BEFORE THE FLORIDA PUBLIC SERVICE COMMISSION

In re: Review of Florida Power Corporation's Earnings, Including Effects of Proposed Acquisition of Florida Power Corporation by Carolina Power & Light

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DIRECT TESTIMONY
OF
E. MICHAEL WILLIAMS

ON BEHALF OF
FLORIDA POWER CORPORATION

JAMES A. MCGEE
FLORIDA POWER CORPORATION
Post Office Box 14042
St. Petersburg, FL 33733-4042
Telephone: (727) 820-5184
Facsimile: (727) 820-5519

Gary L. Sasso
James Michael Walls
CARLTON FIELDS
Post Office Box 2861
St. Petersburg, FL 33731
Telephone: (727) 821-7000
Facsimile: (727) 822-3768
Attorneys for Florida Power Corporation

DIRECT TESTIMONY OF E. MICHAEL WILLIAMS
ON BEHALF OF FLORIDA POWER CORPORATION

I. Introduction

Q. State you name, position, and business address.

A. My name is E. Michael Williams. I am Senior Vice President of Power Operations Group for Carolina Power & Light Company ("CP&L") and Florida Power Corporation ("Florida Power" or the "Company"). My business address is P. O. Box 1551, Raleigh, North Carolina, 27602.

Q. What are your duties and responsibilities?

A. The Power Operations Group is a major component of the Energy Supply business unit. Power Operations includes: Fossil Generation, System Planning and Operations, Combustion Turbine Operations, and Technical Services. These operations total over 15,000 megawatts ("MW") of regulated generating capacity located at 30 plant sites in the Carolinas and Florida.

In this position, I must maintain a balanced and effective program to provide the most economical power from the CP&L and Florida Power fossil, hydro, combustion turbine, and combined cycle facilities while maintaining well-equipped plants, complying with environmental regulations, maintaining the highest possible safety record, protecting assets, and leading them to higher levels of operating performance.

My major job duties and responsibilities include: developing and implementing strategic and tactical plans to accomplish operating objectives; managing and controlling fuel, capital and operating expenditures; overseeing hundreds of employees and hundreds of millions of dollars in assets and operating budgets; and providing a significant degree of leadership so as to lead, motivate, and influence a large workforce to achieve high operation performance levels.

Q. **Please describe your educational background and work expertise.**

A. I earned a Bachelor of Science degree in Nuclear Engineering from Texas A&M University in 1971. In 1982, I completed Louisiana State University's Executive Program. Then, in 1989, I graduated from Harvard Business School's Program for Management Development.

I have 29 years of power plant and production experience in various supervisory, managerial, and executive positions within the former Central and South West Corporation ("CSW") (now American Electric Power or AEP), CP&L and now, Florida Power Corporation. I began my career in the electric utility industry at the Southwestern Electric Power Company ("SWEPCO"), a subsidiary of CSW, as a Staff Engineer in 1972. In 1974, I became a maintenance supervisor at SWEPCO's Lieberman Power Plant, a four unit gas-fired plant. I was moved to the Welsh Power Plant, a three unit coal fired plant, as the Maintenance Superintendent in 1975. Then, in 1982, I became the Plant Superintendent at the H.W. Pirkey Power Plant, a single unit lignite-fired plant. In 1988, I was moved into the position of Manager of Production for SWEPCO and had responsibility for all SWEPCO plants. In 1989, I became the Division Manager, and I was responsible for all transmission, distribution, marketing, and customer service activities with the Western Division, headquartered in Longview, Texas.

Then in 1992, I became the Vice President of Engineering and Production for Public Service Company of Oklahoma ("PSO"), another subsidiary of CSW. Shortly thereafter, in 1993, I became CSW's Vice President of Fossil Generation in Dallas, Texas. In this position, I was responsible for the operation and maintenance of 34 fossil power plants in 4 states, including 5,000 MW of coal units, 9,000 MW of gas/oil units, and 500 MW of peakers. I was responsible for over 1,300 employees (both union and non-union) and annual budgets of approximately $150 million in operating and maintenance ("O&M") and $130 million in capital.

I joined CP&L in June of 2000 as Senior Vice President of its Power Operations Group.

II. Purpose and Summary of Testimony

Q. What is the purpose of your testimony?

A. I appear on behalf of Florida Power to support the reasonableness of power operation costs reflected in the Company's Minimum Filing Requirements ("MFRs").

Q. Have you prepared any exhibits to your testimony?

A. Yes, I have prepared several exhibits as follows:

EMW-1 - Graphs: Power Plant Performance – Equivalent Availability and Starting Reliability

EMW-2 - Plant Maintenance Optimization Assessment Guidelines, EPRI, Palo Alto, CA, and CSI Services, Eddystone, PA: 2000.1000321

EMW-3 - Graph: O&M Cost Performance of Power Plants

Q. What schedules in Florida Power's MFRs do you sponsor?

A. I sponsor or co-sponsor Schedules B-18, B-30, C-8, C-13, C-14, C-19, C-20, C-21,C-27, C-52, C-53, C-57, C-61, and F-17. These schedules are true and correct, subject to their being updated in the course of this proceeding.

Q. Please summarize your testimony.

A. Florida Power's forecasted capital and O&M expenses for power plant operations reflect its commitment to: (a) increase the availability and reliability of its existing power plants at a reasonable cost; (b) bring into service new, cost-effective, efficient, environmentally friendly, and operationally responsive combustion turbine ("CT") and combined cycle ("CC") units with a net savings to O&M expenses; (c) reduce the Company's reliance on demand side management ("DSM"); and (d) continue to meet the dynamic needs of Florida Power's customers.

Fossil Steam Generation – Since the last rate case, the Company has made significant strides towards reducing the O&M expenses associated with its fossil steam generation fleet by retiring old, inefficient plants and scaling back the necessary work force. As captured in its 2002 forecast, Florida Power has achieved and will achieve significant per MWh reductions in O&M costs for these plants through the adoption of CP&L's aggressive maintenance management and outage management systems, organizational re-alignments, and permanent and temporary staffing reductions. Indeed, the reduction in permanent and temporary staffing along with organizational realignments account for a majority of the $15.8 million in synergy savings power operations plans to achieve, as described in Mr. Myers' September 14, 2001 pre-filed testimony.

At the same time, the historic above-average performance of these units will be enhanced and move Florida Power's fossil steam generation fleet into the top quartile in terms of performance and costs. Specifically, Florida Power plans and expects to improve the performance of these units by increasing their equivalent availability to 91 percent.

Florida Power will also be making additional, incremental, capital investments in these plants over the next three to four years in order to continue to ensure historical performance levels and to meet new performance goals. These capital investments are necessary at this time to address plant aging issues and will be focussed on the replacement or refurbishment of essential equipment such as turbines, boilers, and precipitators.

CT and CC Generation – Since 1992, Florida Power has added approximately 1,205 MW of generation to its fleet by timely and cost-effectively building or purchasing state-of-the-art CT and CC power plants. The addition of these intermediate and peaking units adds an enormous amount of operating flexibility to Florida Power's fleet. Fueled primarily by natural gas, they also have the benefit of providing greater fuel diversification to Florida Power's owned generation, further protecting the Company's ratepayers from service interruptions.

Moreover, the Company's CC and CT fleets are both top-quartile performers as measured by equivalent availability and starting reliability, respectively. Florida Power's CC fleet also ranks in the top quartile in terms of cost-effective operation. As noted in the 2002 forecast, Florida Power is expecting an increase in O&M in connection with these units related to rising capacity factors and increased number of starts. However, even with these additional costs, Florida Power still anticipates that its CCs will maintain their top-quartile cost performance.

Merger Synergies – As noted above, the $15.8 million in merger synergies the Power Operations Group plans to achieve are primarily tied to permanent and temporary staff reductions at its fossil steam plants, organizational realignments, and process improvement initiatives. For example, Florida Power has been able to consolidate with CP&L its resource planning function, engineering, and CT operations and to implement process improvement initiatives, such as equipment sharing, across the CT system.

In sum, Florida Power is pleased to report that its 2002 forecast shows a net reduction of $9.8 million in O&M below the 2002 benchmark. This is extraordinary given that it includes the O&M for Florida Power's approximately 1,205 MW of new generation and expected increases in O&M at the Company's CC and CT plants as noted above. Moreover, this has been and will be accomplished without sacrificing fleet performance and, in fact, while improving the performance of its fossil steam units.

It is important that the Company recover revenues sufficient to cover budgeted power operation capital expenditures in order to continue to achieve the reduced O&M expenses enjoyed in this area, as well as reach achievable (yet cost-effective) reliability and availability goals necessary to satisfy its customers.

III. Power Operations Since 1992

Q. Please give us an overview of the evolution of Power Operations since the last rate case.

A. In 1992, Florida Power's generation plants consisted of its fossil steam generators, peakers, and its nuclear plant. These units (excluding the nuclear plant) included base-load coal units and oil- and gas-burning units that were built between the 1950s and 1980s. (See Dale Young's testimony for a discussion of nuclear operations). The Company has operated these plants in a very traditional, yet fiscally conservative, manner.

In connection with its steam units, Florida Power maintained its policy of making conservative capital investments in these plants and focused its budgeted funds on the operation and maintenance of these plants. This traditional operation and maintenance framework permitted Florida Power to operate its steam plants with above-average availability and reliability and top quartile cost performance when compared to other utilities across the nation. See Exhibits EMW-1 and EMW-3.

Some of these plants, however, were very old and although they performed well in comparison to similar plants, they were not nearly as inexpensive to operate as the newer units being built in this time frame. Thus, in 1994 when faced with the opportunity to meet its rising demand with PURPA-driven power purchase agreements, Florida Power determined that it should retire certain of its most expensive fossil steam generation plants.

Specifically, Florida Power retired five of its older fossil steam generating units at the Higgins and Turner sites, including Higgins Units 1, 2, & 3 and Turner Units 3 & 4. These units represented only about 260 MW of generating capacity but were some of the oldest and most expensive units on Florida Power's system to operate on a MWh basis. Accordingly, their retirement reflects a particularly favorable impact on the fossil fleet's O&M, resulting in a $13.1 million variance below the 2002 benchmark.

During this same time frame, Florida Power undertook company-wide cost cutting efforts and managed to scale back the necessary number of permanent employees at its fossil steam generators from approximately 785 to 695. This resulted in significant O&M savings that are reflected as a part of the total permanent staffing reduction savings in the 2002 forecast.

Likewise in the mid-1990s, Florida Power's additional generation needs again rose to a level that required Florida Power to take some action. Florida Power determined that the combination of adding self-generation and increasing its reliance on demand side management to reduce load struck an appropriate balance between the competing interest of reliable, yet cost-effective, service. Taking advantage of technological advances in the industry, Florida Power's planners determined that the most cost-effective additions to Florida Power's fleet were CT and CC units. These natural gas-fired intermediate units and peakers also enhanced the flexibility of Florida Power's self-generation system and added fuel diversification to Florida Power's fleet.

Specifically, between 1996 and 2000, Florida Power added four CT units at its Intercession City site totaling 452 MW. Then in 1997, Florida Power acquired the Tiger Bay facility, which is a 223 MW state-of-the-art CC facility already in operation. Finally, in April 1999, Florida Power brought into service the first of its own planned CC units (Hines 1) at the Hines Energy Complex. Hines 1 added another 529 MW of generating capability to Florida Power's fleet. Most recently, the Company has taken great strides in the ongoing development of Hines 2, another CC unit that will add another 567 MW of capacity to Florida Power's system.

These new CC plants have been performing in the top quartile of the industry both in terms of performance and costs, and Florida Power anticipates that they will serve its customers well for years to come. Likewise, measured on the basis of starting reliability, Florida Power's entire CT fleet also ranks in the top quartile when compared to similar units across the nation. Notably, these additions were also necessary for Florida Power to achieve its agreement with the Commission in connection with the Reserve Margin Docket to increase its reserve margin from 15 percent to 20 percent by summer 2004.

Through the process of the merger, Florida Power had an additional opportunity to evaluate its practices in the area of power operations as well as adopt some of the best practices of CP&L. Based upon this evaluation, Florida Power determined that several important cost-saving changes could be made by implementing CP&L's more aggressive maintenance management and outage management programs at its own fossil steam plants. These programs are described in more detail below. The merger, likewise, permitted Florida Power to reduce significantly its support staff through organizational re-alignments and the number of its employees at its fossil steam plants. Indeed, total staffing reductions in the power operations area account for a majority of the synergy costs savings achieved by this group.

In addition, Florida Power also adopted new availability goals for its fossil steam units. This was done as a part of Florida Power's ongoing efforts since early 2000 to reduce its reliance on DSM due to customer dissatisfaction with service and due to experienced and expected attrition from these programs.

Finally, Florida Power also determined that it needed to make increased capital investments in its existing steam generation fleet due primarily to plant aging in order to ensure the ability of these units to meet old and new performance goals.

IV. <u>Budgeting</u>

Q. Please describe your budgeting process and the measures you take to monitor and control costs.

A. Throughout the Company, including the functional areas under my management, we engage in rigorous cost evaluation and control for all capital expenditures and O&M costs. Our overall goal is to deliver top quartile reliability while maintaining top quartile cost control. Within each business unit, including Power Operations, O&M budgets and recommendations are developed by plant management based on targets keyed to historical spending and, increasingly, by metrics designed to drive functional units to top quartile performance levels. Capital budgets and project recommendations are developed by plant management and engineering staff based on equipment assessments and financial analysis of the individual capital projects. All capital and O&M proposals and requests must be supported and defended through a peer review process, subject to management approval. The monitoring of costs throughout each year is accomplished by monthly reporting of year-to-date budget versus actual spending, analysis of variances, and projected spending for the balance of the year.

V. Steam Generation

1. Performance and Reliability

Q. Please describe the Company's new performance and reliability goals for its steam generators.

A. Florida Power is committed to enhancing the performance and reliability of its fossil steam generation fleet through a number of maintenance and outage initiatives and by investing the necessary capital funds in these units to ensure their continued performance. Through these planned initiatives and capital investments, Florida Power plans to improve the equivalent availability of these units from just above average (See EMW-1 for graph of historic performance) to top quartile in the industry. Specifically, Florida Power's goal is to increase the equivalent availability of its fossil steam units to 91 percent.

Q. Please discuss the impact this new level of reliability and performance will have on the O&M costs of these steam units.

A. Florida Power's new reliability and performance goals actually reduce the O&M expenses associated with the operation of these units. As reflected in Florida Power's 2002 forecast, the Company expects to achieve a $13.5 million variance below benchmark for O&M costs attributable to its fossil steam units by implementing enhanced maintenance management and outage management systems gained through the merger.

Q. Please explain how it is possible to enhance performance and reliability while reducing O&M costs.

A. Florida Power has adopted and implemented several integral programs: Maintenance Management; Preventative Maintenance; Predictive Maintenance; and Outage Management designed to improve plant performance and reduce O&M costs. For example, Florida Power is currently implementing a Predictive Maintenance ("PdM") initiative that has been in place at CP&L since 1998, the benefits of which were recently verified by an industry study conducted by the Electric Power Research Institute ("EPRI") entitled *Plant Maintenance Optimization Guidelines*, EPRI #1000321, Final Report December 2000. This study shows that the several electric utilities that implemented PdM as a maintenance strategy were able to achieve a significant return on investment. See Exhibit EMW-2. Sixty to 80 percent of the savings were realized by improvements in reliability while 25 to 30 percent came from a reduction in non-fuel O&M. See Exhibit EMW-2.

