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FACILITY RELIABILITY AND MAINTAINABILITY: AN INVESTIGATION OF THE AIR FORCE CIVIL ENGINEERING RECURRING WORK PROGRAM

THESIS

Jeffrey A. Jackson
Captain, USAF

AFIT/GEM/DEM/89S-10

DEPARTMENT OF THE AIR FORCE
AIR UNIVERSITY
AIR FORCE INSTITUTE OF TECHNOLOGY

Wright-Patterson Air Force Base, Ohio

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AFIT/LSG/GEM/89S-10

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THESIS

Presented to the Faculty of the School of Systems and Logistics
of the Air Force Institute of Technology
Air University
In Partial Fulfillment of the
Requirements for the Degree of
Masters of Science in Engineering Management

Jeffrey A. Jackson, B.S.
Captain, USAF

September 1989

Acknowledgements

I would like to thank my Lord and Savior, Jesus Christ, for sustaining me throughout the thesis effort. My wife Lisa has earned my unending gratitude for her support in reading, correcting, and re-reading numerous "rough drafts". This study is dedicated to our son Joshuah, who has helped me to see that recreation and play are important ingredients in any endeavor.

The preparation of this thesis would not have been possible without assistance from others. For technical advice and moral support, I would like to thank Captain Michael Falino, my thesis advisor. Special thanks goes to the many maintenance managers, military and civilian, who allowed me to interrupt their busy schedules and helped me to understand the facilities maintenance business better.

Jeff Jackson

Table of Contents

List of Figures

Abstract

The purpose of this thesis was to test the validity of the hypothesis that the civilian service industry does a better job maintaining facilities and utility systems than the Air Force civil engineering community. The researcher looked at several sectors of the US service industry and compared their preventive maintenance programs to the Air Force Recurring Work Program (RWP).

The researcher reviewed contemporary Air Force and civilian literature on preventive maintenance (PM), performed case studies on two civilian maintenance departments, and conducted personal interviews with military and civilian maintenance managers. This data were collected to compare the RWP with civilian PM programs and determine if specific practices were used in the civilian programs that could improve the RWP.

Analysis of the results of the study indicated that the hypothesis was not entirely correct; the Air Force RWP was found to be one of the most comprehensive maintenance management systems studied. However, recommendations for improvement of the RWP were discovered through analysis of the civilian programs.

FACILITY RELIABILITY AND MAINTAINABILITY: AN INVESTIGATION OF THE AIR FORCE CIVIL ENGINEERING RECURRING WORK PROGRAM

I. Introduction

General Issue

According to Air Force Regulation 85-10 the mission of Air Force Civil Engineering (AFCE)

> ... is to provide the necessary assets and skilled personnel to prepare and sustain global installations as stationary platforms for the projection of aerospace power in peace and war (17:9).

This regulation gives the AFCE community responsibility for construction and maintenance on global installations with a replacement cost of well over $115 billior (14:1). These installations can be considered a national asset dedicated to the national defense (43).

At most installations, the mission of constructing facilities, utilities, and pavements required to support the USAF has already been accomplished (21:5). Support facilities are in place and are being used. The remaining portion of the CE mission is to operate and maintain these facilities, utilities, and pavement systems to allow for their continued use (21:5). Operation and Maintenance of these installations includes operating utility plants,

performing minor construction and repairs, and accomplishing preventive maintenance (PM) (21:5).

To accomplish the PM, the AFCE community has developed an extensive system that ensures facility maintenance is completed as required and in a timely manner. This PM program is called the Recurring Work Program (RWP).

Specific Problem

Even with this extensive program, MAJCOMS throughout the Air Force are experiencing problems in the area of PM; the RWP is not being properly managed (1:3, 5:4, 14:1, 18:2). A recent survey by the Strategic Air Command (SAC) Mechanical Equipment Management Evaluation Team (MEMET) determined that equipment was failing long before it reached the end of its expected life. The recurring maintenance, supposedly accomplished under the RWP, was not being performed as identified; consequently, a maintenance management system, which could be beneficial, is not being managed properly (5:2). Some of the problems identified by MEMET included Maintenance Action Sheets (MAS) that reported work which was not completed, and other MAS which annotated recurring work completed on demolished facilities.

Air Force Logistics Command (AFLC) also found problems in RWP management (18:15). Items that did not qualify for inclusion in the RWP were clogging the computer systems,

causing critical items to go without required maintenance. In addition, multiple MAS were created for equipment that required the same maintenance actions, further hindering progress on essential items.

HQ USAF Civil Engineering and Services Management Evaluation Team (CESMET) found that only 63% of the identified maintenance actions were being accomplished (31:10). CESMET asserted "If it's important enough to identify as needing recurring work - then it's important enough to do" (31:10).

Hypothesis

The hypothesis proposed by the researcher was that the civilian service industry does a better job maintaining facilities and utility systems than the Air Force civil engineering community. The researccher will look at appropriate sectors of the US service industry and compare their PM programs to the Air Force Recurring Work Program (RWP).

Research Objective

This research will compare the AFCE RWP to similar civilian PM programs. This comparison will attempt to answer the following questions: What are the differences between successful civilian PM programs and the AFCE RWP, and how can successful aspects of these civilian PM programs be adapted to improve the AFCE maintenance management system?

In order to answer the specific problem faced by the AFCE community, the following research objectives must be fulfilled:

Primary Objective. The primary objective of this study is to determine those management practices that make certain PM programs successful. This objective will be met if the following investigative questions are answered:

a) What methods are being used in civilian industry that are extremely effective?

b) What practices ensure the success of a maintenance management program?

c) How do managers of successful maintenance programs ensure that all required maintenance actions are being performed?

d) How do successful maintenance managers ensure the support of the work force?

Secondary Objective. The secondary objective will attempt to ascertain the applicability of these successful practices to the AFCE community. This objective will be met if the following investigative questions are answered:

a) What differences and similarities exist between the civilian industry maintenance objectives and the AFCE mission?

b) What specific areas of the industry's PM program can be adopted by the AFCE?

c) How can these successful practices be adapted for use in the AFCE community?

Scope and Limitations

This thesis will concentrate on finding the management practices that enhance the end results of preventive maintenance programs. It will not deal

specifically with the issues of worker productivity, but on the results that are obtained when workers and management are working in a system that allows both to perform to their fullest capabilities. The research will concentrate on motivation, material control, organizational structure, workload, and mission to determine if there are specific management practices that lead to success in a PM program and can be applied to improve the AFCE RWP.

II. Methodology

Overview

This research is an historical analysis of preventive maintenance engineering and case studies of successful PM programs. The historical analysis encompassed a literature review and personal interviews with professionals in the field of preventive maintenance. The case studies concentrated on the interactive processes occurring in successful PM programs (20:61).

Historical Analysis

Literature Review. The literature review was an extensive examination of the current literature in the field of preventive maintenance, both military and civilian. It included a combination integrative and theoretical review to synthesize current knowledge and also determined the theories and concepts that drive successful PM programs (20:62).

Personal Interviews. Personal interviews were conducted with maintenance managers at Walt Disney World, Kings Island, Opryland USA, Wright State University, University of Dayton, Tennessee Eastman Kodak, and Continental United States (CONUS) Major Command (MAJCOM) RWP monitors. The personal interviews consisted of open-

ended questions designed to gather specific information on practices that may make a program successful.

Personal interviewing is a two-way conversation initiated by the interviewer to obtain information from a respondent. If carried off successfully personal interviewing is an excellent data collection technique (20:160). The benefits of conducting personal interviews include increased information and increased control (20:160-161).

As with all data collection methods, personal interviewing also has disadvantages. The major problems inherent in the personal interviewing process are cost and bias. The cost of travel and lodging to support the personal interviewing process has proven to be an obstacle (20:52). Biased results are caused by three types of error: sampling error, nonresponse error, and response error (20:161).

The cost of transportation, lodging and time are distinct disadvantages of the personal interviewing data collection method. Costs are particularly high in a study, such as this, that covers a wide geographic area (20:167). The only way to minimize this problem is to carefully plan the agenda of interview visits. The researcher contacted professional organizations interested in preventive maintenance research and determined conference schedules and guest speaker programs in the local area. This allowed the researcher contact with the

highest concentration of knowledge on the subject for the minimum time and money. In addition, the researcher interviewed successful maintenance managers in the Dayton-Cincinnati area and conducted telephone interviews with the MAJCOM RWP monitors.

Bias was reduced by controlling sample error, nonresponse error, and response error. Since this was an exploratory study a judgmental sample of successful preventive maintenance programs were selected on the recommendation of the Director of Operations and Maintenance, Air Force Engineering and Services Center (AFESC), the USAF Inspector General (IG), and the research advisor. The researcher controlled nonresponse by sending introduction letters, performing initial telephone contact to set up convenient appointments, and performing callbacks until the appropriate managers are reached (20:165). To minimize response error all personal interviews were recorded, to reduce transcription errors and make the interview flow more smoothly (20:166).

Case Studies

After identifying successful programs, the researcher performed case studies for Wright-State University and Tennessee Eastman Kodak Chemical Complex. The case studies focused on a detailed analysis of the management practices used by the managers of successful maintenance programs. This technique stressed the

relationship between specific management practices and the apparent success of the program.

The benefits of a case study included:

> Affording the researcher considerable discretion over not only the type of data gathered, but also over the sources from which information is obtained such as: interviews, observations, and documentary material.
>
> Offering evidence on what the researcher considers to be a rare, remarkable, or atypical instance of some phenomenon.
>
> Establishing a pool of data that may be useful at a future point in time. (54:136)

The case study method also has disadvantages which included the facts that:

> Data obtained on a single unit cannot be used as a base for generalization about a larger population.
>
> The case study method is the least systematic of all research methods.
>
> Data collection may alter the setting under study.
>
> Results of case studies are likely to have substantial amounts of bias because of nonsystematic collection, consideration, and interpretation of data. (54:136)

In an effort to minimize the effects of the problems inherent in the case study methodology, the researcher followed the same plan to study each of the PM programs. This plan included a formal request for research support, initial telephone interviews with appropriate managers, personal interviews with selected program managers, program review, and final analysis of data gathered.

The case studies focused on reporting, discussing, and detailing the specific management practices that make these programs successful. Afterwards, personal interviews with the civilian managers were conducted to determine why a particular practice is used in that PM program. Finally, the MAJCOM RWP monitors will be consulted to help determine if the practices are applicable to AFCE.

Summary

This chapter detailed the specific plan for collecting and analyzing the data necessary to fulfill the research objectives in Chapter One. The researcher performed an historical analysis consisting of an extensive review of the current literature and personal interviews with professional managers in the PM field. Using the knowledge gained in the historical analysis the researcher identified and performed case studies on successful PM programs.

III. Review of the Literature

Overview

The purpose of this chapter is to review current literature, both military and civilian, on the subject of preventive maintenance management. The chapter begins with a discussion of the problems that face both military and civilian maintenance departments. Next, the chapter presents the literature derived from military and civilian sources. The literature review is separated into military and civilian categories to make the distinction between the two readily apparent.

Problem

Military. The Deputy Chief of Staff for Engineering and Services, HQ SAC, established the MEMET in 1984 in response to a growing concern about the management of mechanical equipment maintenance throughout the command (5:15). One indication of the lack of maintenance came from contractors installing the Energy Monitoring and Control System (EMCS) (4:18). This system was designed to save energy by connecting all mechanical equipment on the base to a central control panel. From this panel, an operator could monitor the environmental control systems and ensure all systems were operating at the most efficient level of output. The problem contractors found

was quite disturbing; many of the pieces of mechanical equipment had been tampered with by building occupants and CE personnel (4:8). Large numbers of chillers and heating systems were in such disrepair that the contractor determined the EMCS would not work properly if connected to such equipment (4:9). Spot checks by the SAC Inspector General reinforced the notion that a serious problem did exist (5:1).

MEMET's purpose was to "evaluate the overall effectiveness of the Base Civil Engineer in maintaining the mechanical equipment" (5:1). The MEMET theory was that an RWP which is properly managed will have the following characteristics:

1. Lower emergency/urgent job order rates
2. Lower operation and maintenance costs
3. Lower utility costs
4. More available shop time for routine job orders and work orders (5:2)

The team inspected the following areas: maintenance activities, Heating/Ventilation/Air-Conditioning (HVAC) Group, facility surveys, real property records, and long range plans. Maintenance actions were checked to determine if the tasks were being accomplished correctly and as reported. The team also reviewed minutes of the HVAC Group and facility survey folders. The HVAC Group was evaluated against criteria established in the HVAC Group Policy Letter from HQ AFESC/CV, 8 Nov 82 (6:9).

Facility survey folders were examined to see if surveys were up to date and action taken on the findings (5:9). Real property records were inspected for accuracy. Long range plans were checked to ensure HVAC equipment was programmed to replace items nearing the end of its expected life (5:3).

The findings were revealing. Typical results included:

> 1. Personnel signing off as doing maintenance on equipment that no longer existed: in one case, a building had been torn down for two years. These were also signed off within two weeks of the inspection.
>
> 2. Personnel charging time to tasks not performed. Three workers were sent to clean filters in a dorm; 70 hours were charged to RWP but the filters were not touched.
>
> 3. Personnel not completing assigned tasks. Workers said they had spent 21 hours performing RWP on reach-in refrigeration units one week prior to the inspection. The inspector found a dirty condenser on one unit and the other unit was running hot because the fan was inoperative. (5:3)

MEMET found the primary factor causing these problems was lack of supervision. Supervisors were not following up to assure workers accomplished assigned tasks. "Not accomplishing assigned tasks is increasingly being accepted as the Air Force standard with most shops only completing less than 50% of the work that was signed off as accomplished" (5:4). The team depicted this loss in productivity as the "lost work zone", as shown in Figure 1. This zone is the difference between the number of

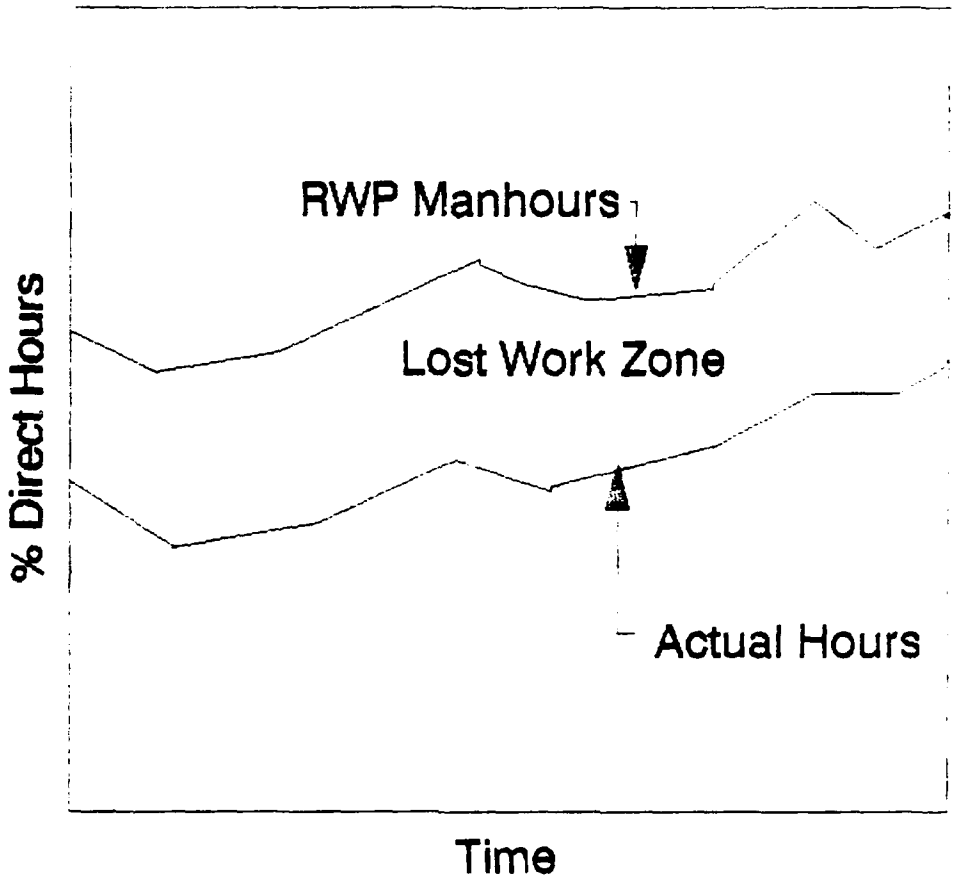

Figure 1. Lost Work Zone
(6:12)

direct manhours reported and actually accomplished under RWP (5:12).

