. Accountability and performance feedback.

a. Auditing of equipment conditions upon arrival at each new jobsite.
b. Feedback of maintenance related problems and costs into the equipment history.
c. Back-charging all maintenance related deficiencies or equipment damages to the previous job.

Chapter V

Summary, Conclusions and Recommendations

Summary

The purpose of this study was to develop a maintenance plan for the cranes and heavy equipment owned by XYZ Construction that would assist in improving safety and efficiency. They are having breakdowns and problems with their equipment that is exposing their workers to risks and costing the company money. These troubles are believed to be related to inadequate field maintenance of their cranes and heavy equipment. The goal of this paper was to provide a plan to help improve these conditions.

In order to meet this goal, a descriptive research design was used. First, this project engaged a review of the maintenance practices used by XYZ Construction in order to determine the current procedures used by the maintenance department. Next, in order to enable a greater understanding of the processes involved a literature review of maintenance systems and their history was conducted. Basic risk management principles were also reviewed because the company considered it imperative to integrate them when controlling these losses. Finally, using this information, a plan was developed to help mitigate the problems the company is currently experiencing.

Conclusions

The findings of this study lead to the following conclusions:

1. XYZ Construction has large number of older machines in rugged field conditions that need regular maintenance and servicing. There are no standardized maintenance practices and this could be creating risks to workers and property.
2. The company currently practices a reactive maintenance system, which seeks to alleviate losses after they occur. However, there are proactive maintenance systems available that help enhance safety, efficiency and productivity.
3. The company could benefit from a proactive maintenance plan. Such a plan could help protect workers and company assets.

Recommendations

The intent of this plan is to promote employee safety and improved equipment efficiency in XYZ Construction’s maintenance procedures for its cranes and heavy equipment. In order to accomplish this, the following recommendations are given:

1. Management needs to provide an expectation of minimum care standards to be used in the maintenance and

repairs of XYZ Construction’s cranes and heavy equipment.

2. Loss histories should be developed and maintained on all equipment owned by XYZ Construction. This is done in order to analyze the losses and rank equipment improvement needs. The following data could be kept on each piece of equipment, in an electronic database:
    a. Age, cleanliness and general condition.
    b. Additions, alterations and special modifications.
    c. Repairs, costs and mechanic performing the repairs.
    d. Accident involvement or other safety related problems.
    e. A jobsite or job number the machine is assigned to.

For field acquisition of this information a generic form was developed, and is listed in appendix B.

3. Annual analysis of the accrued data should be done during a convenient date in the fall. This provides time for program evaluation and implementation of management defined equipment improvement needs during the winter months.
4. On site training for every new equipment operator in regards to specific machine maintenance and

lubrication requirements for specific machines. Training records must be kept with each employee’s personnel file.

5. Proper lubricants must be planned for and kept for each machine at its field location. Equipment manufacturer’s lubrication charts for each machine will also be available on site.
6. Establishing certification of repair personnel, either by experience or by prior association.
7. Auditing of equipment conditions upon arrival at each new jobsite by utilizing the machine’s logbook.
8. Back-charging all maintenance related deficiencies or equipment damages to the previous job.

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Appendix A

Computerized Maintenance Management Software (CMMS) Software Providers

Bender Engineering, Maintstar, Maintenance Management System. 3535 Farquhar Avenue, Los Alamitos, CA 90720

Cygnus Management Systems, Work Epic, Maintenance Management System. 43074 Summerset Rd, Newberry Springs, CA 93265

Eagle Technology, ProTeus/Maintenance Manager. 10500 N. Port Washington Road, Mequon, WI 53092

Appendix B

Crane and Heavy Equipment Assessment Form

For Field Use

Date	XYZ Const.	Equipment Field Assessment Form
	Id. Number	
	Year Built	
	Gen. Condition	
	Alterations	
	Type Repairs	
	Cost	
	Mechanic	
	Safety Issues	
	Other, List	
	Job No.	
	Rec’d. By	