Moreover, the combination of these programs permits Florida Power to continue to make and accelerate a number of important changes to its historical preventative and outage maintenance practices resulting in enhanced reliability and availability and reduced O&M. Through these programs, Florida Power plans to continue efforts to increase regular outage intervals at each of its steam generation plants from the industry norm of 12 months to 24 months (currently at 18 months). Florida Power also plans to continue efforts to increase major boiler and turbine outage intervals at these plants from the industry norm of five years to seven years (currently at six years). The risks associated with these increased outage intervals is, in turn, mitigated by the Company's Predictive and Preventative Maintenance programs through the close monitoring of critical equipment that permits necessary preventative and corrective maintenance to occur as planned work rather than emergent work. Likewise, these programs also permit a decrease in the actual duration of the outages through improved planning, scheduling, and execution. For example, the length of major outages will be decreasing from ten to eight and, finally, to six weeks.

By reducing the necessary planned outages at these units, Florida Power will, by definition, increase their equivalent availability to serve its generation needs. Likewise, these initiatives have the added benefit of assisting Florida Power in its ongoing effort to reduce its reliance on DSM (especially during off-peak or usual outage periods) and may result in a reduction of replacement power costs as well.

2. Capital Investments

Q. Please describe the capital investment Florida Power anticipates making in its fossil steam units.

A. Over the last few years, Florida Power has invested an average of $20 million to $30 million in capital expenditures. During the next three to four years, Florida Power intends to increase annual capital expenditures to $50 million to $60 million. This increase will allow Florida Power to address plant aging issues systematically beginning with those at Crystal River 1 and 2. The focus of these capital projects will be the replacement or refurbishment of essential equipment such as turbines, boilers, and precipitators. The capital investments Florida Power intends to make in these fossil steam generation plants is necessary not only to meet its new performance and availability goals, but to ensure that these plants have the ongoing ability to operate at historical reliability levels. Moreover, the Company fully expects that its capital projects will ultimately result in the ability to maintain top quartile O&M performance, as well as ensure the ongoing performance of the Company's fossil steam generation plants through better reliability, availability, and increased run time.

VI. Other Power

Performance, Reliability, and O&M Costs

Q. How are the Company's new CC units performing?

A. As noted above, the performance of the Company's CC units ranks them in the top quartile of the industry on an equivalent availability basis. See Exhibit EMW-1.

Q. Does top quartile performance translate into high O&M for these plants?

A. No. The cost performance of these plants also ranks in the top quartile nationwide. As shown in the graph attached to my testimony as Exhibit EMW - 3, Hines 1 and Tiger Bay are outperforming over 75 percent of the CC plants (based on a two-year average) throughout the industry on a dollar per MWh basis. However, it is important to note that Florida Power is projecting an increased number of starts at these units, which will impact O&M as discussed below. In the final analysis, though, these highly flexible intermediate units are high performing, cost-effective additions to Florida Power's generation fleet and will undoubtedly serve its customers well for many years to come.

Q. How are Florida Power's CTs performing?

A. Florida Power's CTs (i.e., peakers), measured on the basis of starting reliability, are also performing in the top quartile based on industry comparisons. See Exhibit EMW-3. This is good news for Florida Power's customers who rely on Florida Power's ability to meet spikes in electric energy demand in great part by starting these units.

Q. Is Florida Power anticipating any increase in its O&M costs associated with either its CC or CT units?

A. Yes. Florida Power's 2002 forecast shows a $4.4 million increase in variable non-fuel O&M costs directly related to the rise in the capacity factors of these units and the increasing number of times they have to be started. As shown on the graph set out in Schedule C-57a at pp. 209 - 210, since 1992, the capacity factors and number of starts associated with these units has risen steadily as intermediate and peak load has continued to rise. Nonetheless, the Company anticipates that its CC units will stay in the top-quartile in terms of O&M per MWh.

VII. Power Plant Additions

1. Cost Effectiveness of the Additions

Q. Please describe the power plant additions to Florida Power's fleet since 1992 and how they were selected.

As described above, since 1992, Florida Power has added four CT units at Intercession City and two CC units. The decision to build the CTs at Intercession City and the decision to build Hines 1 was made by Florida Power's planning group through the Integrated Resource Planning process. This process essentially matches Florida Power's forecasted load growth with the most cost-effective power plant additions. The cost-effectiveness of the Hines 1 unit was evaluated and affirmed by the Commission in the Hines 1 need proceeding. (See Order at 92 FPSC 2:659).

Similarly, the Commission approved a Stipulation and Supplemental Stipulation in connection with the purchase of the Tiger Bay CC unit. (See Order at 97 FPSC 6:54).

Q. Please describe in more detail the basis for Florida Power's decision to build the four combustion turbine peaking units installed at Intercession City.

A. Intercession City unit 11 is a unique, jointly owned peaker that began commercial operation in January 1997. Florida Power owns only two-thirds of the unit while Georgia Power owns one-third. The project was a joint effort by the two utilities to obtain additional generation during peak customer demand periods at the time when each needed the power most. Since Florida Power tends to be a winter-peaking utility while Georgia Power's needs are higher in the summer, the sharing of this unit proved to be a very cost-effective way to meet the respective needs of these two utilities while spreading the costs of the plant across a larger group of ratepayers.

During the 1997 Integrated Resource Planning cycle, Florida Power's resource planning models showed a need for an intermediate/peaking block of megawatts in Winter 2000/2001. In order to take advantage of lucrative equipment options secured from Westinghouse, Florida Power requested a bid waiver with respect to the proposed Hines 2 CC unit in order to return that value to its customers.

Accordingly, Florida Power researched alternative cost-effective methods to meet its reserve margin requirement for Winter 2000/2001. Florida Power determined that installing three peaking units at Intercession City (units 12, 13, and 14) would be the most cost-effective alternative available that would enable the Company to meet its projected need in Winter 200/2001. Construction began in February 1999, and the units were in commercial operation in December 2000.

These units are high efficiency, General Electric 7EA peaking units, with heat rates that added significant value to Florida Power's rate payers through lower fuel costs and improved reliability.

Q. What impact will these plant additions have on O&M going forward?

A. The addition of new generation always appears to increase O&M when compared to a prior case that does not include them. In the case of Florida Power's CTs and CCs, the expected O&M costs are about $20 million. However, it is important that the cost-effectiveness of a seeming increase in O&M arising from plant additions be appropriately evaluated by looking at the additional cost of these units on a unit-production basis (measured by O&M costs per MWh). For example, when compared to the units retired by Florida Power on this basis, the O&M associated with the Company's new CTs and CCs is actually $10 –12 per MWh lower. This significant per MWh reduction in O&M through the addition of these state-of-the-art units results in a self-evident benefit to Florida Power's customers (i.e., the availability of more generation to meet load at a reduced per MWh cost).

VIII. Merger Synergies

Q. Please discuss the source and the amount of merger synergy savings that have been attributed to Power Operations.

A. The Company forecasts merger synergies in power operations of $15.8 million. These savings are primarily attributable to staffing reductions at Florida Power's fossil steam plants along with other organizational realignments through the combination of plant services and maintenance groups.

Q. Please describe the staffing reductions (both permanent and temporary) Florida Power was able to achieve at its fossil steam plants since the last rate case and the corresponding impact on O&M.

A. In 1994, Florida Power engaged in cost cutting efforts and was able to scale back the number of permanent employees it needed to operate its fossil steam plants by about 90 employees. More recently, in connection with the merger, Florida Power was able to reduce further the number of permanent employees and temporary employees supporting these plants. Specifically, Florida Power was able to reduce the number of necessary permanent employees at its fossil steam plants by another 90 - 91 employees reducing the total permanent fossil steam generation from 785 employees (1992 levels) to 604 employees (excluding employees reduced through plant retirements). This translates into a $11.3 million variance below the 2002 benchmark. Similarly, Florida Power's ability to reduce temporary staff also results in a favorable variance below benchmark of $5.3 million.

Q. How do Florida Power's staffing levels at these plants now compare to other similarly sized plants in the industry?

A. The staffing at Florida Power's fossil steam plants is still in line with the staffing of similarly sized units in the industry. For example, the staffing at Crystal River is in line with other top quartile coal plants such as Duke Power's Marshall and Belews Creek plants, CP&L's Roxboro Plant, Southwestern Electric Power's Welsh Plant and Entergy's White Bluff and Independence Plants.

Q. What are the process improvement initiatives and organizational realignments that contribute to the merger synergy savings described earlier in your testimony?

A. The process improvement initiatives and organizational realignments that the Company expects will contribute to the expected merger synergy savings in the area of power operations include:

- Crystal River organizational re-alignment / coal yard re-design;
- the sharing of parts across the CT system;
- the consolidation of CT operations;
- the consolidation of fuel management systems;
- the consolidation of engineering;
- the consolidation of fossil finance to energy supply finance; and,
- the consolidation of resource planning functions.

Indeed, many of the organizational changes noted above have already occurred.

Q. What has been the net effect of power plant additions on O&M costs?

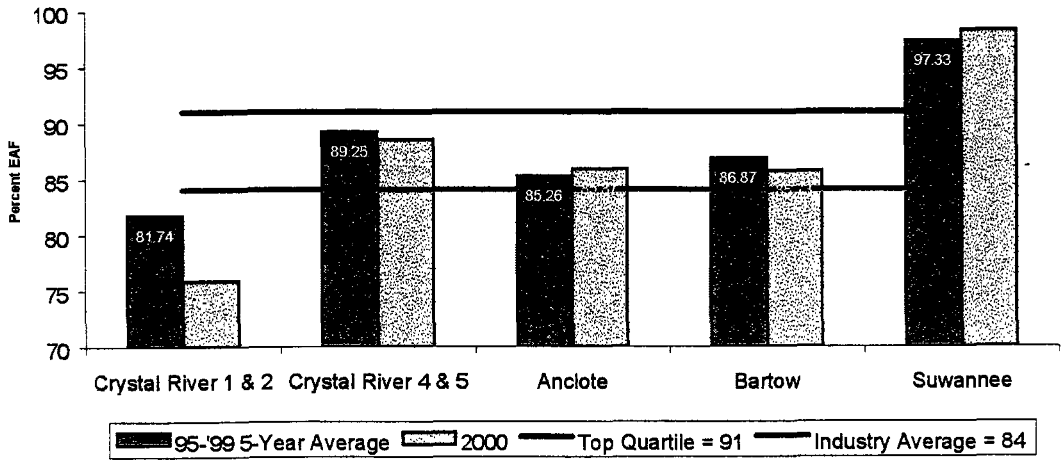
A. It has been very favorable. Even with the addition of approximately 1205 MW of generating capacity since the last rate case, Florida Power shows a favorable variance from the 2002 O&M benchmark of approximately $9.8 million. This is the equivalent of lowering Florida Power's power generation O&M from $5.30 per MWh to $4.50 per MWh. Put another way, this means that Florida Power was able to absorb the O&M associated with the 1205 MW of added plants and still show a net decrease in O&M in the area of Power Operations.

Q. Does this conclude your testimony?

A. Yes.

Equivalent Availability Factor – Coal / Oil / Gas Plants

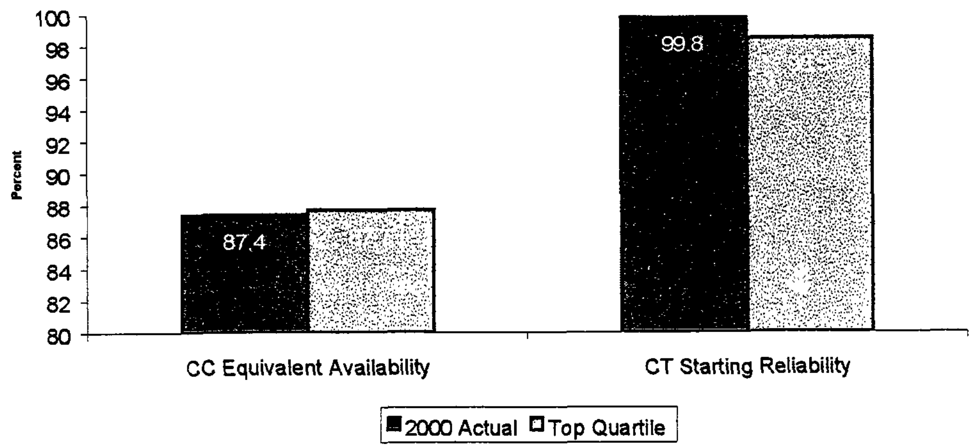
(FPC vs. Industry)



Source: NERC, PPDS, MicroGADS

Equivalent Availability – Combined Cycle Plants
Starting Reliability – Combustion Turbine Plants

(FPC vs. Industry)



Note: CC Equivalent Availability data includes Hines, Tiger Bay, and University of Florida Cogen.
CT Starting Reliability data includes DeBary, Turner, Rio Pinar, Intercession City, Avon Park, Bayboro, and Higgins.

Source: NERC

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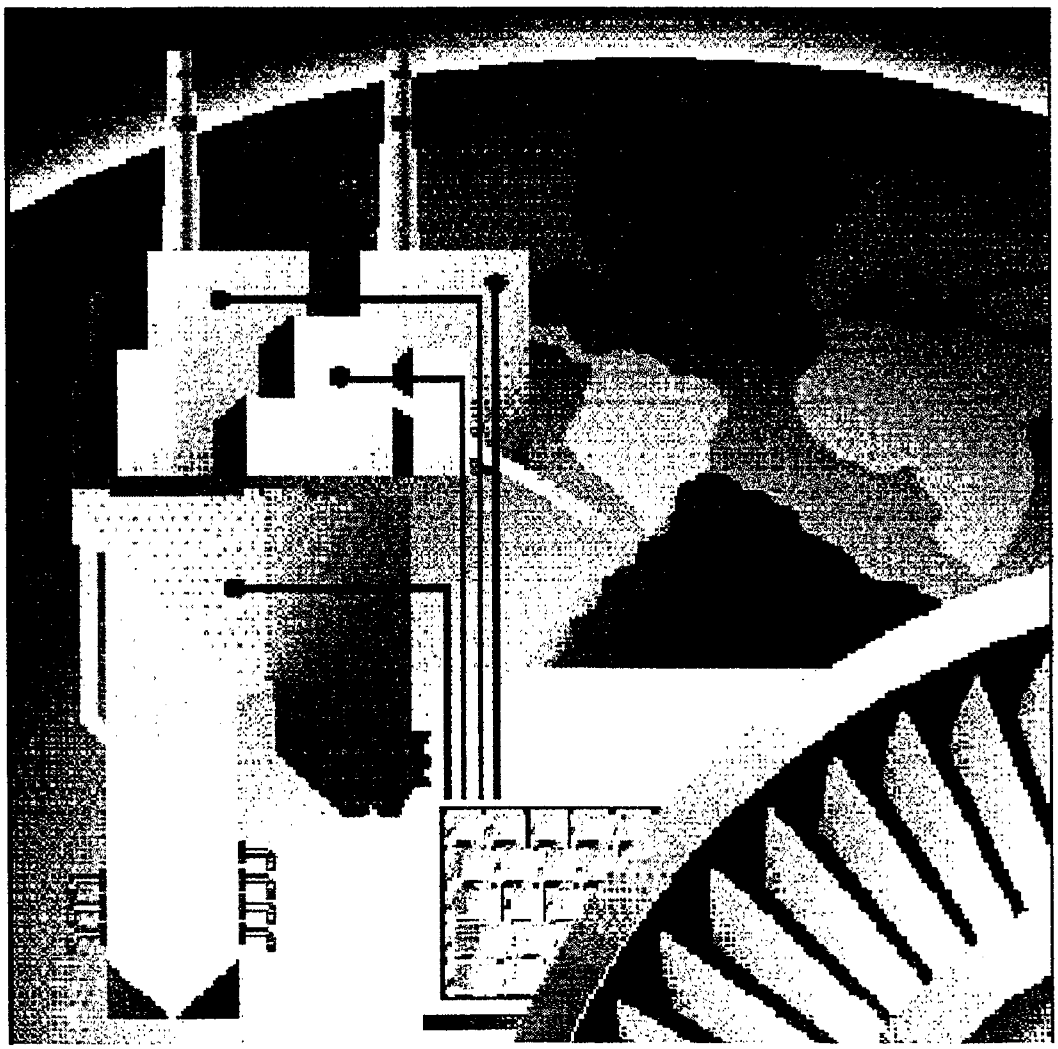
WILLIAMS

Plant Maintenance Optimization Assessment Guideline

Technical Report



Plant Maintenance Optimization Assessment Guideline

1000321

Final Report, December 2000

EPRI Project Manager
M. Perakis

EPRI • 3412 Hillview Avenue, Palo Alto, California 94304 • PO Box 10412, Palo Alto, California 94303 • USA
800.313.3774 • 650.855.2121 • askepri@epri.com • www.epri.com

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CITATIONS

This report was prepared by

CSI Services
440 Baldwin Tower
Eddystone, Pennsylvania 19022

Principal Investigators
R. Colsher
W. Vollmer

N&T Consulting
861 Prospect Hts.
Santa Cruz, CA 95065

Principal Investigator
M. DeCoster

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Plant Maintenance Optimization Assessment Guideline, EPRI, Palo Alto, CA and CSI Services, Eddystone, PA : 2000. 1000321.