Civilian. The problems found by MEMET are not unique to the Air Force. In his article, "Component Plan for Effective Facility Maintenance Management", Michael S. Patrick describes a similar situation involving a hospital Engineering Service Department. Patrick says that a number of problems existed in the department for some time. These included:

1. Poor departmental productivity and effectiveness of departmental staff to accomplish needed services.

2. Inadequate staffing to develop and maintain an engineering program for a facility of this size.

3. Poor image (stemming from No. 1) as perceived by hospital staff.

4. Ineffective organization structures.

5. Inadequate definition of departmental and position roles and responsibilities.

6. Little or no organized control over work assignment, work scheduling and review.

7. Little or no training for staff.

8. Ineffective material control system. (46:39)

When Paul Robert Siebeneicher of Infotron Systems Corporation speaks of the difficulties encountered at its Cherry Hill Industrial Center, many of the same symptoms are evident. He agrees that, "... although some preventive maintenance work was being done, it was a token effort that went undocumented or unchecked" (54:165).

Maintenance problems have been experienced in manufacturing plants, public works departments, schools and colleges, and other facility maintenance programs throughout the world (29:2). The maintenance problems occur because of inadequate maintenance management systems (29:3). The next section enumerates several tested and proven maintenance management system plans that can be used to improve maintenance management.

Key Factors of a Good Maintenance Management Program

Military. The literature is saturated with maintenance management system plans of varying length and content. In the May 1978 edition of the Engineering and Services Quarterly, Captain Toussaint and MSgt Collachi presented an article titled, "The RMP a system to insure control over decreasing resources". Toussaint and Collachi were assigned to the Operations and Maintenance Directorate, Headquarters Air Force Systems Command (AFSC). These men spent two years analyzing the RMP in AFSC. Results of this study emphasized the need to strengthen two areas: management's role in the RMP and education of the craftsmen (13:33).

First, a review of the RMP must have the support of top level management; the BCE and the Chief of Operations must take an active role in the RMP (13:34, 6:10, 19:4-15). The BCE and Operations Chief should check recently accomplished maintenance tasks for accuracy and

completeness (13:34, 6:11). A checklist of RWP indicators for management include:

1. MAS descriptions too broad and general.

2. MAS reflect tasks not accomplished on every visit.

3. Excessive frequencies.

4. Dissimilar equipment covered by one MAS.

5. All like equipment/systems not covered by one MAS.

6. MAS not reflecting building numbers where visits are to be made.

7. Equipment listed in the file is still operational/installed.

8. RMP requirements are not those to be included in Operation and Services Work List.

9. RMP file purged of non-critical items with under $250 value.

10. Start/stop months are included.

11. RMP file purged of seasonal overhaul requirements.

12. Requirements from outdated Air Force Manuals (AFM) deleted.

13. Duplicate visits eliminated.

14. Expiration of warranty pick-up procedures.

15. Annotation of standard hours on completion cards.

16. Duplicate inspections performed by craftsmen and planners deleted.

17. Review and validation of MAS by foreman, superintendent, and Operations Chief. (13:35)

Management accomplishment of this review ensures "you reserve the minimum required manhours to perform the required maintenance tasks" (13:36).

Additionally, personnel at all levels of the operation need to be trained on their role in the RMP (13:36). "All the "million dollar" programs in existence aren't worth a "plugged nickel" if the people that they are supposed to help do not completely understand them" (13:36). CE personnel should strive to use the RMP system to its fullest extent, not attempt to circumvent it (13:36).

In 1981 the Military Airlift Command (MAC) performed a study of MAC RWP because the RWP had been identified by the IG at almost every base during the previous year. (40:1). Repeat write-ups were gaining the attention of MAC commanders at all levels. All IG write-ups cited a "lack of aggressive management attention" as the source of the problem (40:2). This prompted the HQ MAC/DCS for Engineering and Services to commission a study to determine what could be done to "fix" the MAC RWP (40:2).

The study presented nine recommendations to improve the MAC RWP. These recommendations were:

1. Each base should review their RWP and remove or extend the maintenance interval of any item that cannot be economically or mission justified.

2. Screen the recurring maintenance file list and the operation and services maintenance action sheets for duplications.

3. Discontinue maintenance of low cost items unless such maintenance is clearly recommended by the manufacturer or economically justified.

4. Use engineering performance standards (EPS) to estimate manhours for RWP and operation and services.

5. Use EMCS more extensively to monitor equipment/systems status. Rely less on operator checks and move toward a "response to abnormal conditions" methodology.

6. Consider involving facility users in inspection and minor maintenance actions.

7. Ensure life expectancies are realistic.

8. Review collection work orders in the RWP annually in conjunction with the fiscal year review of collection work orders and the work authorization list.

9. Ensure that maintenance actions are assigned and performed by the cost center with the capability to accomplish it most efficiently. (40:3)

The MAC study placed particular emphasis on recommendations 6 and 3 because of the potential for manhour savings. The report urged the BCE to "consider involving facility users in inspection and minor maintenance actions for certain items" (40:1). These items included air conditioners, kitchen equipment, hot water heaters, wire rope, and air compressors. Additionally, the BCE was urged to discontinue maintenance of low cost items "unless such maintenance is clearly recommended by the manufacturer or is economically justified" (40:1).

In 1983, HQ MAC/DE further emphasized the importance of management attention to the proper functioning of the

RWP (39:1-2). MAC sent out RWP information and guidance that clarified the categories of recurring work, and stated MAC RWP policy and procedures. The policy and procedures included a maintenance management philosophy statement. This statement encouraged management attention that ensures:

1. Items in the RWP are necessary, economical, coordinated and beyond the capability of the user/operator.

2. Engineering Performance Standards (EPS) are used to the maximum extent possible.

3. Zonal scheduling is used as an area for significant savings in manhours and costs.

4. Paperwork minimization and simplified scheduling are considered to reduce confusion for the craftsman and the customer.

5. Historical file of maintenance actions for each item in the RWP is established. (39:2)

In 1985, HQ SAC MEMET determined the elements of a good RWP include:

1. Preventive versus breakdown maintenance.

2. Equipment history.

3. Prioritize needs/frequencies.

4. Tools for successful RWP.

5. Detailed information of each item.

6. Management review.

7. Record keeping.

8. Design. (5:11)

Management attention in these eight areas led to a lower emergency/urgent job order rate, lower Operations and

Maintenance costs, lower energy costs, and more available shop time (5:3-4).

An outgrowth of the MEMET plan was adapted by SAC in Nov 1985 and implemented in a program called Geographic Ownership (GO) (6:2). MEMET asserted that the major problem with the RWP was lack of worker integrity and supervisory follow-up (6:2). The GO concept was designed to address these two issues (6:2). GO attempted to capitalize on the pride of the individual worker through decentralization while retaining only the necessary functions in a centralized overhead (6:2). The program designers emphasized that a "bottom up" approach to GO implementation was vital to success; "...the airman must feel that this is his program" (6:3).

The SAC "Excellence" team defined six areas that are the "backbone" of the the GO concept, including:

1. Geographic Maintenance
2. Ownership Concept
3. Shop Specific Programs
4. Measurable Criteria
5. Performance Recognition
6. Training for Military (6:4)

The GO concept revolved around the synergistic relationships between these six factors.

First, geographic maintenance was used for all PM. Geographic maintenance ensures that all maintenance in a particular facility and zonal area was scheduled for the

same day. Geographic maintenance reduces transportation lag time and gives the craftsman more time to perform maintenance activities (6:8). Second, the concept of ownership and responsibility were introduced. "Excellence ensues only if a job is sincerely owned" (48:210). Responsibility for a particular piece of equipment was given to a particular individual. "Ownership means that an individual is responsible and accountable for the operation of the equipment he owns" (6:4).

The next area presented fostered pride in ownership through competition (6:7). Each shop was divided into teams that compete against each other for "Excellence in Maintenance" awards (6:7). Measurable criteria for success must be set to facilitate this competition (6:8). Management must tell the craftsmen what level results are expected from the best team (6:8). Once this criteria is set, top performers should be recognized (5:8). The SAC Excellence Team emphasized that the reward must be a "real" reward; something of value to the individual. Finally, management must ensure training for the military members on all available equipment (6:8).

The SAC Excellence Team reported the following results from implementation of the GO concept:

1. Lower Emergency/Urgent Job order Rate.
2. Increased Customer Satisfaction.
3. Higher Worker Satisfaction.

4. Reduced Paperwork.

5. Increased Vehicle Utilization. (6:13)

After witnessing the results of GO in the mechanical arena, the SAC staff decided to apply this concept across the spectrum of CE specialties in the concept called Readiness and Ownership Oriented Management (ROOM) (6:7).

The organizational structure of the Air Force Civil Engineering Operations Branch "...had remained unchanged for the last twenty-five years" (53). In an attempt to be more responsive to the customer and emphasize PM the civil engineering community in SAC decided to reorganize. The CE branch responsible for facility maintenance is the Operations Branch. Figure 2 shows the current structure of the Operations Branch (17:40). It is a classic example of Sir Fredrick Taylor's specialization and division of labor (10:642). Each shop within each section has a specific trade-area of responsibility, not to be invaded by other shops. This organizational structure had served well for many years, but with the increased emphasis on customer satisfaction, a new structure proved to be necessary (53).

To meet this need, the Strategic Air Command proposed the Readiness and Ownership Oriented Maintenance (ROOM) concept. The ROOM structure is depicted in Figure 3. In this organization the functions that handle the daily maintenance, the zone teams, are separated from those that

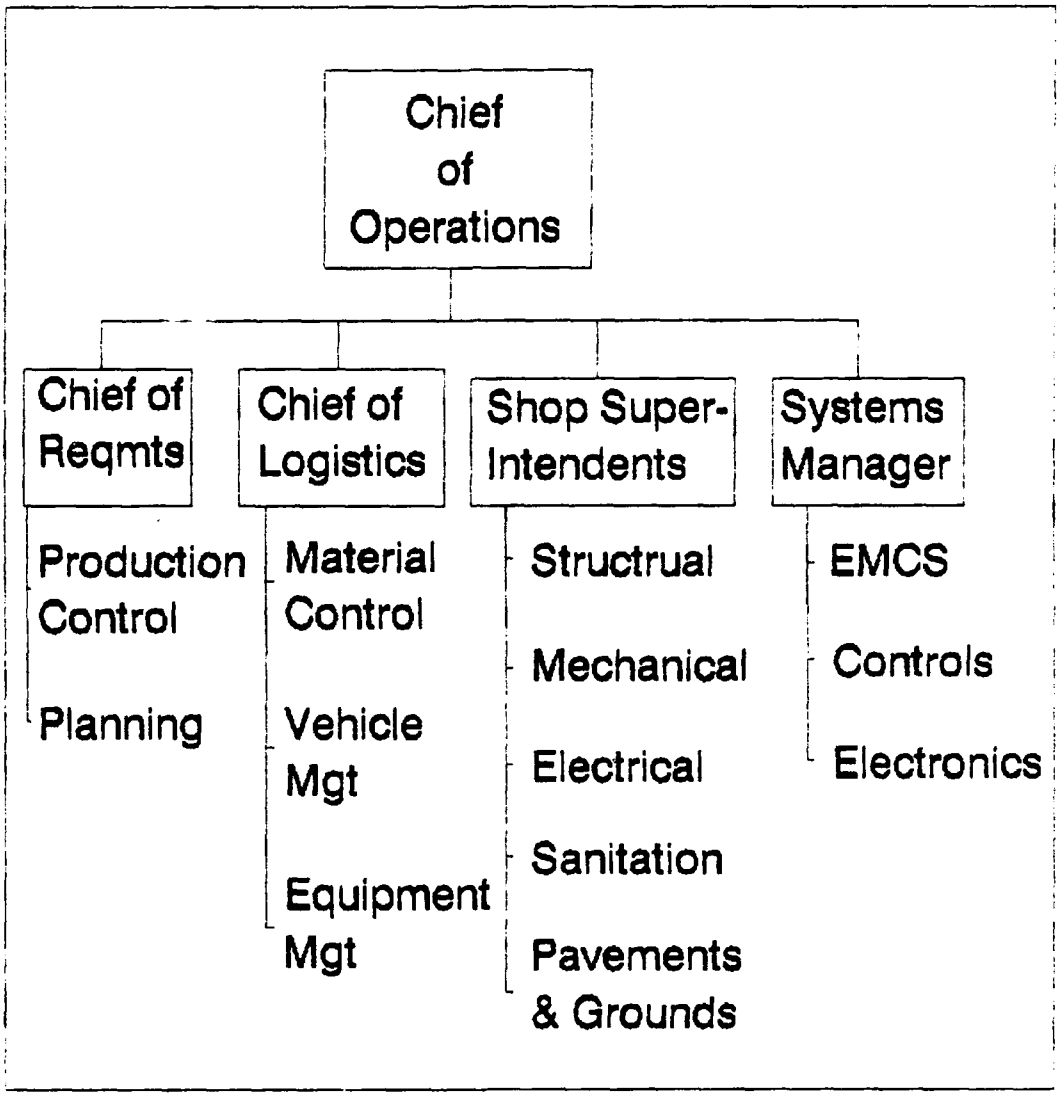

Figure 2. Operations Branch Organization Chart
(17:40)

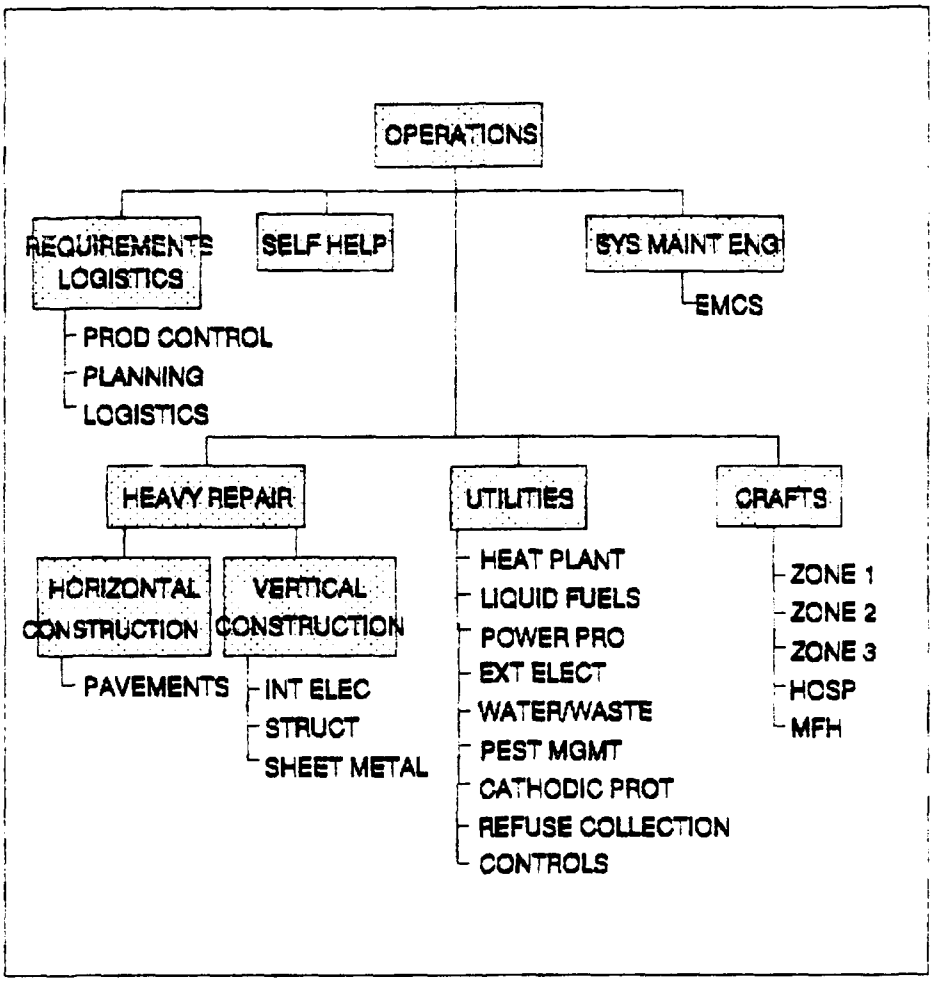

Figure 3. Operations Branch Organization Chart

(30:7)

perform major repairs and minor construction, the heavy repair team (30:3).