REPORT SUMMARY

A Plant Maintenance Optimization (PMO) assessment is a way to help electric power producers achieve lower operating costs and higher reliability and availability by optimizing the overall maintenance program. The assessment starts by introducing the attributes of an ideal program. The second part of the process evaluates the existing maintenance program and identifies gaps between the existing program and the ideal program. The process concludes by developing an implementation plan to move the program toward the ideal state.

Background

EPRI has performed PMO assessments at over 50 power generation plants and other industrial facilities. Subsequent implementation initiatives have reduced overall maintenance costs, improved plant availability, improved equipment reliability, and increased both overall and commercial availability.

Objectives

- To educate an organization in PMO terminology and concepts.
- To gather data and assess an organization on all aspects of plant maintenance.
- To identify and plan activities for optimizing plant maintenance and achieving business goals.

Approach

In the past, a common approach to reducing budgets was to cut operations and maintenance (O&M) staff. The eventual result was lower reliability, increased cost of equipment failures, and high cost of replacement power. What is needed is a reevaluation of maintenance strategies that will result in an optimum strategy that balances cost and reliability.

An optimum maintenance strategy moves an organization from a "reactive" approach or a "preventive" approach to a "planned" approach where maintenance is performed at the most optimum time before equipment fails. In a "reactive" approach, most maintenance work is reacting to unexpected failures. In a "preventive" approach, most maintenance is performed on a scheduled basis.

This guideline provides a roadmap for assessing the current state of a generation plant maintenance program, which is referred to as the "As-Found" program. This guideline also describes how to define a desired program, which is referred to as the "To-Be" program. By comparing the "As-Found" program to the "To-Be" program, the gaps between the two states are identified. This guideline describes how to plan a change effort to narrow those gaps and get to an optimized maintenance program.

Results

The guideline is organized into four parts. These parts provide the tools that are needed to understand the current status of a maintenance program and to prepare a plan to reach a desired program.

Part I of the Guideline develops a common understanding of concepts and terms that are necessary to move forward with the assessment process. This section also describes the "To-Be" program concepts.

Part II of the Guideline is structured for gathering station information and data to define the "As-Found" condition.

Part III of the Guideline directs the team in preparing for and conducting interviews of station operations, maintenance, and support personnel.

Part IV of the Guideline provides insight for developing the "To-Be" PMO program implementation plan.

EPRI Perspective

A PMO assessment is the first step to achieve optimum maintenance in a power plant. The assessment evaluates all aspects of a maintenance program so specific areas can be improved. Several improvement efforts have been completed and are underway in EPRI projects. EPRI intends to go back and assess organizations after improvements to verify that planned improvements have been achieved and to enhance the overall assessment-improvement process.

This report is part of EPRI's development efforts under the Plant Maintenance Optimization (PMO) Target, number 62 in 2000. The PMO mission is to lead the industry by developing and demonstrating products and services that will improve use of power plant maintenance resources and increase profitability for generation businesses.

Keywords

Maintenance
Assessment
Availability
Reliability

ABSTRACT

This Guideline provides the steps necessary for a utility to assess the current status of the maintenance process; and, by using this information with the concepts included in this Guideline, develop an optimized maintenance process.

This Guideline includes measurement tools for assessing the overall level of performance of the organization. After developing the ideal organization for the utility, these tools can be utilized to measure and track the status of the implementation improvements.

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1 INTRODUCTION

A Plant Maintenance Optimization Assessment (PMO) is a way to help electric power producers achieve lower operating costs and higher reliability and availability by optimizing the overall maintenance program. The Assessment starts by introducing the attributes of an ideal program. The second part of the process evaluates the existing maintenance program and identifies gaps between the existing program and the ideal program. The process concludes by developing an implementation plan to move the program toward the ideal state.

Industry Trends

EPRI has worked with over 50 commercial power producers and other industries to implement initiatives related to reducing overall maintenance costs, improving plant availability, improving equipment reliability, and increasing both overall and commercial availability.

In the past, the approach to reducing budgets has been to reduce the O&M cost; however, this action has resulted in fewer maintenance resources being available. As a consequence, fewer maintenance resources resulted in cost increases from increased equipment failures. What is needed then is a reevaluation of maintenance strategies that will result in a low-cost, balanced maintenance strategy.

Through the work with the power producers, EPRI has learned that effective plant maintenance programs must use a well-orchestrated blend of Predictive, Preventive, Proactive, and Corrective maintenance strategies to improve plant reliability in a cost effective manner. As shown in Figure 1-1, experience has demonstrated that significant improvement, resulting in substantial cost savings can be achieved through coordination of these strategies with improvement in the overall utilization of information for decision making. Conversely, by failing to use this mix of information, significant cost increases can be anticipated.

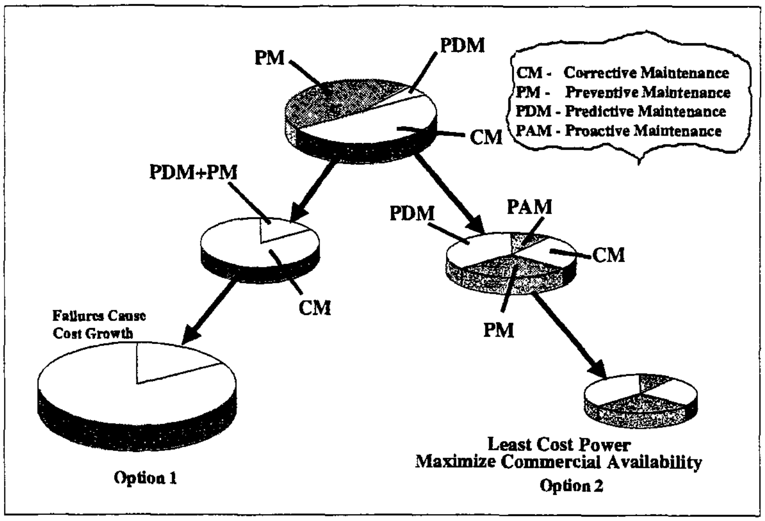


Figure 1-1
Maintenance Cost Reduction Options

Understanding the strengths and weaknesses of existing programs and identifying opportunities for improvement lies at the core of the process that is referred to as *Plant Maintenance Optimization* or PMO.

Plant Maintenance Optimization as a Strategy

Plant Maintenance Optimization (PMO) encompasses the process of moving the maintenance program from a "reactive" approach where maintenance is performed as a result of unexpected failures or a "preventive" approach where maintenance is performed on a scheduled basis, to a "planned" approach where maintenance is performed, using key information, at the most optimum time which is often before the equipment failures. Reactive maintenance is more costly and has a negative impact on plant availability, while PMO is more economical and significantly improves plant availability. PMO also optimizes the existing planned maintenance activities at a plant.

Success in realizing improvements to the overall maintenance process is achieved through understanding the strengths and limitations of each improvement strategy and fully synchronizing the program for optimal results. Output from a Plant Maintenance Optimization Assessment (PMO) as developed in this guideline should help the power producers understand the strengths and weaknesses in their current programs, and also help identify opportunities to improve the overall process.

Experience has shown that significant improvements resulting in substantial cost benefits can be achieved through changes to existing processes with small or moderate investments. Typical savings realized by power producers will be reflected in the following areas as illustrated in Figure 1-2.

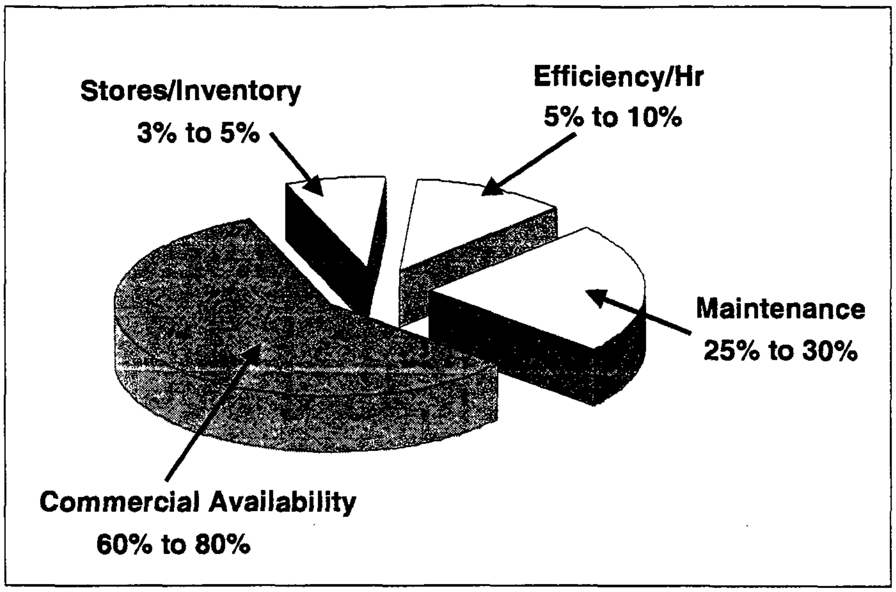


Figure 1-2
PMO Savings Distribution

When these savings are aggregated, the typical Return-on-Investment (ROI) when compared to Megawatt capacity is shown in Figure 1-3.

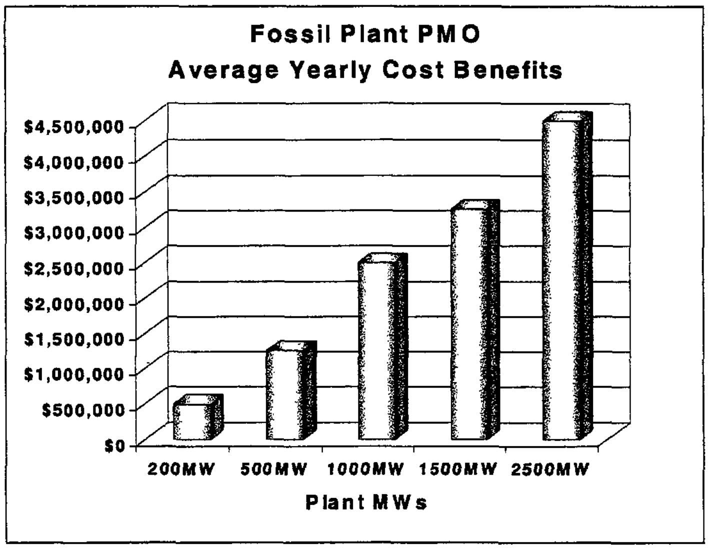


Figure 1-3
PMO Average Yearly Cost Benefits

A significant degree to which a plant is successful in implementing process change often involves intangibles such as personnel understanding and belief in the technologies, good inter-group communication, high level of personnel enthusiasm, and strong management support and sponsorship of the change process.

Summary

The information that follows in this report provides a roadmap for assessing the current state of a power producer's plant maintenance program, which is referred to as the "*As-Found*" program. The guideline will also help the power producer define the desired program, which is referred to as the "*To-Be*" program. By comparing the "*As-Found*" program to the "*To-Be*" program, the gaps between the two states can be defined. Using the gaps in program status, this document will provide guidelines for developing the change effort that is needed to get to the optimized program state. In beginning the optimization process, it is recognized that the effort must be performed for the individual company, at the unique station level since every organization is different. The plant personnel best know the unique problems at a particular site (station vintage, equipment age/manufacture, operation mode/demand, etc).

The guideline is broken-down into four sections. These sections provide the tools that are needed to understand the current status of the maintenance program and to prepare a plan to get to the desired program.

Part I of the guideline is structured to prepare the participants for the process by developing a common understanding of the concepts and terms that are necessary to move forward with the process. This section also discusses the ideal or "To-Be" program concepts, which will be adjusted to the particular site. The following areas are addressed in this section of the guideline:

- Providing an overview of PMO to prepare the team for the assessment process
- Discussion on goal setting
- Introduction to Maintenance Optimization

Having referred to the concepts of PMO (Ideal and "To-Be") in Chapter 1, it is now necessary to review the assessment process in detail. As stated before, the assessment process defines the "As-Found" program, determines the gaps between the "As-Found" program and the ideal "To-Be" program and develops an implementation plan to get to the specific "To-Be" PMO for the facility. The assessment process consists of:

- Information gathering (Part II)
- Conducting Interviews (Part III)
- Developing an Implementation Plan (Part IV)

Part II of the guideline is structured to gathering the information and data about the station that is needed to define the "As-Found" condition. The following areas are addressed in this section of the guideline:

- Identifying prerequisite information
- Developing the "As-Found"
- Mapping the existing work process
- Identifying Work Process Issues

- Identifying issues that can impede PMO
- Plant walk down and observing maintenance efforts in progress
- Selecting plant procedures and records for review
- Reviewing corrective and preventative maintenance documents

Part III of the Guideline provides direction necessary for the team to prepare for and conduct interviews of station operations, maintenance, and support personnel. These interviews will further define the "As-Found" condition. The following areas are addressed in this section of the guideline:

- Conducting on-site interviews
- Composition of Assessment Team
- Identifying targets for interviews
- Data Integration
- Conducting an exit interview with the appropriate project sponsors

Part IV of the guideline provides insight to develop the PMO program implementation plan. The implementation program will be developed using the gaps between the "As-Found" program and the ideal "To-Be" state. The following areas are addressed in this section of the guideline:

- Developing implementation strategy
- PMO Report format
- Presentation of the finished product to appropriate project sponsors

2
PART I – KEY ASPECTS OF PLANT MAINTENANCE OPTIMIZATION

Providing an Overview of PMO to Prepare the Team for the Assessment Process

Prior to assessing the performance of an organization, it is essential that everyone within the target organization be at the same level of understanding of why the plant is being assessed. The following questions need to be answered for the organization prior to proceeding with the assessment:

1. What is a Plant Maintenance Optimization Assessment?
2. What are the concepts of the Plant Maintenance Optimization Program?
3. Why is my employer conducting an assessment of the maintenance program at the specific plant?

Information necessary to answer questions 1 and 2 will be covered in this assessment guide. It will be necessary for the local plant management to provide the information necessary to answer question 3. In a general sense, the discussion with the organization's stakeholders should review the challenges presented by operating in a deregulated environment and why it is mandatory that power producers change the way they operate in order to survive. A part of the answer to question 3 should be specifically tailored to unique situations at the subject facility. This discussion should stress the economics of why it is important for the units to be available to generate in response to varying demand requirements.