In 1988, HQ USAF released AFR 85-2, Civil Engineering General, Operations Management. AFR 85-2 is the current regulation that governs the RWP. Chapter 10 of AFR 85-2 gives a detailed account of the RWP, beginning with a list of benefits to be derived from an effective program. The listed benefits include:

1. Cost effective real property maintenance.
2. Proper maintenance of active real property.
3. Reliable utilities and efficient energy use.
4. Preventive maintenance accomplishment.
5. Maximum customer service.
6. Maximum production.
7. Effective resource allocation.
8. Positive work force control. (16:49)

The regulation gives full responsibility for the RWP to the shop supervisor and the superintendents (16:49). The program is designed to "... reserve hours to ensure recurring work is accomplished first (immediately after emergency and urgent work requirements) by reserving hours for this work before other routine requirements are scheduled" (16:49).

AFR 85-2 also outlines recommended procedures to be followed in implementing the RWP. These procedures include establishing an inventory, identifying maintenance

requirements, preparation of the MAS, scheduling maintenance activities, and reporting procedures (16:50-52).

Civilian. Maintenance management plans are also well represented in civilian literature. Edward H. Hartman, P.E., President of the Maynard Management Institute says that "only 35% of maintenance time is productively used in the average U.S. plant" (29:131). Hartman has determined that maintenance productivity can be increased if management will improve the following eleven areas:

1. Maintenance Requests
2. Maintenance Planning
3. Maintenance Scheduling
4. Work Order Systems
5. Maintenance Control
6. PM and Equipment History
7. Predictive Maintenance
8. Inventory and Stores
9. Training and Motivation
10. Organizational Structure
11. Supervision (29:132-139)

Hartman devised this management plan through extensive study of the Total Productivity Management programs in Japan. The Maynard Institute has successfully adapted this

plan for hundreds of preventive maintenance managements programs in virtually every kind of industry worldwide (32:6).

William Rifkin, V.P., New York Power Authority, says the "...objective of any maintenance program is to optimize the use of time, manpower, funds, and material in order to improve plant availability, reduce forced outages, and improve plant efficiency" (50:3). Mr. Rifkin stresses the use of computers to improve seven critical management system components:

1. Work Scheduling
2. Performance Measuring
3. Long Range Planning
4. Budget/Cost Control
5. Equipment History
6. Material Management
7. Preventive Maintenance (50:3)

The preceding plan was implemented at the New York Power Authority's Long Island Lighting Company with positive results. Two million dollars were saved in maintenance and energy costs in the first year after implementation. Rifkin asserts that,

> ... inflation, high interest rates and soaring fuel costs have caused more attention to be placed on efficiency and reliability of existing equipment. Meeting this challenge demands that maintenance managers perform to the best of their abilities. This can only be accomplished by using a reliable, computerized maintenance management system. (50:3)

Similarly, the consultants to a hospital engineering service department, described by Michael Patrick, Senior Engineer at Sun Health Inc., decided that an effective management system for maintenance and operations should include a:

1. Mission Statement
2. Master Maintenance Plan
3. Work Scheduling/Control System
4. Management and Productivity Reporting System
5. Inventory Stock and Control System (46:40)

According to Patrick, each of the five areas mentioned above were examined in light of the problems faced by the department. First, he developed a mission statement. Mr. Patrick considers the mission statement to be the "cornerstone" around which all goals and objectives are constructed. Next he developed a master maintenance plan. This plan included a comprehensive preventive/planned equipment maintenance program. Additionally, Patrick devised a formal work order system, and meaningful reports were developed to help management monitor the system. The team also determined the number and skill level of personnel needed. Finally, the consultants initiated a new material control system to meet the needs of the department (46:41).

Many of the results remain to be seen, but the department is improving steadily under the new system. Mr. Patrick says,

> Perhaps the most important aspect learned from these studies was the real need for providing for planned maintenance and developing realistic schedules and standards for these activities. (46:42)

Likewise, Mr. Siebeneicher of Infotron Systems Corporation set up a formal preventive maintenance program from scratch to solve Infotron's PM documentation and follow-up problems. First, management documented preventive maintenance performed on each shift. The supervisors established maintenance routes which helped schedule equipment in certain areas. Establishment of maintenance routes led to more reliability; craftsmen arrived to fix a piece of equipment at approximately the time the scheduler told the customer they would arrive. This reliability boosted the department's image and eventually morale began to rise (54:163).

When the shift documentation was completed the supervisors documented the daily PM, then weekly, and finally monthly. By this time all the preventive maintenance tasks were organized on standard forms. Follow-up was performed by the supervisor who had to sign all PM forms before the clerk could close the job. The maintenance manager used a magnetic board to inform both maintenance and production personnel of the PM schedule (54:163).

The results in this plant are astounding. According to Siebeneicher:

> The production uptime increased from 29% to 67% in twelve months. This marked over a 100% improvement in increased productivity throughout the operating departments of the facility. Plant accounting recorded a bottom line operating improvement of over one million dollars per month. The maintenance engineering department's efficiency level increased from 30% to 60%. The credibility gap had disappeared. (54:164)

The preventive maintenance program was not just a part of the overhaul of the maintenance management system at Infotron, it was the "workhorse" of the new system. The other elements included controls and reporting procedures to evaluate the effectiveness of the PM program (54:166).

David L. Berger, Senior Consultant for Industrial Engineering Services says that the purpose of a maintenance management system is threefold; minimize downtime, maximize tradesman utilization, and maximize utilization of other resources such as shop equipment, tools, parts, and energy (8:47). To fulfill this purpose he offers the following management system components:

1. Work Order Control System
2. PM System
3. Inventory Control System
4. Equipment History File (8:47-54)

Paul D. Tomlingson, President of Paul D. Tomlingson Associates estimates that maintenance represents over 20% of plant operating costs (56:108). If these costs can be controlled, the result is greater profitability for the plant (56:113). Tomlingson has devised a method to

evaluate maintenance management programs and has applied his technique at numerous plants throughout the world. He has analyzed the major deficiencies at 35 plants that have completed the formal evaluation process and, from this analysis, he has derived eight key factors that are present in the most successful programs. The "Key Success Factors" are:

1. Defined Supervisory Roles and Responsibilities

2. Easily Understood Maintenance Concept

3. Established Day-to-Day Procedures Based on Plant Policies

4. Used Well Defined Maintenance Terminology

5. Detection Oriented PM Program

6. Work Order Control System

7. Well-defined Maintenance Engineering Function

8. Open and Constructive Dialogue Among Maintenance, Production, Engineering, and Plant Management (56:108)

As stated earlier, Tomlingson has found a high correlation between a successful maintenance program and plant profitability. He advises that,

> ... in this era of intense competition, only profitable plants will survive. The costs of maintenance are among the few major costs that can be controlled. If they are not controlled - and reduced - maintenance costs stand in the way of profitability. (56:110)

Maintenance Management Plan Components

By adopting a tailored version of a maintenance management plan that suits the needs of the particular situation the manager can elicit maximum productivity from the maintenance department (29:132). Many of the components in the maintenance management plan listed earlier have been the emphasis of extensive research effort. One example is the component Customer Orientation. The researcher located five AFIT thesis, nine Air Command and Staff College (ACSC) Papers, two AF Pamphlets, one AFIT Course, and numerous civilian books dedicated to this area of the maintenance operation. The researcher does not intend to reproduce this literature here but will concentrate on the components that are not well covered in the AF literature. Therefore, those areas not well represented in the AF literature will be discussed with particular emphasis on components that recurred frequently in the civilian literature including workload, organization, material control, advanced technology, and artificial intelligence.

Workload. Putting off maintenance today will save time and money in the short run but in the long run it will lead to costly "catch-up maintenance" (46:39). Additionally an increase in automation will increase the maintenance workload in the future. "Today's practices include little time for PM; the maintenance department is too busy putting out fires but PM will gain in importance

in the years to come, it will become a pocketbook issue that will have a great impact on the total cost of production" (58:36).

Historically, maintenance functions have been in the reactive mode, but with a computer based management system the maintenance team can go on the offensive (58:37). Productivity can rise 20 - 40% when in the active mode (58:94). The more time spent organizing and implementing a good PM program the more overall success in maintenance there will be. "A good PM will lead to a 10 minute fix, while replacement or breakdown repair may cost hours" (58:38). This "saved" time can be used to improve other areas of the maintenance operation.

Another important aspect affecting the workload is the determination of how much labor should be spent on the different types of work. The most successful maintenance departments decided how much manpower should be spent on PM, BM, and minor construction (56:108). "These maintenance departments defined work categories well, estimated the manpower required for each, and devised means to confirm that their determinations were correct" (56:108).

The majority of the literature reviewed recognized the importance of preventive and breakdown maintenance. "To maintain and operate a plant at the lowest cost with optimum efficiency and to extend its life, a careful blend of preventive and breakdown maintenance is needed" (2:46).

In its basic form any maintenance program has two types or categories of work: scheduled and unscheduled (4:5).

Preventive maintenance is covered under the scheduled category of work. PM is the routine, recurring maintenance that is accomplished systematically. The man-hour and material requirements are known in advance of the actual work taking place (21:R-2.1). This allows the maintenance manager to plan workers' schedules and material delivery in time for the work to be completed. Scheduling in this manner saves money and time by avoiding the last minute hustle to "scrounge up" people and material to complete a job. Another advantage of planned maintenance is customer satisfaction (21:R-2.2). Customers are notified in advance that maintenance is going to be performed and down-time can be arranged to cause minimal inconvenience.

Unscheduled maintenance is accomplished when equipment has been allowed to deteriorate to a point where a breakdown has occurred, thus the title "breakdown maintenance" (4:10). Normally when a breakdown occurs it must be fixed immediately to allow normal operation to proceed (25). BM leads to crisis management; workers are pulled off of other tasks and required to spend time locating replacement parts and material instead of actually "turning wrenches" (21:R-2.2). Since breakdowns are not scheduled they can be more expensive to fix,

especially when they can occur on weekends, holidays or after hours.

Even with all its disadvantages, breakdown maintenance is a necessary part of any maintenance activity. As stated earlier, the maintenance manager must seek the proper mix of preventive and breakdown maintenance (56:108). Some equipment items may cost more money and time to maintain on a regular basis than to let them breakdown and replace. Therefore, the responsible managers need to examine the total cost picture and compare total maintenance cost versus breakdown maintenance cost (2:45). Figure 4 depicts maintenance costs versus time. The functions represent the total cost of maintenance and the total cost of breakdown maintenance.

If no PM program exists, the total and breakdown cost of maintenance will continue to grow. Figure 5 shows that an optimum maintenance cost can be achieved if PM and BM are managed correctly. When the maintenance program achieves a balance of PM and BM the total cost of maintenance begins to drop. If excessive time and money is spent in either category the total cost will rise (2:46).

Organization. The major emphasis in the area of organizational structure focused on the issues surrounding the effects of a centralized versus decentralized maintenance function. Best results were achieved in

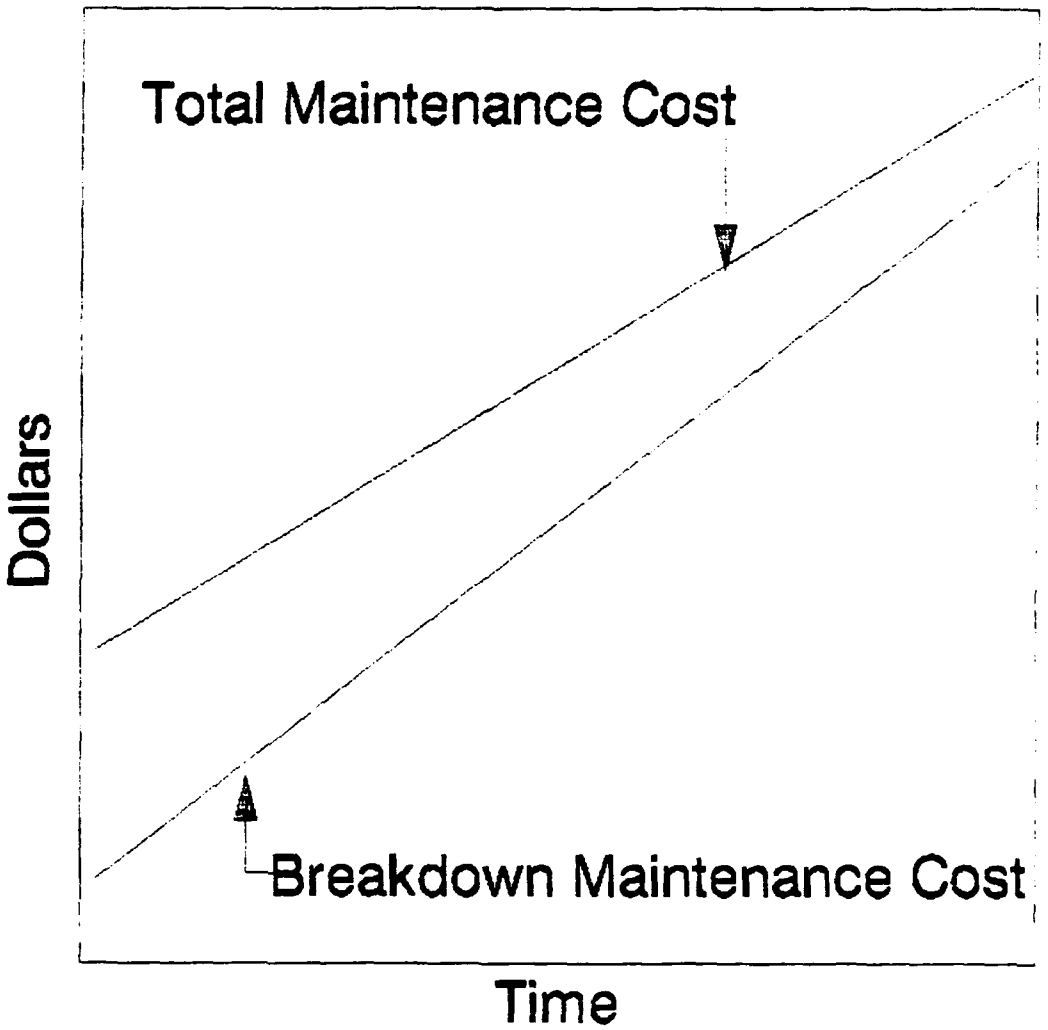

Figure 4. Total vs. Breakdowm Maintenance Cost
(2:48)

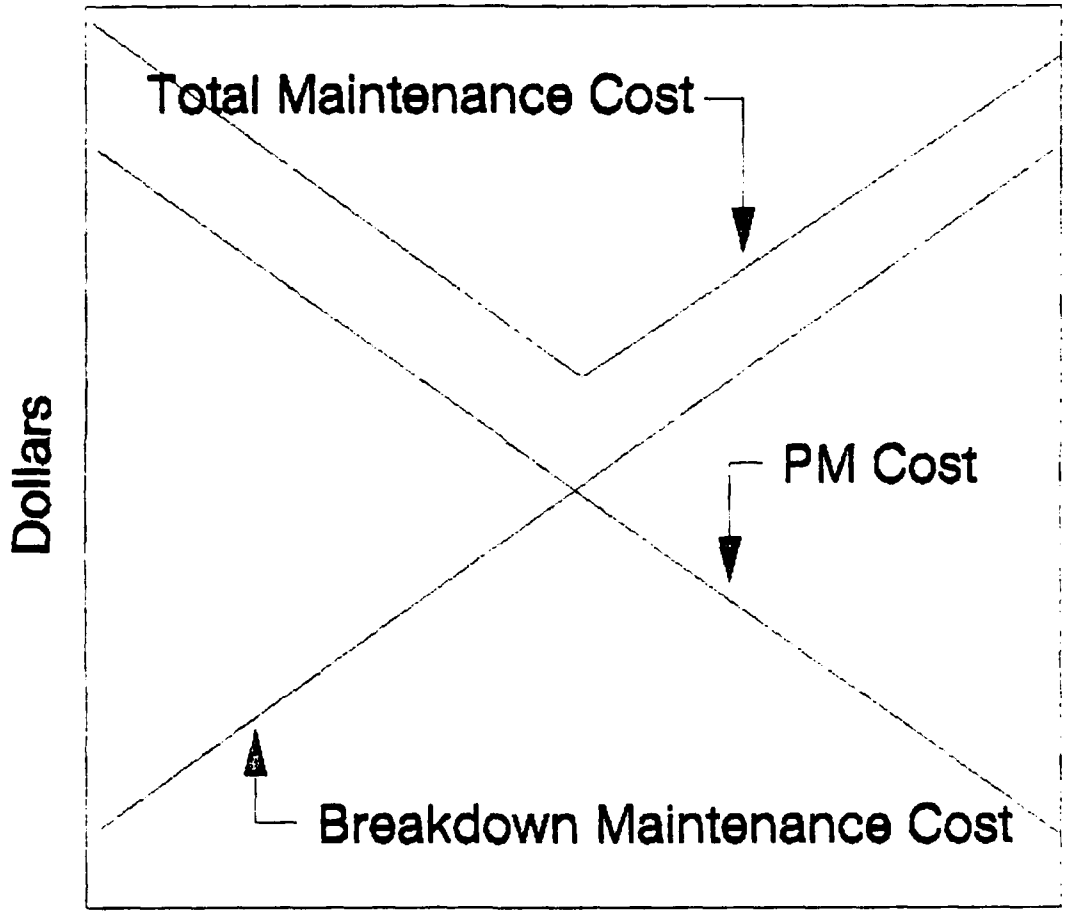

Figure 5. Preventive vs. Breakdown Maintenance

(2:46)

plants that looked for the correct mix of centralization-decentralization in the organization (29:138). This orientation invariably leads to the question of the optimal span of control, the number of workers a supervisor can manage effectively. Research in the organizational behavior arena suggests that the larger the number of people reporting to a single individual the greater the possibility for role conflict and role ambiguity (42:530). The supervisor/worker ratio most commonly reported in the literature is 1/15; that is one supervisor should not try to manage more than 15 workers at a given time (29:138).