Discussion on Goal Setting

Before undertaking another initiative, it is important that the organization be very clear on the magnitude of what they are planning to undertake through the PMO project; and, further, what they hope to accomplish by subjecting the organization to the rigor of implementing another change process. Everyone in the organization is very busy doing productive work and does not need the additional demands of participating in another process change project (commonly known as the "flavor of the month" program). Management is asking the staff to invest significant effort into a change process. The staff must believe that the potential outcome is worth the effort, that there is benefit to the individual, and that management is wholly committed to providing the resources that are necessary to make the change process successful.

Therefore, it is mandatory that management convey their expectations for the process. This expectation should very clearly define exactly what management expects the new process to provide. These expectations should be conveyed to the organization as goals that align directly to the corporate mission, vision, and goals.

To support management's expectations, goals should be developed at a station level that provides direct alignment with the corporate goals. This alignment allows management to quantify exactly how much return is received for the effort (dollars) invested to meet the goal. The station level goals should be developed in specific areas that will benefit from the improvement to the process. It is expected that dollar saving realized from optimizing the maintenance process will provide savings in the following areas as illustrated in Figure 2-1

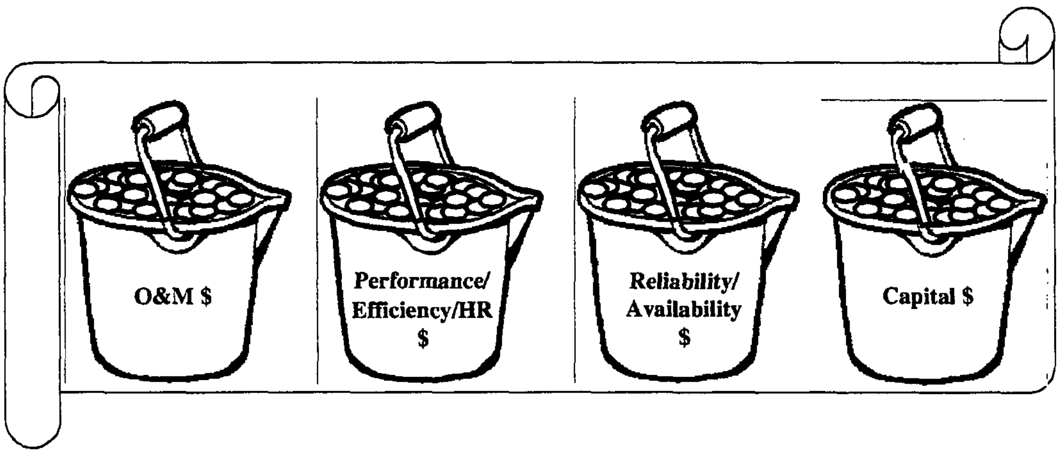


Figure 2-1
Areas of Savings

Goals should be very specific. The goals should be designed so that goal performance is easily measurable. Goals should be designed such that they are both realistic and achievable and they should be timely so that the benefit of achieving the goal will occur in a time period that the improvement is needed.

Areas where goals can be developed include:

Corporate

- Provide quality product at lowest possible cost
- Customer Satisfaction
- Provide uninterrupted/reliable service
- Improve competitive position
- Reduce capital costs

Maintenance Organization

- Minimize O&M costs
- Maximize reliability/availability
- Maximize throughput and quality
- Extend equipment life
- Extend time between planned outages

Examples of Specific Goals are as follows

- Improve summer availability by 30%
- Improve non-summer availability by 15%
- Reduce summer and non-summer heat rate for each unit by 100 BTU/kw-hr

Introduction to Maintenance Optimization

Plant Maintenance Optimization (PMO) involves the people, the work culture and management, the work process, and technology. PMO is a journey that the organization must take as it works to improve the process by learning from the day to day experiences. The chart (Figure 2-2) identifies the Road Map that is needed to take this journey.

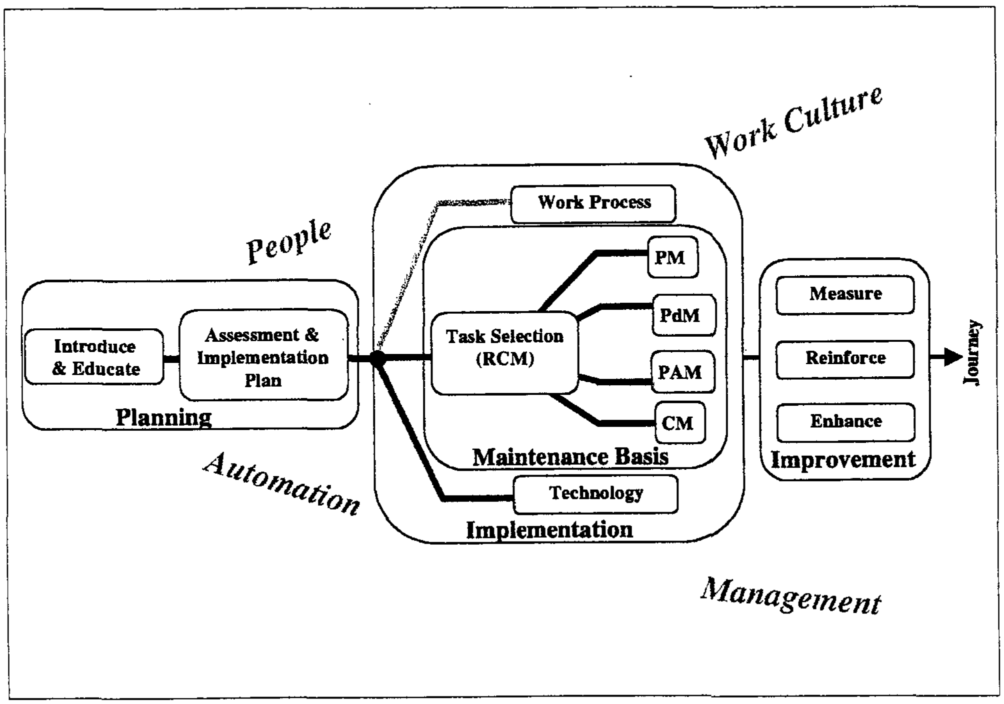


Figure 2-2
PMO 'Road Map'

The assessment part of the Road Map, which is illustrated in the major category of "Planning", is a process to document how the company's maintenance program currently operates. By understanding where management desires the company to be in the future enables the organization to develop the strategies and implement the changes that are needed to bridge the gap.

Inherent in the strategy to optimize the maintenance process is the need to be able to make decisions for appropriate action on the most current information. Current technologies provide an overwhelming amount of raw data. To support this need, it is necessary to base the action decisions on integrated information (refer to Figure 2-3).

The action that results from this process may be to continue to operate in the same mode even though there are indications of a problem. The important part of this action, from a PMO standpoint, is that the decision to continue to operate be based on an evaluation of the information that is available. This decision should include consideration of the potential for failure and the economic consequences related to repair, versus the cost consequences from the lost opportunity to sell the product during a specific market opportunity. Once this decision is made, the work process must execute the decision in a timely manner.

Since PMO is a journey, a continuous improvement process needs to be in place for the PMO to be successful. The flow of essential information is shown in Figure 2-3.

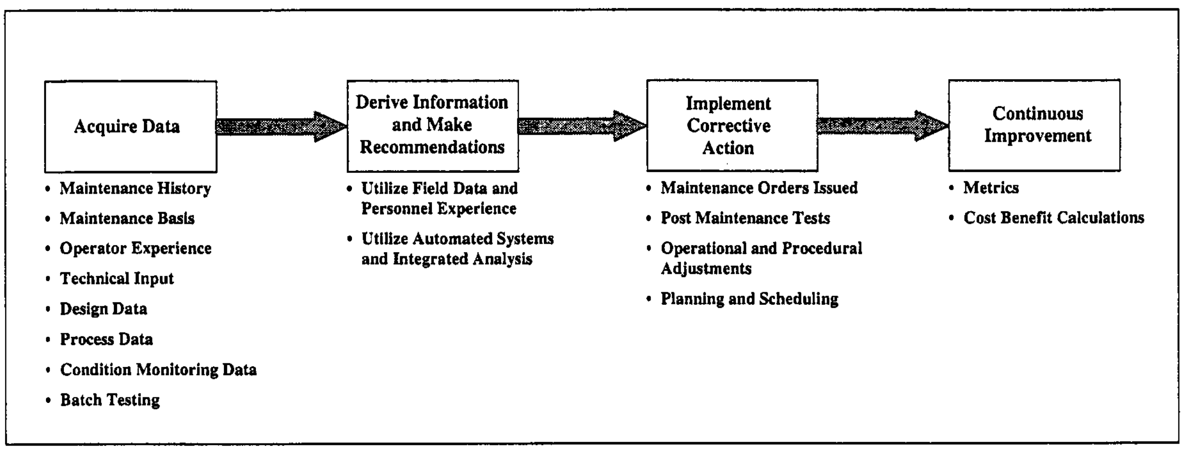


Figure 2-3
Flow of Information

When the plant considers implementation of Plant Maintenance Optimization it is necessary to understand the "what", the "how", and the "who" of PMO.

"What" will a plant do differently?

- Implement Advanced Maintenance Approaches such as: Predictive Maintenance, Reliability-Centered Maintenance, and Proactive Maintenance.

"How" will a plant carry out the specific maintenance tasks?

- By making improvements to the Work Process.
- It will also be necessary to implement New Technologies to optimize the overall process.

"Who" will do the work?

- The staff will continue to do all work using improved Skills, while working in modified Work Culture, with strong Management support.

An effective method used to represent the current state of the maintenance program, the "how", the "what" and the "who", is through the generation of a Spider Chart. The spider or radar chart provides the organization with a graphical representation of the level of performance for each of the individual attributes of PMO. Developing the data to support this chart will be discussed in the section of this guide that follows.

The key elements of Maintenance Optimization are contained in the spider chart shown in Figure 2-4. This chart shows how a hypothetical organization performs when compared to a standard of performance (best-in-class) that was developed after evaluating a broad-based population of plants. From the figure it is apparent that the example organization is strong in *Maintenance and Diagnostic Technologies* and *Work Execution*; however, *Work Identification*, *Closeout*, *Accountability*, *Goal Setting*, and *Benchmarking*, appear to be areas for improvement. Furthermore, the organization does not appear to manage by *Metrics*.

This type of information can be used as a tool by the assessment team to help the organization, by focusing further assessment efforts on the apparent weaknesses. This tool can also be used by the organization to measure progress during implementation of the process.

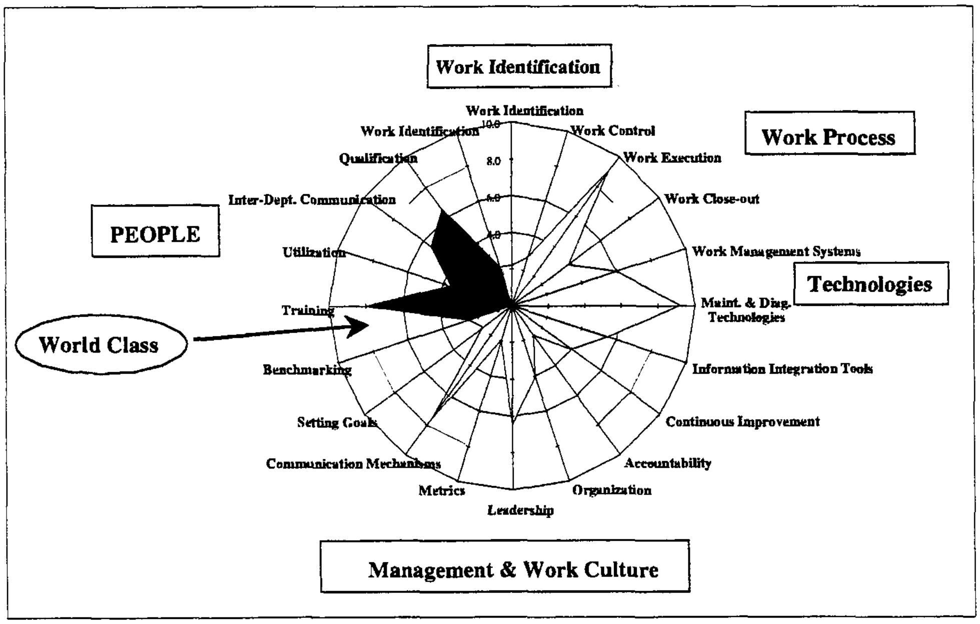


Figure 2-4
PMO Spider Chart

As indicated in Figure 2-4, the specific elements of PMO are identified in the Spider Chart. The following section describes each of the elements.

Work Identification

This element identifies the specific strategies to be used and determines what specific task will be required for a 'timely' decision for the work that is to be done.

There are only four approaches available to identify which maintenance work is to be accomplished: Preventive (PM), Corrective (CM), Predictive (PDM), and Proactive (PAM); and, all are part of the Maintenance Basis. This is illustrated in Figure 2-5.

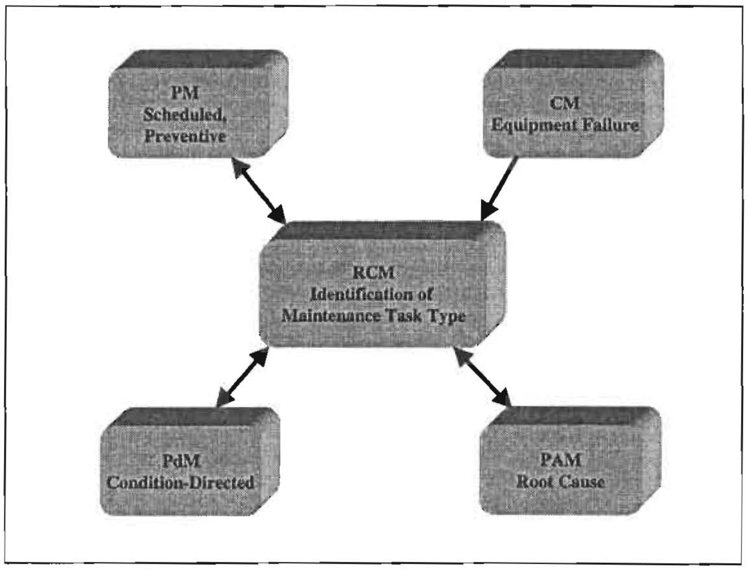


Figure 2-5
Maintenance Basis

Maintenance Basis

The basis that identifies the right maintenance work. To determine the strategy for maintaining the plant equipment, it is necessary to identify the necessary maintenance tasks. EPRI Reliability-Centered Maintenance (RCM) using a streamlined (RCM) analysis should be performed (task analysis and basis) to establish the maintenance basis.

Reliability Centered Maintenance (RCM) programs help power producers optimize maintenance basis while improving plant safety and economy through increased dependability of plant components. RCM includes the following:

- Rank plant system and equipment (Criticality Ranking)
- Determine the failure modes and causes
- Perform a Failure Modes and Effects Analysis (FMEA)

- Establish maintenance tasks (PM, PDM, PAM) and frequency

The process should review the failure modes and causes. Using this information, the strategy to protect the equipment can be determined. It is desirable to let some equipment run-to-failure.

Equipment that *does not* impact the plants key indicators and has a low criticality ranking should be classified as run-to-failure equipment.

Critical equipment is defined as equipment that *does* impact the plants key indicators and has a high criticality ranking. Equipment is ranked as; Safety critical; Environmental critical, Cost critical, Reliability critical, and Efficiency critical. Equipment classified as "critical" should be addressed through one of the following strategies:

- Condition monitoring (PDM)
- Time based (PM, Ops Rounds)
- Projects -Root Cause Based (PAM)

Refer to Reference 4 for more detailed discussion on RCM.

Other tools needed to assure the equipment is maintained as identified in the maintenance basis include:

- Maintenance Procedures
- Operation Procedures
- Standardized Work packages

Questions to be asked are: Is a formalized Root Cause Program in place and being utilized; Is PDM (condition driven) being used; Have PM tasks been reviewed; and, Are "As-Found" conditions documented?

Preventive Maintenance PM

Preventive maintenance uses regularly scheduled inspections, tests, services, repairs, replacements, and other tasks to reduce the frequency and impact of equipment failures. These maintenance activities are performed on a calendar or operating time interval basis to extend the life of equipment and prevent premature failure. Manufactures usually include a list of these activities and their frequencies, which will optimize the life and prevent failure of their equipment. This technique assumes that the condition of the equipment and its need for maintenance can be correlated with time. Preventive is one of the first major breakthroughs resulting in an increase in reliability and availability. One of its benefits is the identification of early stages of equipment deterioration that, unless remedied, would result in secondary damage at failure. This accounts for a significant part of the lowered maintenance costs. It is important to note that the data collection parts of PDM are also PM tasks.

Corrective Maintenance CM

Early maintenance resources were used to react to equipment breakdowns that caused major operational losses. From this practice the terms, "reactive". "breakdown", "corrective", and "run-to-failure" maintenance descriptions were coined for naming the principal maintenance technique that formed this maintenance strategy. Corrective maintenance can be either good or bad. For some equipment, such as smaller components that are not critical to production, it is the best technique to use. For others, though, it will result in very high repair costs and excessive lost production. It is one of the techniques that must be appropriately applied in order to develop an optimized maintenance strategy. Experience shows that for fossil plants this approach is predominate.

Predictive Maintenance-PDM

Predictive maintenance is a systematic approach to determining the need for equipment repair or replacement, and limiting maintenance activities to only those that are required to prevent costly major repairs or unscheduled downtime. Predictive Maintenance is a process that bases maintenance on the condition of the equipment and recommends the corrective action that is to be taken. Using PDM, all corrective action would be done in a timely manner. *(Note: If the PDM program generates urgent and emerging work orders, it is not working.)* Various monitoring systems are used to detect and analyze incipient faults. Attributes of PDM are as follows:

- Establish the Process (such as)
  - Rolls and Responsibilities of the organization
  - Work Process and how PDM fits into the plant's work process
- Implement the condition indicators such as; technologies, maintenance and operators' records, batch testing, and process data. Also utilize the latest automation tools.
- Provide Condition Assessment Reporting
- Continuous Improvement/Metrics such as:
  - Track Net Cost Benefits
  - Monitor Equipment Commercial Availability
  - Track Equipment Maintenance Costs
  - Measure Bad versus. Total Calls
  - Measure High Priority versus. Scheduled Work Orders

For further discussion on Predictive Maintenance refer to references 1, 2, 3, and 5.

Proactive Maintenance-PAM

PAM is used to modify operation or maintenance or change-out component based on root cause analysis. Root Cause is defined as the most basic cause(s) that can reasonably be identified and that management has control to fix, and, when fixed, will prevent or significantly minimize the chances of the problem's reoccurrence. Questions that a Root Cause Analysis should answer are as follows:

1. What happened?
2. Why did it happen?
3. Why was it not prevented?
4. What can be done to prevent/minimize severity of recurrence

Work Process

The process that accomplishes the work. This part of the PMO process addresses the ***How*** maintenance is accomplished. It examines the work process from work initiation, to planning and scheduling (work control), to work execution, to work completion, and finally to continuous improvement. This process is illustrated in Figure 2-6.

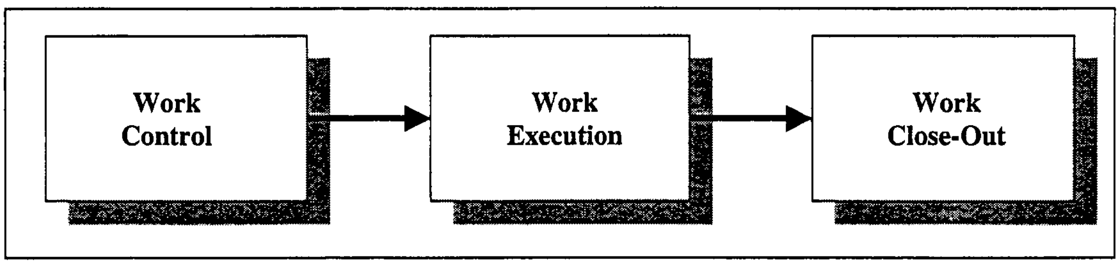


Figure 2-6
Work Process

When evaluating this process, many questions need to be addressed.

2. Work Control

Formalized planning and scheduling program in place. Work order generation and prioritization process is needed to be a part of the process. The process should have an initiator/approval and value ranking process to establish priority.

- There should be a formal planning process with work Packages issued to field.
- Parts availability (Stores/Inventory) needs to be considered and included in the work package. Are parts staged in work area?
- Work packages need to include: work procedures, maintenance procedures, operations procedures, permit and blocking procedures.
- It is very important that document and configuration control be maintained.

High priority work needs to be sponsored. Routine work should be scheduled several weeks ahead. Outage work should be planned and ready for implementation during both planned and unplanned outages. Schedule performance needs to be measured. Replacement parts (just in time) needs to be part of the process. Both outage and major equipment overhaul work should be planned and scheduled.

Metrics for Work Process

- Schedule Compliance
- Back Log Management

3. Work Execution

This is the actual performance of work. The following need to be considered.

- Man-Hour Utilization
- Staff Training
- Tools Availability
- Tool Upgrade to Latest Technology
- Metrics for Work Execution
  - Rework versus Total Work
  - "Wrench" Time versus Total Time

4. Work Order Close-Out

Appropriate information on work performed ("As Found") and "As-Left" condition of equipment must be captured when a Work Order (WO) is closed so maintenance can provide feedback to Operations and PMO. The following should be considered.

- Close-out Feedback to Initiator
- Close-out approval
- House Keeping
- Capture Maintenance History ("as found" - "as left")
- Post Maintenance Testing
- Identify Unplanned Work, Orders for PAM Review
- Continuous Improvement/Metrics
  - Measure work order Initiators Satisfaction
  - Measure PAM review team satisfaction (Maintenance Histories)

Metrics for Work Close-Out

The Table 2-1 provides suggested metrics that are characteristic of measures used by a well-run maintenance process. Suggested goal levels are also provided.

Table 2-1
Suggested Metrics for Maintenance Process

Metric	Measurement	Primary Accountability
CM Ratio	CM/Total Work	System Owner
Schedule Compliance	Planned Hours/ Worked Hours	Team Leader
Planning Effectiveness	Estimated/ Actual Hours	Team Leaders
Resource Utilization	Complete WOs hrs./ Total pd hrs.	Team Leaders
PM Compliance	Completed PMs/ Scheduled PMs	Planners/ Team Leaders
Sponsored Work	Sponsored Hours/ Total Hours	Operations and System Owners
Emergency Work	Emergency Hours/ Total Hours	Operations and System Owners
Rework	Rework Hours/ Total Hours	Maintenance

Technologies

This category of PMO focuses on what advanced ***Tools*** are required to support the workforce. The technology level covers all technical advances such as: automation, condition monitoring, automated maintenance management systems, and distributed control systems. There have been significant advancements in technologies, which can help an organization meet its availability and budget goals.

5. Work Management Systems

A formalized work management system should be in place. Most successful maintenance programs now use a computerized system. A formalized work-scheduling tool should be a part of the process. Reporting and decision making process should be in place.

6. Maintenance and Diagnostic Technologies

Condition based technologies should be used and information acquired from the various technologies should be factored into maintenance decision process. The following is a summary of some of the technologies.

Periodic Condition Monitoring Systems

- Thermography
- Portable Vibration Monitoring
- Lube Oil Monitoring
- Acoustic Leak Detection
- Motor Current Monitoring (Broken Rotor Bars)
- Electric Motor Predictive Maintenance
- Valve Diagnostics
- Transformer Diagnostics

Continuous Condition Monitoring Systems

Turbine/Generator

- Continuous Vibration Monitoring – including (Turbine Balancing and Rotor Crack Detection)
- Ultrasonic Bearing Wear Monitor
- Rotor/Shell Stress Indicator
- Water Induction Detection
- Turbine Performance Monitor

Heat and Turbine Cycles

- Performance Monitoring
- Water Chemistry Expert System

Boiler

- Boiler Performance Monitor
- Boiler Stress Condition Analyzer
- Ultrasonic Gas Temperature Monitor
- Acoustic Boiler Tube Leak Detection

- Acoustic Header Leak Detection
- Carbon-In-Ash Monitor
- Burner Diagnostics
- Boiler PDM Program

Mechanical Equipment

- FW Heater Leak Detection
- Valve Monitoring
  - Stem Force
  - Current Monitoring
  - Valve Leak Detection
- Acoustic Coal Chute Flow Detection

Electrical Equipment

- Circuit Breaker Diagnostics
- On-Line Meggering

Emerging Technologies

- Electric Motor EMF Analysis
- High Temperature Electronics
- Power Scavenging Sensors
- Radiation Hardened Electronics
- FEA - Physical Rotor Modeling - Virtual Sensors
- Formalized Acoustic / Ultrasonic Applications (Renewed Interest)
- Baysian Belief Networks
- Wireless Data Transmission (Vibration, Temp, Flows, etc.)

7. Information Integration Tools

Condition status reporting mechanisms should be in place and these systems should be used to integrate information from multiple sources of information. Systems may be available on the network for multiple user access. Information needs to be current. Financial, schedule and budget information should be available in an integrated system.

PMO Process Automation Tool (EPRI PlantView Tool)

PDM Module

- Equipment Condition Status Summary
- Technology Exams-Readings taken and interpreted at regular intervals
- Equipment Assessments-Component status established at regular intervals

Maintenance Basis (EMOMs) Module

- Maintenance basis Templates
- Standardized Work Packages
- Maintenance Procedures

Case History

- Equipment Problems and Solutions

Cost Benefit

- Continuous Improvement Measure

The Figure 2-7 illustrates the Technology Automation process. It includes networks wireless data transfer and standard data acquisition systems.

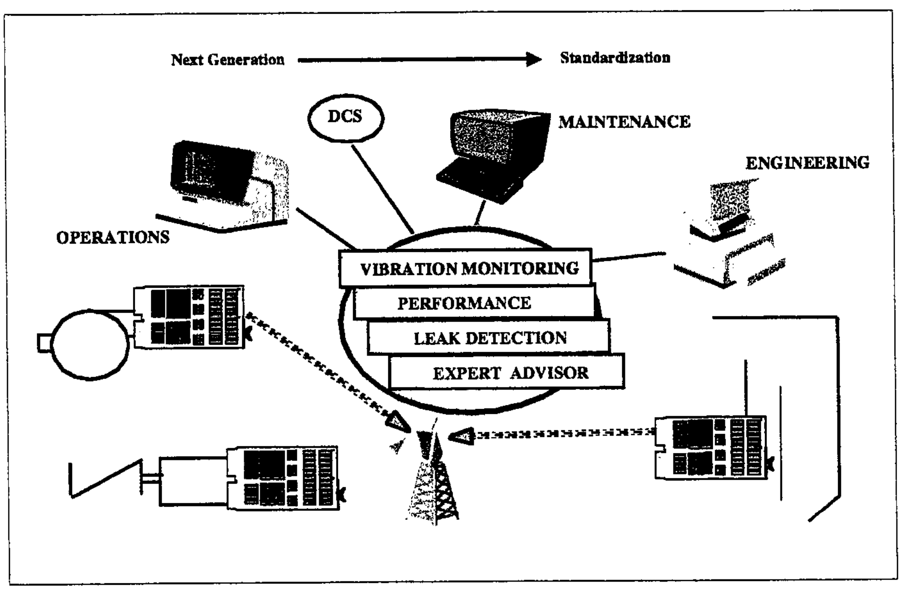


Figure 2-7
Technology Automation Process

Work Culture and Management

For maintenance optimization to be successful, it requires a well-trained work force, good management, and an organizational structure that incorporates decision making based on the advanced maintenance strategies. A work culture that is receptive to new work ideas is needed. This aspect of the PMO approach focuses on ***Who*** does the work.

8. Continuous Improvement Methods

The organization should be a "Learning" organization that is able to avoid repetitive mistakes (refer to discussion under Work Process). The continuous improvement process considers the following.

- Categorize Work Orders ("good" versus "bad")
- Review "bad" Work Orders
  - Root Cause Analysis
  - Failure Mode and Cause
  - Task Addition/Modification
  - Modify/Add Procedure
- Periodic Review of "good" Work Orders (PMs, PDMs, Run-to-Failure CMs)
  - Utilize Maintenance Histories
  - Utilize plant staff experience
- Modify Maintenance Basis
- Continuous Improvement/Metrics
  - Planned versus Reactive
  - Good versus Bad Work Orders
  - Track maintenance costs for different types of work orders

All Maintenance Work Orders are not undesirable. Undesirable Work Orders resulting from unplanned work should be tracked and action plans developed to manage reducing the overall number.

When categorizing the Work Orders, it is necessary to recognize that work orders at most plants are divided into Corrective Maintenance (CM) and Preventive Maintenance (PM). There are various categories of corrective Work Orders.

CM-RTF	*Run-to-Failure* (Pre-planned strategy from RCM analysis)
CM-CDM	*Condition-based Maintenance* (Work resulting from PM, PDM, PAM)
CM-CDM-P1&P2	*Condition-based Maintenance* (Work resulting from PM, PDM, PAM that has urgent or emergency priority)
CM-U	*Unplanned Work*

Also there are different categories of Preventive Maintenance.

PM-PDM	Predictive Maintenance data collection tasks
PM	Preventive Maintenance tasks

9. Accountability

Accountability should be a part of the plant culture. People should recognize what is expected of them and they should perform accordingly. In the end, they should be held accountable for the operation of the plant.

10. Organization

The organization should be structured to be successful using condition-based information (Process Teams, Component Ownership, Process Ownership, Fix-it-now, etc.). Clearly defined lines of reporting, responsibility, and accountability should be evident. The Organization chart, Figure 2-8, provides one example of how an organization can be structured to provide for organized decision-making. The individuals encompassed by the dotted box make up the reliability decision-making group with overview and guidance provided by the upper levels of management.