Considerable attention was also given to the establishment of separate but collocated planning and scheduling functions. "With Planning and Scheduling together it is easier to integrate manhours, material, and priorities" (29:134). Scheduling maintenance activities is identified as the biggest problem in industry maintenance management programs. To help alleviate this problem many companies created a Maintenance Coordinator position to check on material, ensure work in an area was scheduled together, work clearance problems, etc. (35:4). The maintenance coordinator helped to ease the workload on the scheduler, planner and the supervisor (9:81).

Material Control. Materials are a significant cost in maintenance; representing from 40 - 60% of the total maintenance costs (9:8). Opportunities abound in the

materials management area to save money and improve the overall maintenance operation. Patrick includes good material control in his Component Plan for Effective Facility Maintenance Management. He says, "a good material control system includes inventory, purchasing and control systems" (35:46). Rifkin adds that, "it needs to be a computerized and well managed system to produce the best results (50:6). Management must ensure that the store is provided with an adequate number of trained personnel, a reliable inventory system is maintained, and store areas are secured. In addition computerized reorder points should be established and maintained (29:137).

From a survey of 35 companies, Paul Tomlingson of Tomlingson Associates, Inc., found a high correlation between the plants with a successful maintenance department and those with a high quality material control function. This success was marked by "excellent" communications between the material control function and maintenance. The most successful material control functions were managed separately from the maintenance department. "Several exceptional plants pooled critical spare parts and managed them with interactive information systems. Savings in these plants were measured in millions of dollars" (56:110).

Advanced Technologies. Industry is beginning to apply new technologies to maintenance. Lasers, ultrasonic testing, oil analysis, wear particle analysis, infrared

imaging, and vibration analysis are just a few of the new areas being explored in industrial maintenance departments (24:82). The Dallas Independent School District maintenance crews use infrared examination to detect hot spots in their electrical systems and have reported significant savings in manpower and maintenance funds (22:68). Nuclear gauges, electrical capacitance gauges and infrared cameras are increasingly being used in roof testing (38:90-94). Some plants are using water-sensing cable to provide early warning of water leaks in hidden pipes. Raychem makes a leak detection cable that not only notifies the user of a leak but also pinpoints the leak's location (37:68).

Many of these technologies are being used in conjunction with an intensive Predictive Maintenance (PDM) program. The goal of a predictive maintenance program is to identify the symptoms that are characteristic of failure in critical equipment and monitor for those conditions. When the sensors indicate that the equipment is nearing failure, maintenance and production can plan in advance for the equipment to go down for repair. PDM augments PM; both are needed and can save money (38:73). Owens Corning set up a PDM program that drastically reduced downtime due to motor failure (37:188). As seen earlier, Hartman includes PDM as one of the areas that need to be investigated to ensure the success of a

maintenance program. He says that selected equipment should be monitored to catch a breakdown before it occurs (29:136).

Artificial Intelligence. Artificial Intelligence is also being used by industrial maintenance departments. Dr Richard Herrod, manager of industrial AI applications at Texas Instruments, Inc. says, "Expert systems will have a major impact in equipment and process diagnosis, in simulation and tuning processes, and in deciphering and reacting to alarms. They have the potential to change the way we conduct our maintenance and training and how maintenance plans and schedules are made." The potential is there for real savings in maintenance money and manhours. Hughs Aircraft, Rockwell International, and Campbell Soup use AI in their maintenance shops for highly critical equipment. "AI has proven to be useful in other areas of industry but has not reached full potential in the maintenance area" (15:51).

In a maintenance department a typical application would consist of a personal computer running an AI program. The program has captured and stored the knowledge of an expert on a particular system or piece of equipment. Whenever any maintenance technician needs to service that system or piece of equipment, he simply consults the program for guidance. The expert could have transferred, retired or whatever, but the knowledge he amassed on the system is still available (15:52).

Kurt Joerger, manager of business development, Techknowledge, Inc., summarizes how AI can help the maintenance manager:

1. They help move maintenance from reactive to proactive preventive maintenance, reducing the mean time between failures.

2. They reduce the time required for repairs and, thus, repair costs by correctly diagnosing the problem the first time.

3. They can support equipment operators by providing practical advice and on-the-job training that allows them to handle trouble-shooting and repair of typical problems.

4. They help minimize the maintenance task burden on senior plant engineering staff members. (15:56)

Motivation. For this discussion, motivation is defined as the processes inside an individual leading to behavior channeled in such a way that it will benefit the organization as a whole (42:158). Motivation is displayed through the willingness to perform assigned tasks, confidence, cheerfulness and discipline of the individual group member (44:856). This section will focus on the factors affecting motivation as seen in the literature pertaining to civilian maintenance departments.

The first step in ensuring a high level of motivation in the maintenance department is securing top-management support. "In the most successful maintenance departments, plant managers took a direct interest in formulating maintenance policies consistent with production strategy" (56:107). Top management must take an active role in

integrating the maintenance staff into the production team. Frank and constructive dialogue must be fostered between maintenance and production. Plant management must clearly illustrate how maintenance fits into the production operation (56:108).

The next step in motivating the work force is training. "Plants that provide little or no training typically experience high employee turnover; training serves to sharpen knowledge and skills, boost morale, and help in retaining people" (47:52). Craftsmen are motivated by no delays, correct supplies and little waiting for jobs. Training is essential for supervisors, planners and schedulers to ensure that the craftsman has the correct plans, material and time to perform assigned tasks (29:133).

Some companies have tried to improve morale by integrating organizational behavior techniques at the first line supervisor level. Temple-Eastex has set up a grid of personality traits that include: leader, loner, follower, and hat. These were developed to help the supervisor select the optimum set of personalities to lead to highest morale and, thus, productivity. "Every supervisor needs to observe tne strengths, weaknesses, and personalities of crew members. By paying attention to personal styles, the supervisor can create crew combinations that work to improve morale and productivity" (35:55).

In addition, supervisors need to help the workers see their jobs as important to the company, treat the craftsmen as important members of the team, and rewarded them for their work. Essentially a successful motivational effort must follow a pattern that concentrates on these basic objectives. Effort must be made to see the craftsmen as they see themselves and place equivalent values on what they consider to be important (56:18).

Mission. A mission statement is a written document that defines the maintenance departments function, roles and responsibilities within the organization. It should serve as a cornerstone for objectives and planning for the department. In The Maintenance Engineering Handbook, Charles E. Knight, says that,

> "Basically, the reason for operating a maintenance engineering group is to attend to the day-to-day problems of keeping the physical plant-machinery buildings, services-in good operating condition." (36:1-1)

This type of mission statement needs to be adapted and formalized by each plant maintenance department. According to Tomlingson a typical good mission statement reads:

> The primary objective of maintenance is to maintain equipment, as designed, in a safe, effective operating condition to ensure that production targets are met economically and on time. Maintenance will support nonmaintenance project work (like construction) as the maintenance workload permits. In addition,

> maintenance will maintain buildings and facilities and provide support services such as boiler operation or power generation. (56:107)

The experts agree that the objective is to optimize the use of time, manpower, funds, and material in order to improve plant availability, reduce downtime, and improve plant efficiency (50:3). Berger presents the same idea as follows:

> The purpose of a Maintenance Management System is to (1) minimize downtime, (2)maximize tradesman utilization and, (3) maximize utilization of other resources such as shop equipment, parts, tools, etc. (8:47)

According to Air Force Regulation 85-2 the mission of Air Force Civil Engineering (AFCE)

> ... is to provide the necessary assets and skilled personnel to prepare and sustain global installations as stationary platforms for the projection of aerospace power in peace and war. (17:9)

The words may change but the principle ingredients stay the same and with inflation, high interest rates, and soaring fuel costs, more attention is being placed on the efficiency and reliability of existing equipment and facilities (50:3). Maintenance normally accounts for 15 - 40% of the total production costs in industry (29:81). With that much capital tied up in a program top-management needs to supply guidance. Plant management, with the aid of the maintenance managers, must ensure the objectives of the maintenance department are aligned with the overall plant production strategy (29:83). Limits on the amount of nonmaintenance type of work must be set and adhered to.

"Maintenance departments with clear objectives felt they knew where they were going and why" (56:110).

Summary

This chapter presented a review of the literature, both military and civilian, on the subject of preventive maintenance management. The chapter addressed the problems that face both military and civilian maintenance departments. Next, the chapter presented the literature derived from military and civilian sources.

The next chapter will present case studies of two civilian PM programs. The maintenance departments of Wright State University and Tennessee Eastman Kodak are studied in an effort to determine the successful practices employed along with any areas that need to be avoided.

IV. Case Studies

Overview

The following section presents case studies of the maintenance department of Wright-State University (WSU) in Fairborn, Ohio, and Tennessee Eastman Kodak (TEK) Chemical Complex in Kingsport, Tennessee. These maintenance departments were selected for analysis on the recommendation of the maintenance managers interviewed in civilian industry and the Air Force Engineering and Services Center.

Case studies are presented to show how two civilian maintenance organizations perform preventive maintenance. While these case studies are not intended to represent all civilian maintenance organizations, many of the practices employed are common to the organizations studied. Appendix B contains a listing of the organizations that were evaluated during this research process.

The case studies contain a brief history of the facility maintenance department, a presentation of the current organizational structure and policies, and a view of the maintenance management system used to direct the accomplishment of preventive maintenance activities. The interactions within and among these three areas that lead to a good PM program will be the emphasis of the case studies.

Maintenance Department of Wright State University

History. In the early 1950's the Dayton Metropolitan area was experiencing rapid growth in population due to economic expansion. This economic expansion was fueled by the success of industrial concerns indigenous to the Dayton area. These industries included National Cash Register and Delco Moraine. Industry in Dayton brought a large number of middle class families into the area (33:4-7).

Many of these middle class American families had plans and goals for their "baby boomer" children that included a college education. This increase in college prospects, coupled with the fact that Wright-Patterson Air Force Base was expanding the Research and Development effort created an increased demand for a State University in the Metro Dayton area (33:6).

Community activists led by Charles Alynn, Chairman of NCR, and Air Force leadership began to discuss a project to meet the needs of the military and civilian community: the Wright-State University. In 1964 the first facility was constructed and named for Charles Alynn. The 100,000 square feet facility housed the entire campus activities including administrative office space, classrooms, labs and student service areas. The original curriculum included courses in engineering technology, and nursing offered as a joint venture of the Ohio State University and the Miami University (33:9).

WSU Today. From this humble beginning Wright-State University now boasts a physical plant that includes 43 facilities with 2,016,203 square feet of classrooms, auditoriums, laboratories, offices, and gymnasiums. The University is fully accredited, offering a student population of over 16,000 more than 100 undergraduate majors, 27 master's degree programs, and programs of study for the Ed.D., M.D., Pys.D., and the Ph.D. degrees (60:3).

Maintenance Organization. The Facilities Operations Division of Physical Plant has, "... as its ultimate goal, the desire to provide timely and quality service to the university community" (26:1). The Facilities Operations Division is placed in the university organization under the supervision of the Vice President and Director of Administration along with other support divisions, such as Safety, Budget, and Personnel (33:52).

The Facilities Operation Division organizational chart (figure 6) depicts a centralized department broken down into Building Systems and Building Maintenance sections (26:2). The PM shop is included in the Building Systems Section managed by Mr. Don Beckman. In addition Beckman manages the Electrical Shop, Job Order Control, and the Material Stores (7).

To enhance communication, information is routed up and down the service call lines of communication. Management also encourages informal communication networks

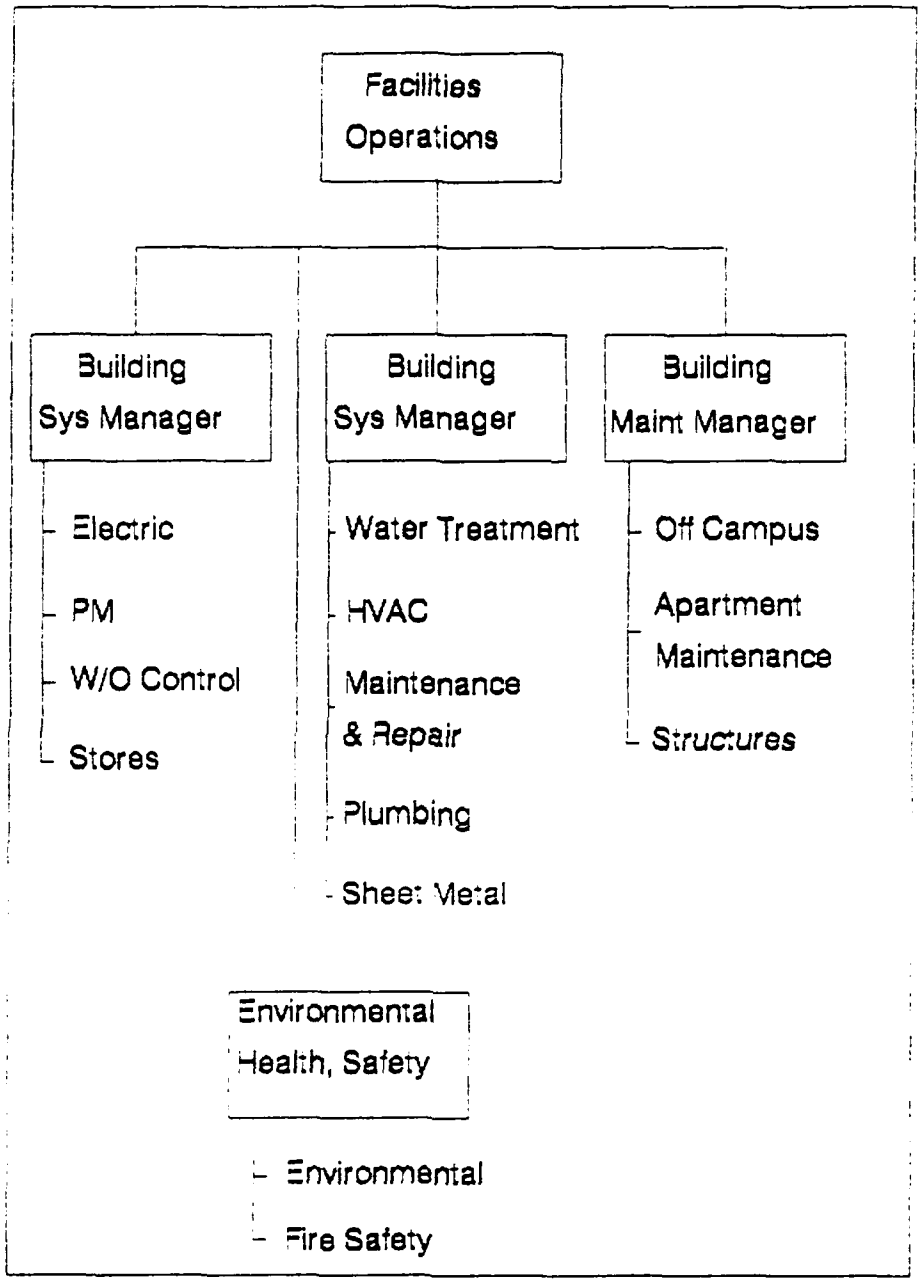

Figure 6. WSU Facilities Organization Chart

(26:2)

between departments. "This is where a lot of the work gets done, the craftsmen get together and decide on a solution" (7).

Funding. WSU is a state university and is funded through the state income tax, student tuition, federal grants, and private donors (60:4). The Facilities Operation and Maintenance activities receive about 9.5% of the University budget each year. In the 87-88 budget, facilities were apportioned over $2 million to carry on facilities activities. This included utilities, employee salary, plant operation, and routine maintenance and repair. Maintenance personnel wages range from $13,700 to $25,900 for maintenance craftsmen and $30,200 to $39,700 for maintenance supervisors and management (45:131).

Personnel. All maintenance personnel are employees of the State of Ohio (49). The labor force has been unionized since November 1988 and, currently, the maintenance craftsmen are members of the 450 Local, Teamsters Union. The present contract allows for no strikes or walkouts. The average tenure of the employees, currently assigned to the Facilities Division, is 10 years (7). Of the thirty personnel within the maintenance department, three are dedicated solely to PM of facilities and utility systems. These three craftsmen perform the PM of all facilities used by the university (7). The average supervisor to craftsman ratio within the

Building Systems section is 1 supervisor for each 5 craftsmen.

All PM personnel are hired to work on the 3rd shift, while classes and administrative functions are not in session. As PM positions are vacated craftsmen are allowed to bid for the job; the qualified bidder with the most seniority is selected for the position (7). The PM craftsmen site higher pay, more work autonomy, and outside interests as reasons for wanting to work the 3rd shift (3).

Policies and Procedures. The WSU maintenance department has a written PM policy which includes an affirmation of the importance of the PM program as well as the need for management involvement in the PM process. Additionally, a comprehensive listing of all equipment within each of the 43 facilities is maintained in an Apple IIE computer system (7). This listing includes the building number, room number, equipment name and brand, and any items required for PM on that piece of equipment (59:10-205). The PM schedule is also generated from this listing and is distributed to 21 separate agencies within the University, including the Office of the Dean, Facility Departments, Administrative Departments, etc. (49).

The currently approved goal for the maintenance department is to spend 50% of the available time on construction, 40% on breakdown maintenance (BM), and the remaining 10% on preventive maintenance (7). Presently,

construction has to be first priority due to the rapid growth of the University; however, there is an initiative to increase the amount of time spent on PM to lower the amount of BM performed (27). The Work Order Control Chief says that PM can drastically reduce the number of complaints due to breakdowns, "...we recently added 2 buildings to the PM Schedule and cut the complaints by over 200 per month" (49).

Service Call requests flow into the centralized work control center where they are logged in and assigned to the shops for completion. Work Order requests are sent to the Director of Physical Plants where a determination is made concerning the best method of accomplishment. A flow chart is provided to the maintenance customers to ensure understanding of the maintenance department work request procedures (26:3). Additionally, periodic maintenance policy letters inform the customer of changes to established procedures that affect maintenance performance (49).

All construction, and PM is planned work. PM planning and scheduling is accomplished by the PM supervisor using the Apple IIE computer system (7). Each facility is scheduled to be maintained during a specific month of the year. Normally, the PM crew will work on five facilities per month. Once the crew enters a facility all PM that is required in that facility will be completed before moving to the next facility (7).

Design projects are reviewed by the maintenance supervisors at the 95% complete stage (27). The engineers and the maintenance supervisors meet weekly to discuss new and old designs. In addition, all equipment specifications are reviewed to ensure compatibility with existing systems (27).

Two buyers are assigned to purchase material and equipment needed by maintenance personnel. PM personnel must compete with the other maintenance shop craftsmen for the time and attention of the two maintenance buyers. The buyers receive material requests, contact vendors, place orders, and pick-up and deliver material to the maintenance complex. Routine requirements are delivered the next day; emergency requirements are expedited, and, normally, received the same day (7).

Material for PM is stored in the equipment rooms next to the equipment it is intended to serve. This has become the practice more of necessity than conscious decision; WSU is growing at a rate that has caused every square foot of available space to be converted to classroom, leaving the maintenance department short on storage and warehouse space (7).

Management Concerns. Both job satisfaction and work conditions are typically favorable among the PM employees interviewed (3). Motivation to accomplish the maximum amount of work is high. Great pride is taken in the fact that only three craftsmen are required to keep the entire

PM operation running smoothly. The craftsmen feel the PM supervisor trusts them and allows them a great deal of autonomy to perform their job (3).

Likewise, the workers are motivated by the supervisors interest in the PM program (49). Each manager supports the program to the fullest extent possible. "If PM needs something it gets it. We realize that if the PM isn't done today then the work will be a work order sometime down the road" (27).

Management feels that the most important factors in a good PM program are the people, time spent on the program, and funding (27). WSU offers all maintenance personnel the opportunity to become more proficient at their trade by sponsoring and funding extensive training programs (49). The Facilities Division managers admit that it is hard to sell PM; "out of sight out of mind is a real problem, but we are in the Presidents Office pushing PM as often as we can" (27). The majority of the customers are unaware of the PM effort. "We figure the less customer involvement in PM the better, we depend on the customer more in the construction and BM areas" (7).

Maintenance Department of Tennessee Eastman Kodak

History. The Chemical Complex was purchased by TEK in 1920. A wood distillation plant was needed to supply methanol to the chemical processing requirements of Kodak

Processing Company. Many of the original facilities still remain in use (41).

TEK Today. Today TEK is the 13th largest chemical producer in the U.S. The operation is housed in 339 facilities located on 3600 acres at Kingsport, TN (30:13). The complex has 28 miles of roads and 37 miles of railroad tracks. At full production, the operation consumes 54 carloads of coal and 485 million gallons of water each day. Electricity for the complex is provided by a 170,000 kw generation plant located on the property (41).

The Tennessee Eastman Company represents over half the worldwide employment of the Eastman Chemicals Division of the Eastman Kodak Company (28:12). The Chemical Division's sales topped $2.6 billion which represents about 20% of Eastman Kodak's annual revenues (41). TEK produces 365 end products from 850 raw materials (28:13).

Maintenance Organization. The maintenance organization includes a centralized overhead that manages a decentralized workforce. The budgeting, personnel, design, and maintenance management areas are centralized for greater efficiency. The shops, however, are located in the "community" of the customers they serve. "We like to have the close customer-craftsmen relationship that the "community approach" provides; the craftsmen become familiar not only with the equipment, but also the supervisors and operators and that makes things run smoother" (41).

Personnel. The Plant Maintenance Division has 12% of the total plant workforce. This includes 200 supervisors, staff and clerks, 100 non-craft helpers, and 800 craft workers. The craft workers are divided into two categories: general mechanics, and control system mechanics. All employees are non-union, but in the past have worked on a strict division of labor within maintenance crafts (28:5).

Funding. The maintenance budget for 1988 was $100 million. Twenty-two percent of the maintenance budget was allocated to the various PM functions. Personnel wages account for a large portion of the PM budget with the remainder used to purchase detection equipment, spare parts, and other PM material. Wages in the PM Department range from $22,500 - $29,000 for PM craftsmen and $25,200 - $43,000 for supervisors and management (41).

Policies and Procedures. Bill Maggard, Director Of Maintenance at the Tennessee Eastman Kodak Chemical Complex, sums up the TEK maintenance philosophy as "Good maintenance costs money and time, poor maintenance costs more of both". At Tennessee Eastman, PM means "prevent maintenance" and to achieve this goal TEK has developed a maintenance management system called Total Productive Maintenance (TPM) (41). The system is a mix of team management, quality improvement, and common sense. TPM involves the achievement of seven major goals:

1. Improve equipment availability
2. Reduce costs
3. Satisfy internal maintenance customers
4. Improve Quality
5. Reduce Waste
6. Job Enrichment
7. Teamwork (41)

TPM is a partnership between operations and maintenance (41). Production and maintenance personnel now share many tasks that in the past were strictly divided. Cross training is used extensively; production and maintenance managers look for jobs that can be cross-trained from PM craftsmen to operators and vice-versa (28:9). Examples of cross-training include shut-down and start-up for equipment maintenance and routine PM of production equipment.

Management Concerns. Performance Management is a key ingredient to the success of TPM at Tennessee Eastman Kodak (41). TEK follows a three step process; first, manage an improvement process through people rather than manage things and activities. Second, change the behavior of people by increasing both skills and responsibilities. Finally, find ways to reinforce behaviors that make things go right rather than giving negative feedback when things go wrong. In maintenance activities, a great deal of energy goes into identifying practices and behaviors the managers wish to reinforce (41). Some of these include:

1. Performing the job correctly, the first time.

2. Reporting work into the computer for facility and equipment history.

3. Performing a failure analysis.

4. Developing methods of predictive maintenance.

5. Team problem solving to improve equipment reliability.

6. Using new technology, such as: vibration testing or computers to calibrate instruments.

7. Reaching TPM milestones. (28:6)

Under a system driven by Performance Management the managerial outlook is changed. No longer do managers consider the buildings, equipment, and inventory to be the assets, now the people are (41). The emphasis changes from managing things (products, equipment, and techniques) to managing a continuous improvement process. Behavioral change, rather than quotas, becomes the goal of management (41).

This behavioral change is embodied in the eight concepts known as the Eastman Way. These concepts include honesty, trust, teamwork, employee well-being, continual improvement, creativity, flexibility, and a winning attitude (28:5). Each month a random survey is made of the workers to report on management's progress toward the ideal established in the Eastman Way concepts. If the workers feel management is not complying in an area, they report it on the surveys and action is taken to correct the situation. Management admits that they are sometimes

disappointed in the results, but a steady trend toward better management-worker relations is emerging (41).

"TPM implementation is a long and arduous process but the results are worth the investment" (41). In the past three years, TEK has achieved a 30% increase in productivity. Maintenance downtime has decreased drastically and even when shut-downs are necessary they are planned well in advance, allowing the production schedule to be modified to minimize disruptions. "We at TEK feel that TPM is the wave of the future with limitless possibilities for improving maintenance productivity" (41).

Summary

This chapter presented case studies of the maintenance department of Wright State University (WSU) in Fairborn, Ohio, and Tennessee Eastman Kodak (TEK) Chemical Complex in Kingsport, Tennessee. The case studies were presented to show how two civilian maintenance organizations perform preventive maintenance.

The case studies contained a brief history of the maintenance department, a presentation of the current organization and policies, and a view of the maintenance management system used to direct the accomplishment of preventive maintenance activities.

The next chapter presents the data collected from personal and telephone interviews with civilian and military maintenance managers.

V. PERSONAL INTERVIEWS

Overview

This Chapter is divided into three sections. The first section presents the data collected through the personal interviews with civilian maintenance managers. The second section details the MAJCOM and Headquarters USAF view of RWP. The final section was designed to ascertain the practices discovered in this research that can be used in the AFCE community. These practices were submitted to 21 Chiefs of Operation attending the Management Applications Course, MAC 430-89B, at the AFIT School of Civil Engineering and Services.

Interviews with Civilian Maintenance Managers

This section presents the data collected through the personal interviews with civilian maintenance managers from Walt Disney World, Tennessee Eastman Kodak, Eastman Kodak of New York, Kings Island, Wright State University, University of Dayton, and civilian maintenance management consultants. Thirteen open-ended questions were asked and the responses were annotated for each maintenance manager.

Walt Disney World

A telephone interview was conducted with Mr. David Sapp on 10 August 1989. Mr. Sapp is the Director of Preventive Maintenance at Walt Disney World, Florida.

Investigative Question # 1. What methods are being used in civilian industry that are extremely effective?

Interview Question # 1. What is the specified purpose of your PM program?

Interview Response # 1. The purpose of our PM program is to maintain facilities and equipment at an acceptable standard for the lowest cost.

Interview Question # 2. Do you use predictive analysis as a part of your PM program?

Interview Response # 2. Very little predictive analysis is used here at Disney. When necessary an outside contractor is hired that can provide the experience and equipment; that way the payoff on the investment is much higher.

Interview Question # 3. What type of management information system do you use?

Interview Response # 3. The management information system that we use is very similar to the Work Information Management System (WIMS) developed by the AFESC. As a matter of fact we collaborated on the development of WIMS with AFESC and came away with a similar product.

Interview Question # 4. How do you ensure that new equipment and facilities will be maintainable, once constructed?

Interview Response # 4. Design reviews are held at the 95% complete stage.

Interview Question # 5. Are there any specific management practices that you use in your PM program that you consider extremely effective?

Interview Response # 5. We recently started using the Engineering Performance Standard (EPS) for planning our PM work. We feel that this will greatly enhance our productivity in the area of PM.

Note: Time and duties did not allow Mr. Sapp to answer the remaining eight questions.

Tennessee Eastman Kodak

Telephone interviews were conducted with Mr. William Maggard from 12 December 1988 through 21 June 1989. Mr. Maggard is the Director of Maintenance for the Tennessee Eastman Kodak Chemical Complex in Kingsport, Tennessee.

Investigative Question # 1. What methods are being used in civilian industry that are extremely effective?

Interview Question # 1. What is the specified purpose of your PM program?

Interview Response # 1. The purpose of the PM program here at TEK is to prevent maintenance. We actively seek to avoid problems by maintaining the equipment before breakdowns occur. Of course all of this is accomplished to increase availability of the facilities and equipment to the production process.

Interview Question # 2. Do you use predictive analysis as a part of your PM program?

Interview Response # 2. Predictive maintenance is an integral part of our PM program. Personnel are trained on the latest and most effective techniques to help spot potential problems early and correct them on the spot.

Interview Question # 3. What type of management information system do you use?

Interview Response # 3. The MIS used for PM is tied into the companies mainframe computer and is accessible by managers at all levels of the plant operation. This allows not only the maintenance personnel immediate access to pertinent information, but also allows production personnel to access the PM schedule to aid in planning downtime and rerouting of production.

Interview Question # 4. How do you ensure that new equipment and facilities will be maintainable, once constructed?

Interview Response # 4. At TEK team management is an important aspect in all decisions that are made. Maintenance, production, engineering, and management work together from the start on all facility and equipment acquisitions. This allows maintenance to help direct new designs toward the most reliable and maintainable solutions.

Interview Question # 5. Are there any specific management practices that you use in your PM program that you consider extremely effective?

Interview Response # 5. Performance management and team management are the foundation upon which our management philosophy is built. Performance management is an attempt to manage behavior rather than quotas. Once management changes it's focus, in this way, then it is time to involve the workers in the decision making process through team management. This style of leadership has worked very well for us in the past and we anticipate a continual process of improvement in the future.

Investigative Question # 2. What actices ensure the success of a maintenance management program?

Interview Question # 6. What do you consider to be the three most important factors in a PM program?

Interview Response # 6. People, leadership, and training. These three must be brought together to realize any amount of success in any program.

Interview Question # 7. What areas of your PM program do you consider to be most successful?

Interview Response # 7. Involving the customer in the PM program has been very successful. We cross-train mechanics and machine operators to perform many of the same tasks that were strictly divided in the past. Now mechanics don't need a machine operator to start a machine to check a repair, he can do it himself; likewise, a machine operator can perform simple maintenance himself and save time.

Interview Question # 8. What areas of your PM program receive the most attention from top management?

Interview Response # 8. Top management at TEK is most interested in behavior change. They want to see equipment uptime increase, of course, but they are really interested in seeing the results of our worker surveys that report on managements achievement of the TPM goals.

Interview Question # 9. Has top management clearly defined the roles and responsibilities of the PM program?

Interview Response # 9. Top management has given the maintenance department a written charter that includes the roles and responsibilities of the PM program. From this charter the maintenance managers and personnel have developed specific goals and objectives for each area of maintenance.

Interview Question # 10. How successful do internal customers consider your PM program to be?

Interview Response # 10. Customer involvement is very important in the achievement of our team management goals. We work closely with the customer to develop requirements and achieve production consistency. In this way we ensure that the customers needs are met, and this boosts production and thus profits.