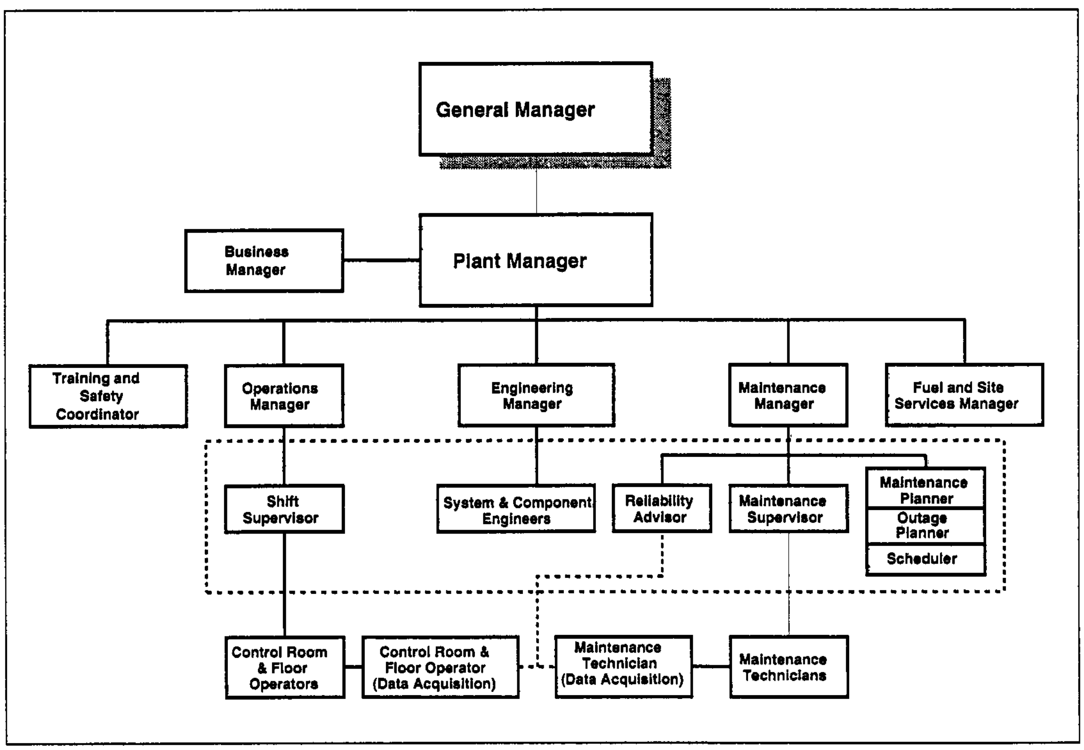


Figure 2-8
Organizational Chart

11. Leadership

Management should provide sponsorship for changes as well as clearly defining expectations, and providing the necessary budget for initiatives to be successful. Metrics should be used to manage the business. Workers must be empowered to make decisions, and adherence to the plan and schedule should be monitored.

12. Global Metrics and Reporting

Metrics available that adequately measure success of the process (financial, reliability, safety, regulatory, customer satisfaction, Plant Capacity, Plant Availability (EFOR), O&M budget, Plant thermal performance) should be available to manage the day-to-day and longer-term performance of the plant.

13. Communication Mechanisms (Inter-Organization)

The quality (formal and informal) of communications and information exchange between Maintenance, Management, Operations, Engineering, and others within the organization.

14. Goal Setting

Goals should be prepared for the Maintenance Program. They should be in alignment with the overall objectives (refer to discussion under goal setting).

15. Benchmarking

Benchmarking of the plant performance should be performed to allow for a direct comparison of the organizational practices with the Best-in-Class, or at least standard practices within industry.

People/Skills

16. Training

The training program should be reviewed from content and direction perspectives, to ensure that they prepare people with the skills necessary to support the program.

17. Utilization

Productivity and utilization factors for the labor resources should be measured and tracked.

18. Inter-Department Communication

The quality of both formal and informal communication and information exchange within the organization is very important.

19. Qualifications/Job Descriptions

A documented measure of the qualification and skills of functions within the organization, with a focus on whether qualifications and skills are capable of supporting program goals. A skills matrix should be available that identifies the unique skills required to perform various maintenance functions.

PMO Process Summary

The PMO process includes taking the 19 elements described above and integrating them into a cohesive approach.

The advanced maintenance strategies address *What* maintenance approaches will be undertaken to move the maintenance program from reactive or scheduled to planned. This approach includes optimizing the maintenance basis, implementing predictive maintenance program, and developing a living proactive maintenance program.

Plant Maintenance Optimization includes both the *Maintenance Basis* and the *Work Process*. The sequence of the process is illustrated below. Figure 2-9 identifies how work gets identified, how it is conducted through the work process, how the work gets reviewed regularly, and how adjustments to the maintenance basis are made as needed.

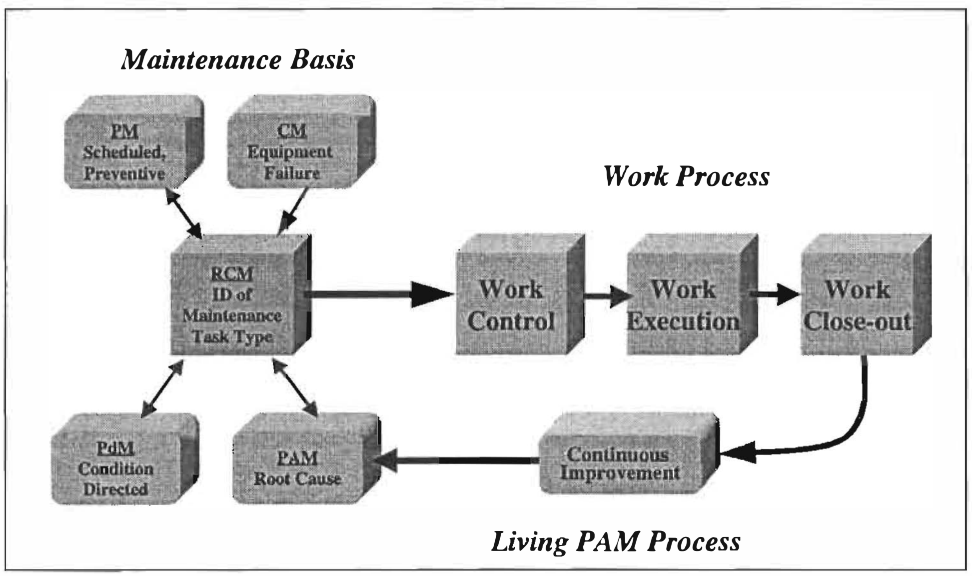


Figure 2-9
Sequence of Maintenance Basis/Work Process

3
PART II – INFORMATION GATHERING

Identifying Prerequisite Information

To assess an organization with the intent of designing an optimized maintenance program, it is necessary to review, understand, and use the information that is available within the existing systems of the current organization. This serves several purposes.

1. The team performing the assessment must have a working-level understanding of the condition, capabilities and limitations of the equipment, systems, and processes in place at the target facility

2. The basic premise of optimizing the maintenance process is that systems are needed to capture needed ***data*** and that the data can be converted to the relevant ***information*** needed to make informed ***action***-based decisions. The assessment team must be able to test and evaluate the effectiveness of these systems.

The following list of information should provide the basic knowledge basis needed to begin the assessment process:

- Plant operating history for the past 1 to 3 years
  - availability
  - efficiency
  - MW production
- Plant Process Drawings
- Capital Improvement Process (Projects accomplished/cost)
- Major equipment list (by system) with operating history
- Plant organizational chart with specifics on maintenance staff functions and responsibilities
- Description initiatives and process changes underway
- Trend in maintenance budgets over past three years, and changes resulting from recent initiatives

Along with the above information, it will be necessary to conduct workshops to generate the following information.

- Spider Chart (refer to information that follows under conducting PMO overview workshop)

- Issues that could impede PMO implementation
- Marking the As-Found Work Process (refer to information that follows under conducting PMO overview workshop)
- Listing of Work Processes Issues (refer to information that follows under conducting PMO overview workshop)

Finally it is necessary to review the procedures and maintenance records and to conduct a plant walk-down.

Developing the "As-Found"

Having reviewed the concepts of PMO in Section 1 of this Guideline, it is now necessary to begin acquiring data about the organization. The Spider Chart is an appropriate place to capture this data. As a starting point for the assessment, it is important to understand where the organization feels it stands when compared to other, similar type organizations. To provide a picture of this performance, the group should perform a self-evaluation using the questionnaire in Table 3-1. The individuals should score how well they feel the organization performs against the individual attributes. Scoring should be provided with a score from 1 to 10, with 10 being the highest level of performance. It is advisable to have a facilitator support this activity.

Results from this evaluation should be segregated by level (i.e. management, work group supervision, and worker). Using this information, a *Spider Chart Self Evaluation*" should be prepared for responses of the entire group. Separate spider charts should also be prepared for each of the general levels within the organization, i.e. management, supervision, and worker. Comparing the information from the different levels will enable the assessors to identify areas within the organization where alignment exist as well as areas where there is disagreement on how the organization performs.

Table 3-1
Spider Chart Self-Evaluation

	Select one **Score:**	Manager Supervisor Worker **1 to 10**
	Work Identification	
1.	***Work Identification*** *– Has RCM been performed? Is formalized Root Cause Program in place? Is PDM being used? Have PM tasks been reviewed? Is "As-Found" condition documented?*	
	Work Process	
2.	***Work Control –*** Is formalized planning and scheduling program in place? Is work scheduled greater than one week ahead? Do standard work packages exist? Is schedule compliance measured?	
3.	***Work Execution –*** Actual performance of work includes man-hour utilization, training, tool availability, tool upgrade to latest technology, continuous improvement metrics (rework vs. total work, wrench time vs. total time)	

Table 3-1
Spider Chart Self-Evaluation (Continued)

		Select one	Manager Supervisor Worker
		Score:	1 to 10
4.	***Work Order Close-Out*** – Is appropriate information on work performed and "As-Left" condition of equipment captured when WO is closed so maintenance can provide feedback to Operations and PDM?		
	Technologies		
5.	***Work Management Systems*** – Is a formalized work management system in place? Is it being computerized?		
6.	***Maintenance and Diagnostic Technologies*** – Are condition-based technologies being used and is information being factored into maintenance decision making process?		
7.	***Information Integration Systems*** – Do condition status reporting mechanisms exist? Do these systems integrate information from multiple sources? Are systems available on network to multiple users? Is information current?		
	Work Culture and Management		
8.	***Continuous Improvement Methods*** – Is the organization a 'Learning' organization that is able to avoid repetitive mistakes?		
9.	***Accountability*** – Is accountability a part of the plant culture? Do people recognize what is expected of them? Do they perform accordingly?		
10.	***Organization*** – Is organization structured to be successful using condition-based information?		
11.	***Leadership*** – Does Management provide sponsorship for PDM, expectations, and necessary budget for initiatives to be successful? Are metrics used to manage business?		
12.	***Global Metrics and Reporting*** – Are metrics available that adequately measure success of the process?		
13.	***Communication Mechanisms (Inter-Organization)*** – The quality (formal and informal) of communication and Information Exchange between Maintenance, Management, Operations, Engineering, and others within the organization.		
14.	***Goal Setting*** – Have Goals been set for the Maintenance Program? Are they in alignment with the overall objective?		
15.	***Benchmarking*** – Has Benchmarking activities been performed to allow a direct comparison of the organizational practice with the Best-in-Class, or at least standard practices within power industry?		
	People / Skills		
16.	***Training*** – Review training program from content and direction perspective to ensure it prepares people with skills to support program.		
17.	***Utilization*** – A review of productivity and utilization factors of the labor resources		
18.	***Intra-Department Communication*** - How well is information communicated within the work group.		
19.	***Qualifications / Job Descriptions*** – A documented measure of the qualification and skills of functions within organization with a focus on whether qualification/skills are capable of supporting program goals.		

(Note: See Appendix 1 for a form to be used in this exercise.)

Identifying Issues Preventing a Successful PMO

Having presented the PMO concepts to the organization, measured current level of performance (Spider Chart), and mapped the organization work process, it is now necessary to surface issues that can prevent the PMO process implementation from being successful at this plant. To identify these issues, canvas an assembled cross section of the staff. Have each individual identify 3 issues that impede flow of information within the work process. Discuss each issue and ask clarifying questions until there is clarity among the group on the specifics of the issue. After the list of items has been developed, have the group prioritize the issues. Table 3-2 lists some typical issues that have been developed during visits to other plants. It is advisable to have a facilitator support this activity.

Table 3-2
Issues Preventing PMO Success

1. Training on technologies
2. Root Cause Analysis is needed
3. CMMS – limited functionality, limited metrics
4. Integrating results into the maintenance plan
5. Lack of technologies
6. Buy-in from everyone
7. Manpower restrictions, can't take any more on
8. Level of awareness to all plant personnel as to why we're doing this. Get a true shared vision
9. Too many fires to put out during transition to adequately manage the program
10. Lack of budget (and further demands, cuts, re-appropriation)
11. Failure to follow up on PDM recommendations
12. Lack of accountability of PMO team leader and people
13. Company must be willing to replace and upgrade plant equipment
14. Ability to document and communicate costs and benefits of PMO
15. Management acceptance of PMO results (approval to act on PDM recommendations)
16. Bad data (SRCM) leads to a bad plan. (Don't get adequate or 'right' data)
17. PMO team must be open to all people, all departments, in their data collection
18. Roles and responsibilities not understood
19. Resistance to change, especially new diagnostic tools and recommendations
20. 'False Alarms' could kill the project (especially during the learning curve)
21. Large backlog of PM Work Orders
22. Missed 'failure' detection causes credibility loss
23. Plant Management and Load Dispatcher may override PMO recommendations in favor of generation
24. What is in it for me? (clearly communicated)
25. Adequate and accurate information on Work Order required. Good creation – good close-out

Mapping Existing Work Process

To get a better understanding of where changes may be necessary in the work process, it is necessary to understand how the process really operates in the field. The reality of how things actually get done in the field may vary significantly from how the process is defined in existing procedures and guidelines.

To construct the existing work process diagram, have members of the organization walk through the process. The assembled group should be able to identify the following:

- how work is identified (CM, PM, PDM, PAM)
- once the work task is identified, who is involved in the various decisions on whether or not the work gets done
- who determines when the work gets done
- who determines which individuals or teams perform the work task
- who plans the work
- who assembles parts
- who is responsible to document and close out the individual tasks
- who determines if post maintenance testing is performed
- how is work history captured

In going through this mapping process it is very important to understand every interface, handoff, and decision/approval step in the process. Furthermore, does the process loop back on itself, or is there a clear, direct flow from start to completion. It is advisable to have a facilitator support this activity.

The flow diagram Figure 3-1 represents the "as-found" work process at a typical plant. This format can be used to assemble the above requested information.

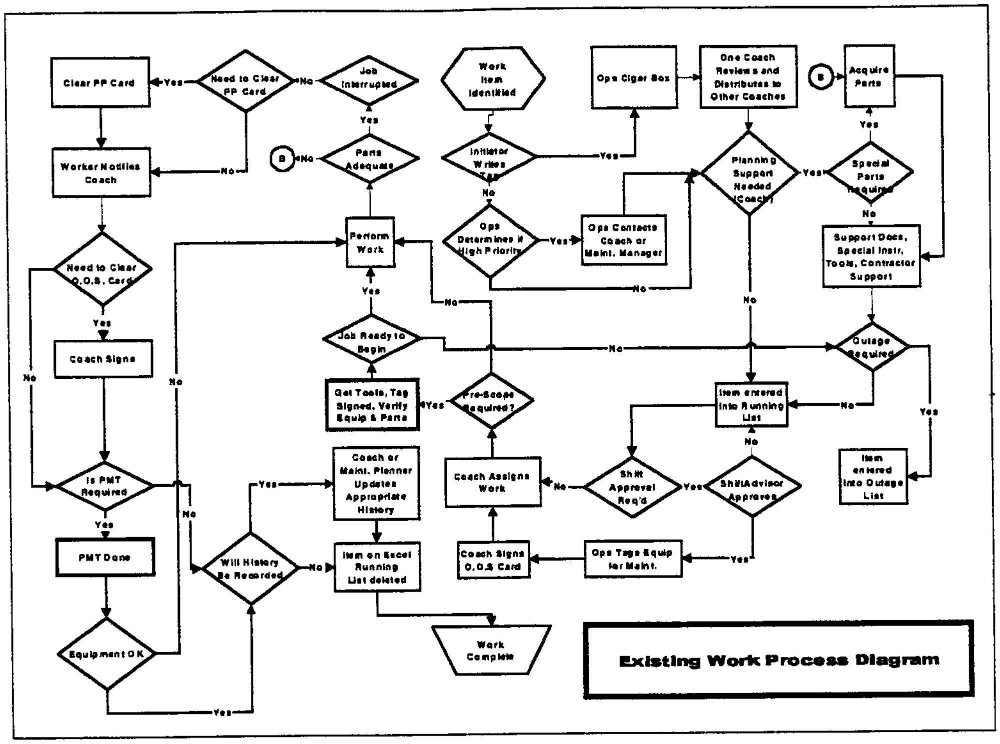


Figure 3-1
Existing Work Process

Work Process Issues

Another useful exercise that the organization should perform is to identify problems or potential roadblocks with the work process. To identify these issues, canvas the assembled cross section of the staff. Have each individual identify at least 3 issues that impede flow of information within the work process. Discuss each issue and ask clarifying questions until there is clarity among the group on the specifics of the issue. After the list of issues has been developed, have group prioritize the issues. Table 3-2 lists some typical issues that have been developed during visits to other plants. It is advisable to have a facilitator support this activity.