Investigative Question # 3. How do managers of successful maintenance programs ensure that all required maintenance actions are being performed?

Interview Question # 11. How do you ensure that all maintenance actions are being performed?

Interview Response # 11. From the start of a new design the maintenance department works to ensure the maintainability and reliability of the equipment or facility under consideration. Additionally, we require that our contractors use equipment that our maintenance personnel are trained to maintain or provide training as a part of the contract. We also require the contractor to provide us with maintenance task lists and frequency information for all equipment installed.

Interview Question # 12. What role do your supervisors play in your PM program?

Interview Response # 12. Supervisors at TEK are really there to that help the work teams achieve their TPM goals.

Investigative Question # 4. How do successful maintenance managers ensure the support of the work force?

Interview Question # 13. How do you motivate the work force?

Interview Response # 13. Team management is the greatest motivater that we apply at TEK. We get the craftsmen involved in the entire maintenance process and give them responsibility for the results. The workers feel better about themselves and the job they are performing; this lead to higher productivity.

Eastman Kodak of New York

A telephone interview was conducted with Mr. Ralph Leaman on 17 July 1989. Mr. Lehman is the Director of Maintenance for Eastman Kodak of New York, in Rochestor, New York. This interview was recommended by Mr. Walt McDaniel of HQ AFESC.

Investigative Question # 1. What methods are being used in civilian industry that are extremely effective?

Interview Question # 1. What is the specified purpose of your PM program?

Interview Response # 1. The purpose of our PM program is to save money and time. We feel that PM saves money by reducing the amount of time required to keep our facilities and equipment in operating condition.

Interview Question # 2. Do you use predictive analysis as a part of your PM program?

Interview Response # 2. We currently do not use any predictive analysis as part of our PM program. However, we are in the process of building a predictive analysis department at the present time.

Interview Question # 3. What type of management information system do you use?

Interview Response # 3. Management information systems is one of our major weaknesses. We are computerized, but each maintenance section has different computers and software. Therefore, we can't communicate

between the systems and that causes a lot of duplication of effort.

Interview Question # 4. How do you ensure that new equipment and facilities will be maintainable, once constructed?

Interview Response # 4. All new equipment and facilities are checked out for maintainability in a maintainability and reliability study that is performed by the maintenance department planners and management.

Interview Question # 5. Are there any specific management practices that you use in your PM program that you consider extremely effective?

Interview Response # 5. We work hard at keeping commitments that have been made to our internal customers. We post the PM schedule for the following two weeks and stick to it. This has helped to keep our credibility high amount the customers we service.

Investigative Question # 2. What practices ensure the success of a maintenance management program?

Interview Question # 6. What do you consider to be the three most important factors in a PM program?

Interview Response # 6. The most important factors in any PM program is trained personnel, rigorous documentation, and top management support. Without all these factors working together a PM program will falter.

Interview Question # 7. What areas of your PM program do you consider to be most successful?

Interview Response # 7. Again, documentation is probably the area of our PM program that is the most successful. Correct documentation is the key to a PM program that is consistent; and consistency is one of our measures of success.

Interview Question # 8. What areas of your PM program receive the most attention from top management?

Interview Response # 8. Top management is very interested in having a "quality" PM program, but it is very difficult to maintain quality when personnel and funding are being cut. Top management has to prioritize and sometime we have to take our share of the cuts.

Interview Question # 9. Has top management clearly defined the roles and responsibilities of the PM program?

Interview Response # 9. Here at Eastman the engineers develop the maintenance roles and responsibilities and then sell it to top management.

Interview Question # 10. How successful do internal customers consider your PM program to be?

Interview Response # 10. I would say that the majority of our customers don't realize that we are out there performing PM. The only time maintenance customers think about maintenance is when something breaks down, then we tell the machine operators that if we had been able to perform PM regularly the breakdown might have been avoided.

Investigative Question # 3. How do managers of successful maintenance programs ensure that all required maintenance actions are being performed?

Interview Question # 11. How do you ensure that all maintenance actions are being performed?

Interview Response # 11. The maintenance department works closely with the manufacturer, on equipment, and the contractor, on facilities, to ensure that any new items installed in the plant are maintainable by maintenance department personnel.

Interview Question # 12. What role do your supervisors play in your PM program?

Interview Response # 12. The supervisor is the "backbone" of our PM program. They schedule the work, but more importantly the supervisors follow-up on PM by performing spot checks of the previous day's work. If errors are founds the paper trail is still available to track the craftsman and have him correct the deficiency.

Investigative Question # 4. How do successful maintenance managers ensure the support of the work force?

Interview Question # 13. How do you motivate the work force?

Interview Response # 13. Motivation has not been a problem for us, management has a good relationship with the union and the workers. This strong relationship goes a long way in motivating the workforce.

Kings Island

Several attempts were made to interview Mr. Greg Sullivan, Director of Maintenance, Kings Island, Kings Island, Ohio. Mr. Sullivan requested a questionnaire, after initially contacted, but never returned the questionnaire or granted a telephone interview.

Wright State University

A personal interview was conducted with Mr. Don Beckman on 15 March 1989 at Allyn Hall on the campus of Wright State University. Mr. Beckman is a Building Systems Manager in charge of PM at Wright State University, Fairborn, Ohio.

Investigative Question # 1. What methods are being used in civilian industry that are extremely effective?

Interview Question # 1. What is the specified purpose of your PM program?

Interview Response # 1. The specified purpose of the PM program at Wright State University is to ensure safety, save Ohio taxpayer's money, and save maintenance man-hours.

Interview Question # 2. Do you use predictive analysis as a part of your PM program?

Interview Response # 2. Our maintenance personnel are not currently trained on any of the predictive maintenance techniques that are used in industry. We are, however, looking into a program that is in use at the

Miami University that seems to be working well. Money and personnel will be the deciding factors as to whether Wright State will attempt such a program or not.

Interview Question # 3. What type of management information system do you use?

Interview Response # 3. All PM checklists and schedules are maintained on an Apple IIE system utilizing standard PM software. We like the flexibility and autonomy offered by the personal system, as apposed to tying into the university mainframe.

Interview Question # 4. How do you ensure that new equipment and facilities will be maintainable, once constructed?

Interview Response # 4. Maintenance personnel and the design engineers work closely to ensure that any new systems are maintainable and reliable. In addition, maintenance supervisors and the design engineers hold weekly Design Review meetings to keep Maintenance abreast of all designs currently in progress.

Interview Question # 5. Are there any specific management practices that you use in your PM program that you consider extremely effective?

Interview Response # 5. Worker autonomy is probably the most successful area in our PM program. The workers are hired to perform PM on the 3rd shift, while classes aren't going on. It is also gives the craftsmen a great

deal of freedom to do their job as they sees fit; and we are pleased with the results.

Investigative Question # 2. What practices ensure the success of a maintenance management program?

Interview Question # 6. What do you consider to be the three most important factors in a PM program?

Interview Response # 6. Money, trained personnel, and tools and equipment. Without any of these three it is almost impossible to have a successful PM program.

Interview Question # 7. What areas of your PM program do you consider to be most successful?

Interview Response # 7. Consistency is our strong point. We have dedicated PM personnel and that allows us to maintain a very consistent program. A look at our records would reveal that on any date in 1978 we performed PM on the same building that the craftsmen are in on that date in 1989.

Interview Question # 8. What areas of your PM program receive the most attention from top management?

Interview Response # 8. Reliability of new systems has become an important issue in the last six months. Top management devotes a lot of attention to ensuring that we are acquiring facilities and equipment that will be easily maintained in the future.

Interview Question # 9. Has top management clearly defined the roles and responsibilities of the PM program?

Interview Response # 9. Maintenance policy letters are circulated throughout the University by top management. These letters detail al new maintenance policy, as well as, inform the customer of the current maintenance emphasis. In addition, we do have a PM handbook that helps the customer and the craftsmen understand the PM program policies and procedures.

Interview Question # 10. How successful do internal customers consider your PM program to be?

Interview Response # 10. Most of our customers are too involved in their own areas of responsibility to really appreciate the need for or amount of work involved in PM. Usually the only contact the PM craftsmen and the customer have is if an emergency occurs during the PM shift and the PM craftsmen are required to respond.

Investigative Question # 3. How do managers of successful maintenance programs ensure that all required maintenance actions are being performed?

Interview Question # 11. How do you ensure that all maintenance actions are being performed?

Interview Response # 11. We rely heavily on the integrity of the craftsmen. However, periodic spot checks are made by the PM supervisor and if a problem is identified the craftsman is notified. Management feels the PM craftsmen will perform their jobs better if they are given authority and responsibility for the results.

Interview Question # 12. What role do your supervisors play in your PM program?

Interview Response # 12. The supervisors basically plan and schedule the work and expedite material requirements. In addition, they perform periodic spot checks of the PM craftsmen work.

Investigative Question # 4. How do successful maintenance managers ensure the support of the work force?

Interview Question # 13. How do you motivate the work force?

Interview Response # 13. PM personnel currently employed by the University have been here for over 10 years. They are very self motivated; they enjoy working the third shift and the autonomy that it affords them.

University of Dayton

A telephone interview was conducted with Mr. James Hogue on 17 July 1989. Mr. Hogue is the Director of Maintenance for the University of Dayton, Dayton, Ohio.

Investigative Question # 1. What methods are being used in civilian industry that are extremely effective?

Interview Question # 1. What is the specified purpose of your PM program?

Interview Response # 1. We currently do not have a written PM policy, but like any other PM program we are interested in extending the life of our facilities and equipment.

Interview Question # 2. Do you use predictive analysis as a part of your PM program?

Interview Response # 2. In-house PM personnel are not trained on any predictive maintenance techniques. All of our predictive maintenance requirements are met by hiring an outside contractor. The contractor is on retainer and performs the predictive analysis on all major HVAC systems on a quarterly basis. After the analysis is performed a report is produced that details the actions necessary to correct all deficiencies identified in the study.

Interview Question # 3. What type of management information system do you use?

Interview Response # 3. Manual tracking of all PM requirements is currently used. A computerized system is in the planning stage. We feel the system we currently use is very accurate, however, the aim of computerization is to reduce paperwork.

Interview Question # 4. How do you ensure that new equipment and facilities will be maintainable, once constructed?

Interview Response # 4. We keep a listing of approved systems that our personnel are trained to maintain; this listing is used by the design engineers to ensure the systems they specify are approved for installation on the campus. Furthermore, we require all

contractors to provide us with PM documentation for all new systems installed under contract.

Interview Question # 5. Are there any specific management practices that you use in your PM program that you consider extremely effective?

Interview Response # 5. The most successful practices that we have implemented is using working supervisors. The morale of the craftsmen and the supervisors has increased dramatically.

Investigative Question # 2. What practices ensure the success of a maintenance management program?

Interview Question # 6. What do you consider to be the three most important factors in a PM program?

Interview Response # 6. The most important areas in the PM program at UD are manpower, record keeping, and equipment.

Interview Question # 7. What areas of your PM program do you consider to be most successful?

Interview Response # 7. General PM, changing filters, lubricating shafts, checking belts, and the like, is our most successful area of our PM program. The predictive analysis program is saving us a lot of money, but that is accomplished by contract.

Interview Question # 8. What areas of your PM program receive the most attention from top management?

Interview Response # 8. Top management is currently very interested in the predictive analysis program. They

see the potential for dollar and man-hour savings through use of the contractor and the advanced technology used in the program.

Interview Question # 9. Has top management clearly defined the roles and responsibilities of the PM program?

Interview Response # 9. As I stated earlier, we currently do not have a written PM policy. Most of the policy and procedures are simply verbal agreements between myself and University management.

Interview Question # 10. How successful do internal customers consider your PM program to be?

Interview Response # 10. Most of our customers don't know we are around until they have an emergency.

Investigative Question # 3. How do managers of successful maintenance programs ensure that all required maintenance actions are being performed?

Interview Question # 11. How do you ensure that all maintenance actions are being performed?

Interview Response # 11. The supervisors are out in the field with the craftsmen about 75% of the time; we use working supervisors. This allows the supervisors an enormous amount of time for follow-up. They know the quality of the work, first-hand, because they are right there on the job site.

Interview Question # 12. What role do your supervisors play in your PM program?

Interview Response # 12. At UD, we believe in working supervisors. Each supervisor is also a trained technician and he uses his skills on a daily basis along side the craftsmen. This shows the craftsmen that the supervisors consider the PM job to be an important part of the maintenance program. The supervisors have other duties, but their main emphasis is leading the craftsmen by example. At the present time the supervisors here are more motivated than any I have worked with in my career, so having them stay technically qualified and turning wrenches seems to be working.

Investigative Question # 4. How do successful maintenance managers ensure the support of the work force?

Interview Question # 13. How do you motivate the work force?

Interview Response # 13. Motivation of PM craftsmen is a real problem, PM is very repetitive work and it is difficult to keep the craftsmen interested in the job for long periods of time. We try to rotate the workers between PM and others areas in the maintenance department on a six month basis. This has really seemed to help in our case.

Maintenance Management Consultant

A telephone interview was conducted with Mr. Paul Tomlingson on 14 December 1988. Mr. Tomlingson is a management consultant with Pual D. Tomlingson Associate in

Denver, Colorado. While not a maintenance manager Mr. Tomlingson has helped to establish PM programs at over 50 industrial plants worldwide. His experience in the PM field is extensive and varied.

Investigative Question # 1. What methods are being used in civilian industry that are extremely effective?

Interview Question # 1. What is the specified purpose of your PM program?

Interview Response # 1. The primary objective of a PM program is to maintain equipment and facilities, as designed, in a safe, effective operating condition to insure that production targets are met economically and on time.

Interview Question # 2. Do you use predictive analysis as a part of your PM program?

Interview Response # 2. The best industry programs rely extensively on predictive analysis of production and mechanical equipment. Predictive techniques help to uncover problems before they reach a critical stage.

Interview Question # 3. What type of management information system do you use?

Interview Response # 3. MIS should be viewed as a decision making tool, not an end in itself. The type, manual or computerized, is not important as long as the data is accurate and aids in decision making.

Interview Question # 4. How do you ensure that new equipment and facilities will be maintainable, once constructed?

Interview Response # 4. The maintenance department needs to develop an atmosphere of mutual trust between maintenance personnel and design engineers. The engineers need to get out in the field and talk to the craftsmen about new designs and their effect on the craftsmen.

Interview Question # 5. Are there any specific management practices that you use in your PM program that you consider extremely effective?

Interview Response # 5. The most effective Pm programs that I have been associated with, quickly learned how to involve the customers in spotting maintenance problems. The maintenance department developed an easily understood maintenance policy and enlisted the support of the customer.

Investigative Question # 2. What practices ensure the success of a maintenance management program?

Interview Question # 6. What do you consider to be the three most important factors in a PM program?

Interview Response # 6. The most important areas that require time and effort on the part of management are the development of an easily understood maintenance policy, definition of supervisory roles and responsibilities, and the establishment of maintenance procedures based on plant policies.

Interview Question # 7. What areas of your PM program do you consider to be most successful?

Interview Response # 7. The most successful maintenance programs understood the value of a good maintenance management plan. They established a plan and stuck with it. This plan allowed management to act in a consistent manner to problems that arose, instead of reacting by taking the path of least resistance.

Interview Question # 8. What areas of your PM program receive the most attention from top management?

Interview Response # 8. Top management's role in any PM program is to develop a short, concise policy statement supporting PM. Something like "...PM takes precedence over all other types of maintenance except bona fide emergencies".

Interview Question # 9. Has top management clearly defined the roles and responsibilities of the PM program?

Interview Response # 9. The majority of the companies in industry do not, but the ones that do have much better PM programs.

Interview Question # 10. How successful do internal customers consider your PM program to be?

Interview Response # 10. PM managers need to talk to the customer. In terms that the customer can understand. Publish a maintenance handbook with procedures and policies that the customer can follow and apply. Above all get out and talk to the customer.

Investigative Question # 3. How do managers of successful maintenance programs ensure that all required maintenance actions are being performed?

Interview Question # 11. How do you ensure that all maintenance actions are being performed?

Interview Response # 11. Supervisors need to be in the field, checking the quality and accuracy of the maintenance.

Interview Question # 12. What role do your supervisors play in your PM program?

Interview Response # 12. Good supervisors are critical to the success of a PM program. They must be well trained and competent in all PM techniques. The supervisors need to spend a lot of time in the field, following up on the craftsmen, not behind a desk "pushing" paper.

Investigative Question # 4. How do successful maintenance managers ensure the support of the work force?

Interview Question # 13. How do you motivate the work force?

Interview Response # 13. If management develops a good maintenance management system the workers will be motivated to perform the work. If the management system is poor the craftsmen will be frustrated by delays and lag time and the motivation to work will drop.

Interviews with Air Force Maintenance Managers

The second section details the MAJCOM and Headquarters USAF view of RWP. The MAJCOM RWP monitors in SAC, TAC, MAC, AFLC and ATC were contacted to uncover new initiatives currently under way at the MAJCOM level. All military and government civilian employees contacted provided interviews as requested. To understand the HQ USAF view of the RWP the researcher attended a briefing given by the HQ USAF Director of Operation and Maintenance, LtC Robbins to the MAC 430-89B course at the AFIT School of Civil Engineering.

MAJCOM RWP Monitors. As stated earlier, only a few of the MAJCOMS had a designated RWP monitor. If a command did not have a designated monitor, that command was not included in this study. Each of the RWP monitors were asked to describe any new initiatives that were currently underway in their MAJCOM. Additionally, they were asked to comment on the recent changes to AFR 85-2, Civil Engineering General: Operations Management.

MAJCOM monitors liked the options provided by the new AFR 85-2. Engineering Performance Standard (EPS) is one area that several of the RWP monitors mentioned. MSgt. Johnson of HQ TAC said "...EPS has been a point of contention for the craftsmen for a long time and now it is not required; if the base has a better way of estimating time they can use it" (34). WIMS currently forces the use EPS but HQ TAC is working on deleting that requirement.

Most MAJCOM RWP monitors considered the new AFR 85-2 to be a psoitive improvement. AFR 85-2 gives the bases the right to manage their own programs, and includes fewer compliance and reporting items. "This pushes the decision to the lowest level, where it should be" (12). None of the MAJCOMS contacted require reports on RWP to be sent to the MAJCOM level.

HQ SAC and HQ TAC are presently placing a great deal of emphasis on the RWP in conjunction with the various organizational changes geared around zonal maintenance. "One of the biggest reasons for ROOM was to find a way to accomplish the day-to-day maintenance" (12). The TAC monitor reinforced this point, but also added a word of caution. Zonal maintenance is performed by multi-craft teams that are physically located out in the zones. All maintenance and repair are completed in a facility in one stop. A problem has arisen, the customers see all these craftsmen in their building and want them to work on "pet projects" rather than perform RWP. Johnson says that a renewed emphasis is now being placed on RWP completion before other types of work (34).

AFLC has a program that is one step beyond MEMET. The Infrastructure Program started in a similar manner, but they continued the program into a seminar for engineers and technicians. "We bring them together to talk about the effects that each have on the other. We analyze 17 systems and, together, try to identify the key

failure factors that need constant attention" (11). The real emphasis is on work requirement identification and information generation. In addition, we are working toward an artificial intelligence module that will interface with all WIMS data files, tying engineering to RWP, warranties to RWP, etc (11).

Headquarters Engineering and Services Center. LtCol Robbins presentation to the AFIT Operations Management Applications 89B class detailed the importance of the RWP to the overall mission effectiveness of the USAF. He stated that the RWP was the "bread and butter" of the CE Squadron, and if accomplished correctly would repay significant dividends on the investment of time and money expended.

Throughout his briefing LtCol Robbins placed considerable emphasis on the relationship between the Operations Branch and Engineering Branch and the effect that this relationship has on the RWP. He encouraged the Cheifs of Operation to develop a good working relationship between the PM craftsmen and the design engineers that would lead to a more effective and technically correct RWP.

Additionially, he advised the class members that although AFR 85-2 states that the RWP is a shop/superintendent level program, DEM and BCE involvement is a must. "It is up to the DEM to verify the RWP is being accomplished (51). To meet this challenge he

suggested the DEM needs to set priorities for the accomplishmenmt of RWP tasks. These include performing RWP tasks on facilities in the following priority order:

1. Mission Essential facilities.

2. Key buildings that change the perception of base leadership.

3. All other buildings.

By following this priority order when allocating RWP manhours the Chief of Operations is assured that the most important areas are covered first, and if adjustment is required, less important, visible areas are delayed until the next period.

Validation by MAC 89B Class Members

This section is designed to ascertain the practices discovered in this research that can be used in the AFCE community. To answer investigative questions 2 to 4 of the secondary objective the researcher presented preliminary results of this study to the MAC 430-89B, Management Applications Course, Air Force Institute of Technology, School of Civil Engineering and Services. The class members were briefed on the thesis effort and asked to comment in writing on the applicability of the results to AFCE. Additionally, classmembers were asked to include any areas they felt were overlooked in the study and offer suggestions on implementation of the study results in the CE RWP.

Only three of the 21 students returned the material as requested, and even these were incompleted. The researcher contacted the remaining 18 class members by telephone and asked if the information could be returned as soon as possible. However, no additional surveys were returned in time to be included in this study.

Summary

This chapter presented interviews with civilian maintenance managers, MAJCOM RWP Monitors, and the AFESC/DEM. This data was collected to disclose additional information on the subject of PM from civilian maintenance managers and military personnel responsible for the RWP.

The next chapter will present the analysis of the data collected in this research study. Each investigative question is answered in an attempt to fulfill the study's research objectives.

VI. ANALYSIS

Overview

This chapter contains an analysis of the literature review, case studies and the personal interviews. Each investigative question is analyzed and discussed. The goal of this analysis is to answer the primary and secondary research objectives of this study.

Primary Objective

The primary objective of this study is to determine those management practices that make certain PM programs successful.

Investigative Question #1

a) What methods are being used in civilian industry that are extremely effective?

For the most part the maintenance departments in civilian industry are managed in much the same manner as their counterpart in the Air Force. While exceptions did exist, the majority of the PM programs studied worked with the same management practices that have been incorporated into the RWP.

Industry views PM as any action taken to prolong the life of equipment and to avoid premature failures. PM has the objective of avoiding breakdown maintenance and achieving more planned work. Labor used for planned work is more productive and downtime for individual jobs is

reduced as well. The results of a successful PM effort include fewer failures, more planned work, fewer emergencies, reduced overtime, extended equipment life, better manpower use, improved equipment operation, less downtime, and reduced maintenance costs.

PM is viewed as a key element in management of the maintenance function. It is suggested that a strong management endorsement must be secured, such as, "PM should take precedence over every aspect of maintenance except bona-fide emergency work".

One extremely effective practice used in civilian industry is the use of a comprehensive maintenance management plan. One suggested maintenance management plan that is called a "Strategy for a Successful PM Program" includes:

Agreeing with Production on the Scope and Frequency of Services

Agreeing on the Roles of Operators

Spelling out Manpower Needs

Informing Production of PM Schedule

Agreeing on a Method of Measuring PM Compliance

Agreeing on a Method of Measuring the Success of the PM Program

One of the most successful maintenance departments studied was the maintenance department at the Tennessee Eastman Kodak Chemical Complex in Kingsport, TN. Over the past five years, TEK has developed a maintenance management system, called Total Productivity Management

(TPM), that pulls together some of the concepts in many of the Air Force quality programs. However, the TEK system involves a philosophy that leads to cultural change in the maintenance arena.

Performance Management is a key ingredient in making TPM so successful at TEK. First, manage an improvement process through people rather than manage things and activities. Second focus on changing the behavior of people by increasing both skills and responsibilities. Third, behavior is changed by finding ways to reinforce behaviors that make things go right rather than giving negative feedback on things gone wrong. In maintenance activities, a great deal of energy goes into identifying practices and behaviors the managers wish to reinforce.

Under a system driven by Performance Management the managerial outlook is changed. No longer do managers consider the buildings, equipment, and inventory to be the assets, but the people are. The emphasis changes from managing things (products, equipment, and techniques) to managing a continuous improvement process. Behavioral change becomes management's goal rather than quotas.

The use of a comprehensive maintenance management plan is the practice that distinguished the "wheat from the chaff" in the civilian maintenance programs studied. A well thought out maintenance management plan and consistent attempts to work within that plan boosted morale and productivity.

Investigative Question # 2

b) What practices ensure the success of a maintenance management program?

The practice that is most common to the successful PM programs studied is the use of a maintenance management system. The backbone of this system is a written PM policy. This policy follows the procedures and guidelines set up by the operational managers at all levels and works to reduce the friction inherent between maintenance and operations.

Maintenance policy has to be easily understood by not only all maintenance personnel but by all customers that maintenance serves. Therefore, it must be well thought out, logically put together, and succinctly communicated to the craftsmen and customers. This written policy should include a maintenance mission statement, a list of maintenance department responsibilities, and a statement of commitment to the PM program from top management.

In addition to a mission statement, maintenance managers need to develop a maintenance management plan. A composite plan resulting from a combination of the plans studied include the following components and subcomponents:

Customer Orientation:

1. Simplify Maintenance Requests

2. Formulate and Communicate an Easily Understood Maintenance Concept

3. Establish Day-to-Day Procedures Based on Operational Policies

4. Use Well Defined Maintenance Terminology

5. Codify a Maintenance Mission Statement

6. Post Schedules for all to see

7. Use standard forms and Standard procedures

9. Publish a Maintenance Customer Handbook

Planning:

1. Enlist Top Management Support for Maintenance Plans

2. Set up Maintenance Priorities

3. Develop a Written Maintenance Policy

4. Develop Long Range Maintenance Plans

5. Establish Maintenance Goals

6. Plan Maintenance Activities to Meet Goals

Scheduling:

1. Develop a Master Maintenance Schedule

2. Establish Standard Maintenance Routes

3. Strictly adhere to Maintenance Schedule and Routes

Control Function:

1. Measure Maintenance Performance

2. Establish a Cost Control System

3. Develop a Management and Productivity Reporting System

4. Modify Work Order Control System

History File:

1. Develop and Maintain an Equipment History File

2. Purge the Master maintenance file of unnecessary requirements

3. Validate Requirements Annually

Predictive Maintenance:

1. Establish a Detection Oriented PM Program

Material Control:

1. Gain Positive Control Over Inventory and Stores

2. Institute a Material Management System

Training and Motivation:

1. Encourage Training Programs for Maintenance Craftsmen

2. Keep Maintenance Personnel Turn-over Rate Low

3. Treat Craftsmen as Important Members of the Team

4. Reward Top Performers

Organization:

1. Develop a balanced Organizational Structure

2. Construct a Well-defined Maintenance Engineering Function

3. Maintain Open and Constructive Dialogue Among Maintenance, Production, Engineering, and Plant Management

4. Dedicate Personnel to PM

5. Set a Craftsmen to Supervisor Ratio at about 8 to 1

Supervision:

1. Define Supervisory Roles and Responsibilities

2. Ensure Supervisors Follow-up

Management Issues:

1. Use MIS to the Maximum Extent Possible
2. Work PM Craftsmen on 2nd or 3rd Shift
3. Keep Dialog Open Between the Maintenance Craftsmen and Engineering Personnel
4. Sell PM
5. Make Maximum Use of Advanced Technology
6. Use Multi-Skilled Craftsmen
7. Use Performance Management
8. Use Work Sampling Techniques
9. Use the Current Regulations to Your Advantage

Most successful maintenance managers adapted a similar maintenance management plan as necessary to meet the needs of the organization they manage. It is not necessary for all maintenance managers to adopt this particular plan, but it is important for management to develop a maintenance management plan and follow it.

This research indicates that the most successful maintenance departments develop some form of a maintenance management plan. This plan is used to ensure comprehensive coverage of all maintenance activities. Adapting a customized version of a maintenance management plan that suits the needs of the particular situation can help the manager obtain maximum productivity from the maintenance department.

Investigative Question # 3

c) How do managers of successful maintenance programs ensure that all required maintenance actions are being performed?

The most important action to ensure that all required maintenance actions are being performed is to critically review or create a master maintenance file. This file should contain all maintenance requirements for the calendar year. Management needs to make certain that the maintenance actions contained in this file are accurate, comprehensive, and reviewed at least annually.

Another important factor is to ensure the maintainability of future systems. The maintenance department must make every effort to develop open lines of communication with the design engineers. Whether through formal design review meetings or informal communication links, maintenance craftsmen and design engineers must communicate with one another.

Additionally, it is the responsibility of the maintenance manager to ensure that there is adequate supervisory follow-up on maintenance craftsmen. This means the maintenance manager will have to get out and check on the PM craftsmen. If the "boss" is out checking up on the craftsmen, the supervisors will, eventually, be out in the field ahead of him.

Investigative Question # 4

d) How do successful maintenance managers ensure the support of the work force?

Work force support is strongly related to the level of motivation among the craftsmen. Motivation in the maintenance department is enhanced by securing top-management support for maintenance programs. In the most successful maintenance departments, plant managers took a direct interest in formulating maintenance policies consistent with production strategy. Top management must take an active role in integrating the maintenance staff into the production team. Frank and constructive dialogue must be fostered between maintenance and production. Plant management must clearly illustrate how maintenance fits into the production operation.

The next step in motivating the work force is training. Plants that provided little or no training typically experienced high employee turnover; training serves to sharpen knowledge and skills, boosts morale, and helps in retaining people. Craftsmen are motivated by no delays, correct supplies, and little waiting for jobs. Training is essential for supervisors, planners, and schedulers to ensure that the craftsman has the correct plans, enough material, and adequate time to perform assigned tasks.

In addition, supervisors need to help the workers see their jobs as important to the company. They must treat craftsmen as important members of the team and justly reward them for their work. Essentially, a successful motivational effort must follow a pattern that

concentrates on these basic objectives. Effort must be made to see the craftsmen as they see themselves and place equivalent value on what they consider to be important.

Secondary Objective

The secondary objective will attempt to ascertain the applicability of these successful practices to the AFCE community.

Investigative Question # 1

a) What differences and similarities exist between the civilian industry maintenance objectives and the AFCE mission?

A mission statement is a written document that defines the maintenance departments function, roles, and responsibilities within the organization. It should serve as a cornerstone for objectives and planning for the department.

A mission statement needs to be adapted and formalized by each plant maintenance department. The experts, both military and civilian, agree that the objective is to optimize the use of time, manpower, funds, and material in order to improve plant availability, reduce downtime, and improve plant efficiency.

Investigative Question # 2

b) What specific areas of the industry's PM program can be adopted by the AFCE?

The majority of the practices used in successful civilian maintenance programs are already institutionalized in the RWP. Whether, through regulation

or standard practice, the maintenance management system that supports the RWP ranks among the best of the programs studied. The major difference in the RWP and civilian PM programs are the results achieved given such a system.

The profit motive caused civilian departments with a less developed maintenance management system to achieve more impressive results. The civilian managers were forced to do "more with less". Many of the maintenance departments studied used manual systems of identifying and tracking maintenance requirements, and still performed PM more consistently than is commonly credited to the RWP. A number of practices that lead to a successful PM program in the civilian industry were identified in previous sections of this chapter. All of these practices, in one form or another, can be adopted for use in the AFCE RWP. The practices that promise the most success include:

1. Performance management
2. Team management
3. Comprehensive maintenance management plan
4. BM vs PM
5. Centralized vs Decentralized
6. Advanced Technology
7. Artificial Intelligence
8. Worker motivation
9. Open Communication Between Engineering and Maintenance
10. Supervisor Follow-up

11. Top management support

12. Personnel training

Methods for adapting these practices into the AFCE RWP will be addressed in the following section.

Investigative Question # 3

c) How can these successful practices be adapted for use in the AFCE community?

The practices identified in the previous section of this chapter for adoption into the RWP, with minor changes, are adaptable to fit the AFCE environment. Each practice will be discussed to determine the extent of changes necessary for adoption into the RWP.

Performance management will take the most effort and time to fully incorporate into the AFCE RWP. Performance requires a cultural change; the managers must begin to manage people rather than quotas. Additionally, management has to focus on behavioral change in the workers. Increased attention is given to improving worker skills and increasing worker responsibilities. Finally, performance management requires that a great deal of energy be expended in findings ways of enforcing positive results, rather than giving negative feedback for mistakes.

Team management principles are being used throughout the Civil Engineering Squadron in AFLC. The program is experiencing positive improvement in productivity and

morale. The overall results remain to be seen, but the outlook is promising.

A comprehensive maintenance management plan can be derived from the many plans presented in this study. The Chief of Operations and Shop Foremen responsible for RWP must adapt a version of these plans that meets the needs of their situation. The most important thing is to formulate a plan that covers all PM areas and then stick to it.