Table 3-3
Work Process Issues

1. History not captured 2. Parts delays 3. lack of Resources during short outages 4. No formal Work Request Process, no parts system to equate Equipment ID to OEM P/N, no system to identify lead time for parts 5. Poor Work Prioritization 6. No Approval Process 7. Communication between Operations and Maintenance 8. No formal Scheduling Process 9. Jobs not ready for maintenance worker 10. Running maintenance resources limited 11. Need better Problem Definition 12. No priority on work close-out

Plant Walk-Down/Observing Maintenance Efforts in Progress

In-process work should be selected and observed that is characteristic of how work is actually being accomplished in the field. The review should compare how the organization thinks work is being accomplished (refer to "As-Found" work process prepared by group) versus how work is actually accomplished in the field.

Selecting Plant Procedures and Records for Review

Procedures should be selected and reviewed that reflects how work is accomplished. The procedure review should compare how the organization thinks work is accomplished (refer to "As-Found" work process prepared by group) versus how work is actually controlled by procedures.

Reviewing Corrective and Preventative Maintenance Documents

A representative number of work orders should be reviewed to determine whether or not the "As-Found" conditions and "As-Left" conditions are appropriately captured in the work orders. The work orders should also be reviewed to see if replacement parts are adequately captured in the histories as well as whether or not the craft time has been documented. The work order should be reviewed to determine whether the task was conducted in accordance with appropriate procedures and whether post maintenance acceptance testing was performed and documented.

4
PART III – CONDUCTING INTERVIEWS

Conducting Interviews

The assessment process is somewhat akin to conducting a root cause analysis on the maintenance process and the organization. The team is trying to determine:

- *What* is the plant maintenance program?
- *How* are specific maintenance tasks are executed?
- *Who* does the maintenance work?
- *What* advanced tools are being used to perform maintenance tasks?

The assessment team should test the validity of the various data that were self-identified by the organization (refer to Section II of this Guideline under the heading of "Information Gathering"). These data include:

- "Prerequisite Information (refer to Section III)
- Spider Chart "Self Evaluation"
- Mapping "As-Found" workflow
- "Work Process Issues"
- "Issues" that can impede implementation of PMO
- Plant walk down/in-process work observations
- Procedures and records review
- Corrective and preventive maintenance record review

The assessment interview process should work toward developing an understanding of the causal factors that led to the identification of the various data. The data, as presented, may only represent the apparent problem, which, in fact, on further investigation may be masking the true problem or issue. When reviewing the spider chart data for the various levels within the organization, responses for segments of the spider chart should be reviewed for consistency. Does the data show that the management responses are in agreement with the data provided by supervision and worker, or is there significant level of disagreement on how the organization performs? Alignment at a high level of performance indicates that the entire workforce sees the attribute as a strength. Alignment at a low level of performance indicates that the entire workforce sees that attribute as a weakness. Areas where there is a variation in the level of response should be a focus of the individual interviews. This line of questioning should be pursued on both a vertical cut-Management, supervisor, worker, and horizontal cut from worker, etc. to worker or group to group. By proceeding with this line of questioning with various individuals in the same work group, with individuals from interfacing work groups, and with individuals from various levels of management, the root cause of the responses should be better understood. Reviewing procedures and walking down systems can also help fill voids in understanding the organization.

Typical questions for use in the interview process are included in Appendix 3. These questions should be modified and tailored to the specific facility being assessed. These questions have been developed to assist the interviewer's focus on issues that may prove useful in identifying gaps within the organization. This question set has been segregated on the five basic areas for Plant Maintenance Optimization:

- Work Identification
- Work Process
- Technologies
- Management and Work Culture
- People

When conducting the interviews, confidentiality is of utmost importance if useful responses are expected from those being interviewed. It is important that the interviewee be comfortable with the process. It should be stressed that the interviewer is taking notes but that the information will be held confidential among the assessment team. Further, it should be explained that the answers given would be presented only in a summarized format such that responses will not be able to be attributed to individuals.

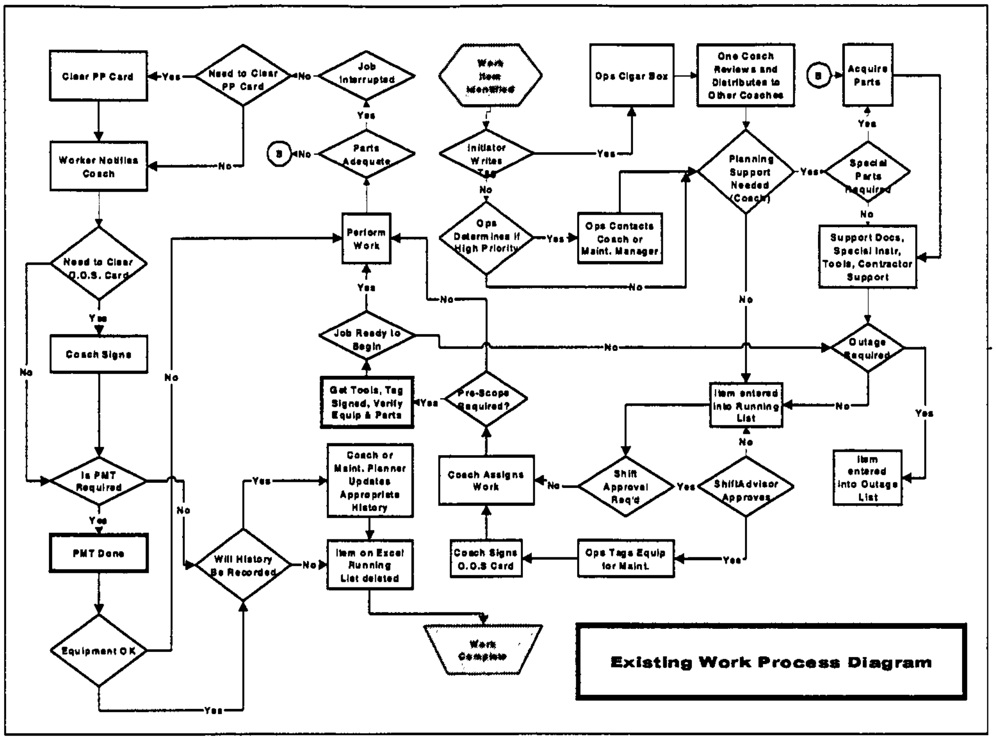
Composition of Assessment Team

Experience has shown that the most effective team size for conducting the individual assessment interviews is two individuals. Depending on the size of the target population, the overall project may need to be composed of several assessment teams with different two-person teams being used for interviewing different levels within the organization or interviewing different disciplines. The two-person team allows one member of the team to formulate and present the question to the interviewee, while the other team member listens intently to the answer and captures the essential information provided by the interviewee. This process allows the initial questioner to listen to the response and formulate the next question, or to request clarifying information on the initial response.

The two-person team should be comprised of individuals with different backgrounds or skill sets.

Targets to be Interviewed

Experience has shown that a population between 10% for the largest organizations and 15% for the mid-sized organizations of the target workforce should provide an adequate basis for a



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The two-person team should be comprised of individuals with different backgrounds or skill sets.

Targets to be Interviewed

Experience has shown that a population between 10% for the largest organizations and 15% for the mid-sized organizations of the target workforce should provide an adequate basis for a successful PMO Assessment. For the smaller organization, the target interview population may have to be further increased in order to get independent validation on the issues. Table 4-1 provides a suggested list of interviews.

Figure 4-1
Suggested Interviewees

Interviewee	**Number**
Corporate Management	
Generation VP	1
Central Support Organizations	3
Plant Management	1
Operations Management	
Operations Manager	1
Shift Manager	2
Lead Operator	2
Operators	2
Floor Operators	2
Maintenance Management	
Maintenance Manager	1
Maintenance Foreman	3
Maintenance Mechanic-Electrical	2
Maintenance Mechanic-Mechanical	2
Maintenance Mechanic-I&C	2
Maintenance Planning and Scheduler	1
PDM Group Manager	1
Storeroom	1
Engineering Management	
Engineering Manager	1
System Engineers	2
Design Engineers	2
Contractors Supporting Maintenance	2
Total	34

To get verification of effectiveness of communication channels and to validate objectives of assessment, it may also be necessary to conduct part of the assessment at the corporate headquarters. This will be determined by the extent of autonomy provided to the subject site.

Data Integration

Following each day of interviewing, while the information is still fresh, the various teams should meet to discuss the apparent findings (strengths and opportunities). Information gleaned from these data integration sessions should be used as a basis for preparing for the next set of interviews. Using this information, missing information can be pursued and areas where adequate responses have been provided can be ignored in subsequent interviews. However, when apparent conclusions have been identified, these conclusions should be tested through the subsequent interviews to establish validity.

Conducting Exit Meeting with Appropriate Project Sponsors

Prior to preparing the implementation plan, an exit meeting with the sponsoring management should be conducted. At this meeting, preliminary observations should be discussed.

5

PART IV – DEVELOPING AN IMPLEMENTATION PLAN

Having defined the attributes of an optimized maintenance process in Part I of this guideline, it will be necessary to identify which areas to focus on when developing a customized PMO implementation plan for the individual power producer. To do this, it will be necessary to analyze all of the data that was acquired in Part II, Information Gathering, and Part III, Conducting Interviews. This data includes:

- Spider Chart
- "As-found" work process
- Work Process Issues
- Issues that will prevent the PMO from being successful
- Prerequisite information
- Data from interviews
- Information obtained from plant walk down
- Information collected from reviewing plant procedures and records
- Information obtained from reviewing PM and CM work orders
- Exit Meeting

By reviewing and digesting this information, an overall picture of where the organization today can be developed. Strengths, opportunities, and recommendations should be determined. With a firm understanding of where the organization is today compared to the concepts of PMO, the gaps in performance will be evident. The implementation plan should be developed to address:

- Gaps between the As-Found and the desired program state
- Implementation cost and return on investment
- Step by step schedule for implementation of each activity

Table 5-1 can be used as a tool to help quantify the areas of strengths and opportunities within the organization when compared to the key attributes of PMO. Use the top-level attribute for each category as the ten (10) and the lowest entry as the zero (0). Score performance against each of the 19 individual attributes. Whenthis has been accomplished, a clear picture of the current organization performance should be apparent. This information should be compared against the spider diagram that was developed in Part II, Acquiring Data. Looking at this comparison, it is possible to document the assessors' opinions on organization performance against how the organization believes it performs.

Table 5-1
Strengths and Opportunities Quantifiers

Score	Work Identification	Work Process		
High	**Work Identification**	**Work Control**	**Work Execution**	**Work Close Out**
10	Integrated CBM Program	Priorities are set and approved	Zero Rework	Post Maint Testing Identified
↑	SRCM Has been accomplished	Work packages are prepared	Good Metrics	As Found and As Left captured in CMMs
	PM/PDM)	Parts Availability	Planned hours vs. actual within 10%	Maintenance Histories Updated
	Strong RCA	Clearances/Blocking Timely - Work Packages	Task benchmarking has been performed	Initiator gets feedback
	Work Order review process	A multi-week scheduling process is being used		Good Housekeeping
		Scheduling Compliance is greater than 95%		Work Reviewed by supervisor
		Parts unavailable		
↓		Priorities are not reviewed	No benchmarking	
Low	Large Backlog of PM and PDM work	Work Packages are not prepared	Planned hours vs. actual not tracked	Limited learning from work performed
0	Highly Reactive Work Environment	No scheduling process	Large Percentage of Rework	No feedback

Technologies

Work Management System	Maintenance & Diagnostic Technologies	Information Integration Technologies
Great Metrics - Global and Component Specific	All know what & where info is	All decisions driven by integrated info
RCA identified from Histories	E&CI Optimized	Easy access to all information
Good Maintenance Histories	Technologies (Oil Analysis, IR, Vibration, Leak	System and Component based info
High percent of work uses CMMS	detection On-line and periodic data, leak detection)	Integration Tools exist
User friendly		LAN Exists
		CMMS - Financial System - Dispatch info
		DCS or Plant Process Computer
Do not have a CMMS		
Very Limited use	Reactive not taking advantage of Condition Info	No integration tools exist

Management and Work Culture

Continuous Improvement	Accountability	Organization	Leadership
Good process in-place yielding results - learning org.	All are held accountable for performance	Everyone is responsible to PMO	Walks the Talk - Direction and Discipline
Team Problem Solving	Good metrics provide clarity	Process Teams	accountability
Periodic self appraisals	Owners exist - Process, Technology, Equipment	Process Owners - Equipment Owners	effectively
RCA in place	Performance linked to plant success	Vertical Organizations Ops, Maintenance,	Reinforces by confirming why and
Employees solicited for ideas	Employees know roles and responsibilities	Technology, Engineering	provides rewards
Must be recreated for further improvement			
		Does not promote good communications	
"Program of the Month"	Empowerment incorrectly has halted accountability	done	Program of the Month
Too reactive for betterment	No Ownership until reaching Plant Manager	Heavy functional boundaries - turf battles	Incongruent Behavior
Global Metrics	**Communication (Inter)**	**Setting Goals**	**Benchmarking**
Mgmt Initiatives linked to Metric Improvement	Mgmt Issues are understood by workforce	Plant Goals linked to various plant org goals	exists at Workforce
Creative Global goals have focused improvement	Communication paths exist	Good alignment of Goals (pers - org - plant)	Studies have been performed recently
Plant Strategies linked to Goals with Metrics	technology, engineering	Good local metrics	
Work linked to Metric Improvement		Workforce know plant goals and strategy	
HR, O&M Costs, EFOR, System Availability		Workforce is business literate	
Overall Plant Goals Tracked and Posted		Workforce participates in setting goals	
		Employees have current expectations	
	Turf Battles prevent good communication		"We're the Best" prevention
Goals seem unrelated to work ongoing at plant	systems	Workforce unsure of plant objectives	Unaware and unconscious to best practice

People

Training	Utilization	Communication (Intra)	Qualifications
Training driven off Existing/Required Matrices	System work grouping - Good Metrics	People learn from each other	Responsibilities
Manage skill/knowledge of organization	Good Planning - Scheduling - Schedule adherence	People work well within Teams	No rework - people are well qualified
PMO Awareness is well understood	Multi-discipline capability	Team to team communication free-flows	Qualifications measured - Re-qualified
Training performed as requested	FIN approach	Proactive behavior	Written Job Descriptions
Training Budget exists			
		Compliant behavior	
		Resistance exists	Rework not measured
Training budget cut with no plans	Frequent trips to storeroom or parts unavailable	People are fearful for their jobs	No qualification tracking

(Note: See Appendix 2 for a form to be used in this exercise.)

Each area where the performance is identified as being low should be further explored to fully understand the causal factors for this level of performance. Each of these causal factors should be developed into clearly stated findings. Using these individual findings, develop individual recommendations or corrective actions that, when implemented, will move the organization toward the desired level of performance.

Prior to implementing any changes to the existing organization, the expected return on the investment for each change should be developed. Management must understand the extent of the investment required and, further, what savings can be expected. Consideration should also be given to the time required to implement the specific changes. This information can be used when the organization develops the priority and schedule for implementing each of the recommendations.