Management needs to review the master maintenance file and determine the optimum mix of BM and PM. This practice is already an annual requirement set up in AFR 85-2. Items that are more costly to maintain than to replace should be deleted, if they will not adversely effect the mission.

Similarly, maintenance managers need to determine the organization structure that best suits their situation. Air Force regulations have recently been relaxed in this area, and some MAJCOMS are implementing more decentralized organizations. It is up to the manager that works with the customer on a daily basis to determine the best mix of organizational decentralization. The customers needs must be met while still maintaining positive control over the workforce.

The Air Force CE community has the equipment available to make use of most of the PM advanced technology. The problem is lack of training on the use

and advantages afforded by using this technology. Many of the CE shop Tables of Allowance include equipment such as infrared scanners, vibration testing equipment, oil analysis equipment, etc. Training needs to be provided to the craftsmen, so this vital source of productivity in the civilian community is not lost in the AF RWP.

Workers in civilian industry are motivated by the same types of things. The motivation techniques discussed in this study are not new or novel. These techniques focus on the worth of the craftsman to the maintenance organization. Rewards, certificates, and days-off can all play a part in motivating the workers, but until they realize that management respects their contribution to the organization, all the rest is wasted.

Open communication between the Operations and Engineering Branches has long been a problem. The personnel in one branch seem to think the people in the other branch are "speaking a different language". This, of course, is not true. If interaction between the branches is increased the workers in both areas will begin to see that the same goal is present and that mutual support is the best and only way to achieve that goal.

The final two areas are top management support and supervisor follow-up. These items fit together like "hand and glove"; if top management is not interested in the PM program, than first line supervisors will not be interested in the PM program. Top management must walk

through the mechanical areas and set the standards for the foremen and craftsmen to meet. This practice will have a snowball effect; if the BCE takes the Chief of Operations out to look at RWP compliance, the Chief of Operations will take the Superintendent, the Superintendent will take the foreman, and the foreman will take the craftsman. In this way the chain is complete and everyone knows that the RWP is important and being accomplished.

Summary

This chapter presented an analysis of this research study. The goal of this chapter was to fulfill the research objectives by answering each investigative question. The investigative questions were answered using the data collected from the literature review, case studies, and personal interviews.

The overall determination of this analysis is that the AF RWP is one of the best maintenance management systems currently in use. However, this study did uncover some maintenance management practices that would increase the effectiveness of the RWP. The next chapter will present recommendations on the implementation of these practices into the RWP.

VII. RECOMMENDATIONS

Overview

This chapter presents a summary of the research study, conclusions derived from the study, and recommendations for implementation and further research. The conclusions and recommendations presented in this chapter are based on the literature review, case studies, and the personal interviews.

Research Summary

The objectives of this study were to determine those management practices that make certain PM programs successful and how those practices can be adopted into the RWP. The hypothesis stated that civilian industry is performing PM better than the AFCE community.

To determine the validity of this hypothesis the researcher compared the management practices of civilian PM programs and the AFCE RWP. The comparison took the form of an extensive literature review, case studies, and personal interviews of military and civilian PM program managers.

Low response rate among civilian and military maintenance managers severely limited the research. As was expected, the maintenance managers were extremely busy managing their departments. The researcher contacted 45 practicing maintenance managers in civilian industry and

the Air Force. Of these, only 15 responded and allowed interviews or case studies to be performed. This limited the field of data collected and caused the results to be partially biased.

However, the information collected did provide the Air Force with insight into the world of civilian PM programs. This information will be valuable to the Air Force only if applied to the RWP in a conscious effort to improve upon the current PM program. The following conclusions and recommendations serve as a guideline for implementation of the results of this study into the RWP.

Conclusions

1. Civilian and military maintenance managers deal with many of the same problems that hinder the effectiveness of the PM programs they manage. Lack of top management support is the most common complaint among PM program managers.

2. PM programs in civilian industry have much the same aim as the RWP in CE. The profit motive changes the emphasis of the program for the civilians, but the overall mission is to maintain the facilities and utilities in the most economical manner.

3. In the RWP, the Air Force has one of the best maintenance management structures observed. However, this exceptional structure is not being used to its fullest extent. Many civilian PM programs had less funding, fewer

personnel, and a less advanced maintenance management system and still out-performed the RWP.

4. There is much to be learned from civilian industry in the management of PM. Collaboration through workshops, seminars, Education with Industry, and reciprocal visits should be seriously considered.

Recommendations

1. Ensure Top Management Support

Top-management support is imperative for the proper functioning of any PM program. The Base Civil Engineer and the Chief of Operations must get involved in the RWP. Their presence must be felt in each mechanical room on the base. The craftsmen must realize that the RWP is important to all levels of management from the shop supervisor to the Wing Commander. The Chief of Operations should brief the Wing Commander on the high cost of good maintenance and the enormous cost of low or no maintenance. He should detail the hours spent each week on the RWP and the estimated savings that the weeks work is expected to yield. The Base Civil Engineer should take the Wing Commander on a tour of the months best mechanical room, offer an open house type tour to the base personnel. Any means available must be used to publicize the importance of the base infrastructure.

The Chief of Operations needs to set up an awards program that recognizes the achievement of maintenance

personnel. Personnel who "do nothing but change filters everyday" need special attention to ensure their morale doesn't wain. Foster competition between the craftsmen for the "Best Mechanical Room on Base" and reward the shop with the highest and most complete RWP compliance with time off, a shop party, or some other "real" reward. Recognize the top performers in the maintenance area just as you would the craftsmen who work on the Wing Commander's pet construction project. If the Chief of Operations and the Base Civil Engineer emphasize RWP the Wing Commander will begin to realize the importance of the base infrastructure.

Visiting dignitaries, such as senators, congressmen, and general officers should be taken on a tour that includes stops to "show off" the base infrastructure, instead of hiding it. Have the craftsmen responsible for the mechanical room there to meet the visitors and explain their importance to the base, and, therefore, AF mission.

2. Construct a Good Maintenance Management System

Develop a mission statement. Considers the mission statement to be the "cornerstone" around which all goals and objectives are constructed. Next, develop a master maintenance plan. This plan should include a comprehensive preventive/planned equipment maintenance program.

A written PM policy should be distributed throughout the Base Civil Engineering organization as well as to all

CE customers. Establish an "easily understood" maintenance concept and communicate that policy to customers to reduce confusion and frustration. This policy must include approved goals for the maintenance department. Such as 10% of the available time on construction, 20% on breakdown maintenance, and the remaining 80% on preventive maintenance. However, it is up to the Chief of Operations to determine the amount of Hours that should be spent on RWP. If 80% is considered to be too much time on RWP, simply determine the correct amount and and perform that amount. The number one problem encountered by most PM shops is non-compliance with the schedule. As CESMET said, "... if it's important enough to identify, it's important enough to do".

Establish day-to-day procedures based on the commander's policies. Working to ensure that PM adds to the base mission accomplishment, never detracting from readiness.

3. Critically Review Your Current RWP

AFR 82-2 gives full responsibility for the RWP to the shop supervisor and the superintendents; however, for a program to be successful, the responsibility for PM must be felt at the highest level of the organization possible. A review of the RMP must have the support of top level management; the Base Civil Engineer and the Chief of Operations must take an active role in the RMP. The Base Civil Engineer and Operations Chief should check recently

accomplished maintenance tasks for accuracy and completeness. Additionally, management must ensure that personnel at all levels of the operation are trained on their role in the RMP. "Lack of aggressive management attention" was one of the missing ingredients in all the unsuccessful PM programs studied is this research effort.

The Chief of Operations must ensure that the recurring maintenance file list is periodically screened to reduce duplication and purge outdated requirements. Each item in the list must be re-evaluated on at least an annual basis. This will help discontinue maintenance of low cost items unless such maintenance is clearly recommended by the manufacturer or economically justified. Ensure that maintenance actions are performed by the cost center with the capability to accomplish it most efficiently. When at all possible consider involving facility users in inspection and minor maintenance actions.

4. Adopt a comprehensive maintenance management plan.

The Chief of Operations must encourage the superintendents to adopt a maintenance management plan that is comprehensive enough to incorporate all areas affecting the RWP. The plan presented in this study can be used as a guideline, but should be adapted to fit the situation at hand.

5. The following areas for additional research are suggested as thesis topics for future Graduate Engineering Management students:

1. Study successful Air Force PM programs.

2. Develop and "RWP specific" maintenance management plan that can be used AF wide.

3. Develop RWP customer service questionnaire.

4. Further explore the benefits and application of TPM in the AFCE community.

5. Study advanced technology use in CE.

6. Study AI use in CE.

Appendix A: Definition of Terms

The following are CE specific and technical terms and phrases that will be used throughout this thesis:

a. Recurring Work (RW). Work for which the scope and frequency are known without an advance visit to the job site and includes:

(1) Equipment or systems maintained by Base Civil Engineering (BCE) on a regular frequency.

(2) Operations such as grass cutting, cleaning storm drains and pavement cleaning, etc.

(3) Services such as entomology and refuse collection and disposal, etc.

(4) Other recurring work includes items for which the frequency is known and the scheduling features of the BEAMS RWP can be effectively utilized (for example, seasonal ordering of supplies or facility surveys, etc.) (8:117).

b. Preventive Maintenance (PM). Routine, recurring work required to keep a facility and its equipment in such a condition that they can be used at original or design capacity or efficiency (2:46).

c. Breakdown Maintenance (BM). Restoration of a facility and its equipment to a condition equal to original or design capacity and efficiency by replacing parts or materials after they have deteriorated (2:46).

d. Successful PM program. Preventive maintenance program that saves money and man-hours while extending the life of equipment or facilities.

e. Maintenance Action. Specific predetermined tasks to be done. Tasks are listed on an AF Form 1841, Maintenance Action Sheet (MAS) (8:117).

Appendix B: PM Organizations Studied

Canada Packers, Inc.
Toronto, Ontario

Disney Land
Lake Bueana Vista, Florida

Eastman Kodak of New York
Rochester, New York

Global Knapp, Inc.
Hayward, California

H.B. Maynard and Company, Inc.
Oak Brook, Illinois

Infotron Systems Corporation
Cherry Hill, New York

Kings Island
Kings Island, Ohio

New York Power Authority
New York, New YOrk

Sunhealth, Inc.
Raleigh, North Carolina

Tennessee Eastman Kodak
Kingsport, Tennessee

University of Dayton
Dayton, Ohio

Wright State University
Fairborn, Ohio

Appendix C: Personal Interview Questionnaire

Questions to be discussed in a scheduled telephone or personal interview. The researcher will contact you in the next two weeks to set up an interview at your convenience.

Investigative Question # 1. What methods are being used incivilian industry that are extremely effective?

Interview Question # 1. What is the specified purpose of your PM program?

Interview Question # 2. Do you use predictive analysis as a part of ypur PM program?

Interview Question # 3. What type of management information system do you use?

Interview Question # 4. How do you ensure that new equipment and facilities will be maintainable, once constructed?

Interview Question # 5. Are there any specific management practices that you use in your PM program that you consider extremely effective?

Investigative Question # 2. What practices ensure the success of a maintenance management program?

Interview Question # 6. What do you consider to be the three most important factors in a PM program?

Interview Question # 7. What areas of your PM program do you consider to be most successful?

Interview Question # 8. What areas of your PM program recieve the most attention from top management?

Interview Question # 9. Has top management clerarly defined the roles and responsibilities of the PM proigram?

Interview Question # 10. How successful do internal customers coinsider your PM program to be?

Investigative Question # 3. How do managers of successful maintenance programs ensure that all required maintenance actions are being performed?

Interview Question # 11. How do you ensure that all maintenance actions are being performed?

Interview Question # 12. What role do your supervisors play in your PM program?

Investigative Question # 4. How do successful maintenance managers ensure the support of the work force?

Interview Question # 13. How do you motivate the work force?

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VITA

Captain Jeffrey A. Jackson [redacted] After graduating from Webster County High School in Dixon, Kentucky in 1981, he entered the University of Kentucky pursuing a degree in Civil Engineering. In 1985, he graduated from the University of Kentucky with a Bachelor of Science degree in civil engineering. Upon graduation, he received his commission as a reserve officer in the USAF through the ROTC program. Initially, he was assigned to Offutt AFB, Nebraska, and worked as a Project Programmer in base civil engineering. During his tour at Offutt, he fulfilled the duties of Project Programmer, Chief of Readiness, ROOM Implementation Officer, and OIC Heavy Repair. In October 1987, he was selected to attend the Graduate Engineering Management (GEM) program at the School of Systems and Logistics, Air Force Institute of Technology, in June 1988.

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REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1a. REPORT SECURITY CLASSIFICATION
UNCLASSIFIED

1b. RESTRICTIVE MARKINGS

2a. SECURITY CLASSIFICATION AUTHORITY

2b. DECLASSIFICATION / DOWNGRADING SCHEDULE

3. DISTRIBUTION / AVAILABILITY OF REPORT
Approved for public release;
distribution unlimited

4. PERFORMING ORGANIZATION REPORT NUMBER(S)
AFIT/GEM/DEM/89S-10

5. MONITORING ORGANIZATION REPORT NUMBER(S)

6a. NAME OF PERFORMING ORGANIZATION
School of Systems
and Logistics

6b. OFFICE SYMBOL (*If applicable*)
AFIT/LSM

7a. NAME OF MONITORING ORGANIZATION

6c. ADDRESS (*City, State, and ZIP Code*)
Air Force Institute of Technology
Wright-Patterson AFB OH 45433-6583

7b. ADDRESS (*City, State, and ZIP Code*)

8a. NAME OF FUNDING / SPONSORING ORGANIZATION

8b. OFFICE SYMBOL (*If applicable*)

9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER

8c. ADDRESS (*City, State, and ZIP Code*)

10. SOURCE OF FUNDING NUMBERS

PROGRAM ELEMENT NO.	PROJECT NO.	TASK NO	WORK UNIT ACCESSION NO.

11. TITLE (*Include Security Classification*)
FACILITY RELIABILITY AND MAINTAINABILITY: AN INVESTIGATION OF THE AIR FORCE CIVIL ENGINEERING RECURRING WORK PROGRAM

12. PERSONAL AUTHOR(S)
Jeffrey A. Jackson, B.S., Captain, USAF

13a. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT (*Year, Month, Day*)	15. PAGE COUNT
MS Thesis	FROM _____ TO _____	1989 September	135

16. SUPPLEMENTARY NOTATION

17. COSATI CODES			18. SUBJECT TERMS (*Continue on reverse if necessary and identify by block number*)
FIELD	GROUP	SUB-GROUP	Air Force Civil Engineering Preventive Maintenance Recurring Work Program
15	05		

19. ABSTRACT (*Continue on reverse if necessary and identify by block number*)

Thesis Advisor: Michael Falino
Assistant Professor of Engineering Management
Department of Management Applications

Approved for public release: IAW AFR 190-1.

Larry W. Emmelhainz

LARRY W. EMMELHAINZ, Lt Col, USAF 11 Oct 89
Director of Research and Consultation
Air Force Institute of Technology (AU)
Wright-Patterson AFB OH 45433-6583

20. DISTRIBUTION / AVAILABILITY OF ABSTRACT
☒ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT ☐ DTIC USERS

21. ABSTRACT SECURITY CLASSIFICATION
UNCLASSIFIED

22a. NAME OF RESPONSIBLE INDIVIDUAL	22b. TELEPHONE (*Include Area Code*)	22c. OFFICE SYMBOL
Michael Falino, Assnt. Professor	(513) 255-4552	DEM

DD Form 1473, JUN 86 *Previous editions are obsolete.*

The purpose of this thesis was to test the validity of the hypothesis that the civilian service industry does a better job maintaining facilities and utility systems than the Air Force civil engineering community. The researcher looked at several sectors of the US service industry and compared their preventive maintenance programs to the Air Force Recurring Work Program (RWP).

The researcher reviewed contemporary Air Force and civilian literature on preventive maintenance (PM), performed case studies on two civilian maintenance departments, and conducted personal interviews with military and civilian maintenance managers. This data were collected to compare the RWP with civilian PM programs and determine if specific practices were used in the civilian programs that could improve the RWP.

Analysis of the results of the study indicated that the hypothesis was not entirely correct; the Air Force RWP was found to be one of the most comprehensive maintenance management systems studied. However, recommendations for improvement of the RWP were discovered through analysis of the civilian programs.