The development of the implementation priority should be based on goals of the Corporation. If goal setting is identified as one of the weak areas, the implementation plan should start by developing specific goals for the plant that will align with the Corporate goals (refer to discussion on goal setting in Part 1). Once these goals have been identified, the rest of the implementation plan can be developed to support these goals. However, it is very important that no change to the existing processes should be attempted without having appropriate metrics in place to measure effects from implementing the change. It is expected that all action plans that are developed as a result of the assessment will provide the organization with a significant return on its investment; however, that may not always be the case. Therefore, without having the tools in place to track the performance using very specific metrics, success cannot be demonstrated.

Furthermore, it is important to understand that by changing the process, and having implemented changes that will provide overall performance improvement over time, there is a transition period of time when the cost to do business actually increases. Management should be prepared ahead of time to recognize this initial increase. As the implementation effort moves forward, problems with the equipment are going to be identified and must be dealt with. These are items that would appear further down the operating cycle as problems; but now through early identification, the opportunity allows for the problem to be resolved before the item can result in catastrophic failure.

Refer to Figure 5-1 which describes the effects that changes have on maintenance costs over time from the initiation of the PMO implementation Plan.

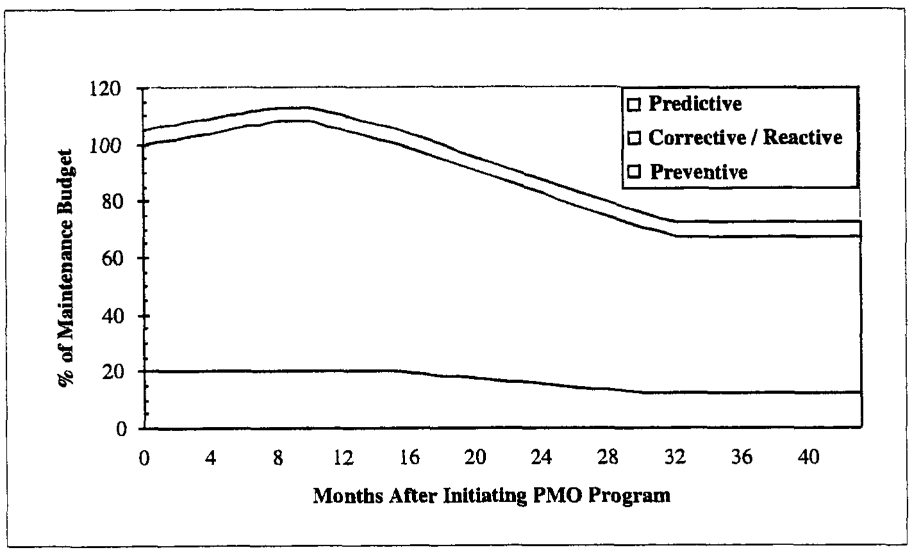

Figure 5-1
Effects of PMO Implementation Plan

Developing Implementation Strategy

Creating alignment between stakeholders and selecting significant issues.

The model, illustrated in Figure 5-2, shows how the integration of decision making and feedback (continuous improvement) leads to optimization of the plant maintenance process.

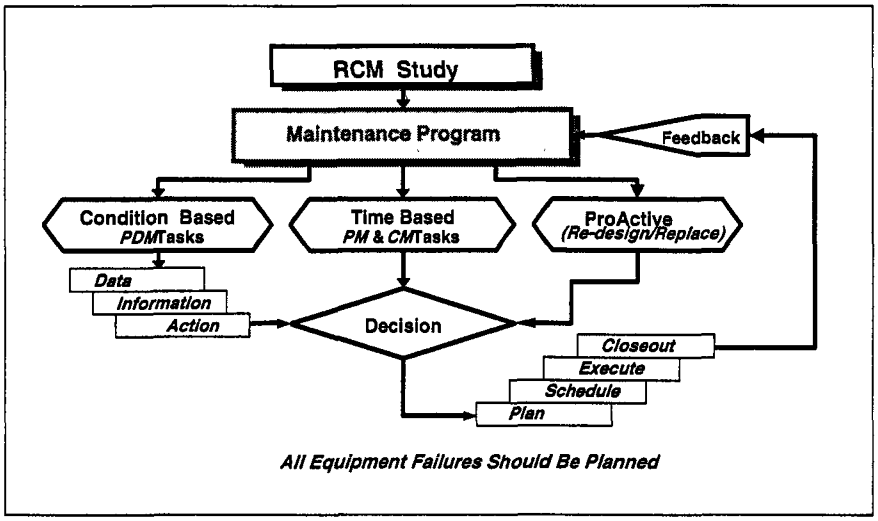

Figure 5-2
Integration of Decision-Making

In the section that follows, typical recommendations will be addressed for each of the 19 key attributes needed for an effective PMO.

Work Identification

1. Work Identification

- A Reliability-Centered Maintenance (RCM) program should be used to identify a protection strategy for each piece of critical equipment.
- The RCM program should be interactive to the point that when equipment failure is experienced that falls outside of the conditions dictated by the RCM program, the program protection strategy should be modified when the root cause of the failure has been identified.
- Clearly defined preventive, corrective, predictive, and proactive maintenance practices should be in place.
- Separate, identifiable budget for PDM organization.
- The goal of the maintenance program should be to work toward a highly planned workload with no more that 30% of the work being Corrective maintenance.
- Work orders should be reviewed to identify repetitive failures.

- A Proactive approach should be taken to solve these problems (modify operation or change-out component based on operation history and root cause analysis).
- In cases where the failure mode is not apparent and the impact from the failure is significant, a Root Cause Analysis should be used to identify the failure initiator.
- CMMS history should be reviewed prior to issuing new work order.
- A root cause analysis should be performed for recurring failures to identify root cause of failure initiator.

Work Process

One of the many results contained in the implementation plan is a recommendation around the work process. The work process flow diagram shown as Figure 5-3 was developed for a typical plant that was optimizing the maintenance process. The diagram was developed to resolve weaknesses in the existing work process (refer to "As-Found" work Process diagram developed in Part II Information Gathering), and to incorporate improvements in the overall use of information in decision making.

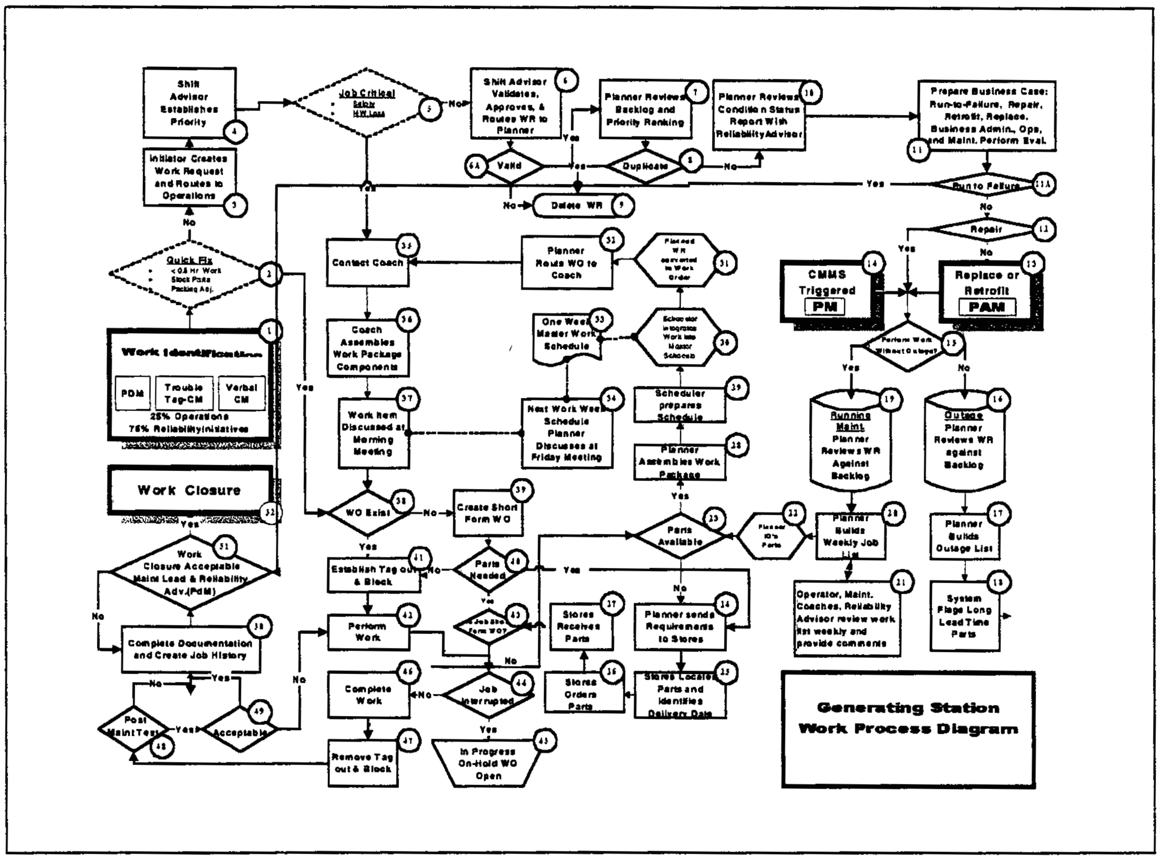

Figure 5-3
Work Process Diagram

2. Work Control

- A formalized planning process should be in place (preferably Computer-based).
- Criteria should be developed for setting priorities (consider criticality of equipment, economics of time related generation).
- Prepackaged work packages should be developed which include; work procedure references, drawing references, parts required, permit and blocking plans, and prerequisites.
- Minor work (less that one hour and on non-critical systems) can be accomplished without a formal work order. These are the tasks that never get done because of low priority. Consider a roving multi-skilled team that roves the plant one-day or week per month to address these problems. These teams are known as-FIN "fix it now or "you find it, you fix it".
- Parts availability and minimum/maximum stocking levels should be reviewed on an annual basis.
- A multi-week scheduling process should be in place and performance to plan should be measured.
- Scheduling Compliance should be greater than 95%.
- A progressive planning process should be in place so that work is identified and scheduled for work several weeks out. As the scheduled work date gets closer, more detailed planning is accomplished. By the one-week prior to work date, the completed work package should ready to work. Having work packages on the shelf and ready to go gives flexibility to the organization since the work can be substituted for scheduled work if an existing is placed on hold for any reason.

3. Work Execution

- Rework should be minimized. A system should exist to track rework. The goal for rework should be zeros.
- Good Metrics should be developed and used to manage work and backlog.
- Planned hours should be within 10% of actual hours.
- Task benchmarking should be performed.

4. Work Order Close-Out

- Post-Maintenance Testing should be identified in work order.
- "As-Found" and 'As Left' conditions should be captured in CMMS history.
- Maintenance Histories should be updated for each work order.
- Work order initiator should get feed on "As-Found" condition.
- "As-Found" condition compared to condition identified in diagnostic data.
- Good housekeeping should be encouraged-workers have pride in keeping work area clean.

- In-process and completed work should be reviewed by supervisor.

Technologies

5. Work Management Systems

- Metrics should be both Global and Component Specific.
- The root cause of the problem should be identified in History.
- Good Maintenance Histories should be maintained.
- A high percent of work should be managed through the Computerized Maintenance Management System (CMMS).
- The CMMS should be user friendly to the occasional user as well as the heavy duty user.

6. Maintenance and Diagnostic Technologies

- All workers should be familiar with diagnostic technologies, know what information is available, and know where information is stored.
- Equipment and Condition Indicator Matrix should be developed and in used in decision process.
- The following technologies should be considered as the minimum for diagnostic testing:
  - Oil Analysis
  - Thermography
  - Leak Detection
  - Vibration
  - On-Line and Periodic
  - Lubricant Analysis

7. Information Integration Systems

- All decisions should be driven by integrated information.
- Easy access to all information.
- Responsibilities should be both System and Component based.
- Integration Tools should exist.
- LAN to provide easy access to information should exist.
- The CMMS should Financial information and man-hours for each task.
- DCS or Plant Process Computer should be in use.

Work Culture and Management

8. Continuous Improvement Methods

- Good processes should be in place which yield results characteristic of a learning organization.
- Team Problem Solving should be in place.
- Periodic self-appraisal process should be in place.
- Root Cause Analysis process should be in place.
- Employees should be solicited for ideas.

9. Accountability

- All are held accountable for performance (both individually and globally)
- Good metrics provide clarity
- Owners exist for Process, Technology, and Equipment
- Performance linked to plant success
- Employees should know roles and responsibilities

10. Organization

- Everyone should be responsible to PMO.
- Process Teams should exist.
- Both Process Owners and Equipment Owners should exist.
- The organization should be vertically structured for Operations, Maintenance, Technology, and Engineering.

11. Leadership

- Leadership must Walk-the-Talk for both direction and discipline.
- Management must provide adequate resources and demands accountability.
- Expectations must be very clear. Metrics should be used to measure progress.
- Management should reinforce by confirming why and provides rewards.

12. Global Metrics and Reporting

- Management Initiatives must be linked to Metrics to measure improvement.
- Creative Global goals are needed to focus improvement.

- Plant Strategies must be linked to Goals with Metrics.
- Work linked to Metric Improvement.
- Overall Plant Goals should be tracked and posted for work force (HR, O&M Costs, EFOR, System Availability).

13. Communication Mechanisms (Inter-Organization)

- Management Issues need to be understood by workforce.
- Communication paths exist (open door policy by management).
- No boundaries between operations, maintenance, technology, engineering.

14. Goal Setting

- Plant Goals need to be linked to various plant organization goals.
- Good alignment of Goals in necessary (individual understands how his contribution aligns with work group and to plant).
- Good local metrics so local accomplishment is recognized.
- Workforce must know plant goals and strategy.
- Workforce must be business literate (understands competitive market environment challenges and benefits of economic availability).
- Workforce must participate in setting goals.
- Employees have current expectations.

15. Benchmarking

- Benchmarked Best Practice knowledge must exist at Workforce level.
- Data needs to be current (Studies have to be recent).

People/Skills

16. Training

- Training should be driven off Skills Existing versus Skills Required Matrices.
- The organizations skill/knowledge basis needs to be managed.
- PMO Awareness must be well understood by workforce through management.
- Training should be performed as requested.
- Training Budget should exist.

17. Utilization

- System work grouping-Good Metrics.
- Good Planning-Scheduling-Schedule adherence.
- Multi-discipline workforce capability.
- FIN (fix-it-now) approach.

18. Inter Department Communication

- People learn from each other.
- People work well within Teams.
- Team to team communication free-flows.

19. Qualifications/Job Descriptions

- Skills required for work clearly defined.
- Clear and Concise Roles and Responsibilities.
- No rework-people are well qualified.
- Qualifications measured-Re-qualified.
- Written Job Descriptions exist and are frequently reviewed.

Plant Maintenance Optimization Report Format

- Executive Summary
- Program Overview
- Purpose
- Scope
- Findings and Recommendations
- Goal
- Economic Environments
- Reporting
- Work Flow
- Existing Organizational Structure
- Maintenance Basis
- PDM Process
- PAM Process

- Continuous Improvement Process
- Roles and Responsibilities
- Organization Structure with PMO
- Financial Analysis
- Program Cost Summary
- Cost Benefits
- Training Requirements
- Appendices
- References
- Implementation Schedule

Presentation of Finished Product to Appropriate Project Sponsors

It is important that the individuals who participated in the assessment be included in the roll-out process. These people invested their time and shared their thoughts on how things should work. They should be given the opportunity to understand the reasoning behind the recommendations that the assessment team has assembled. This provides one additional sanity review. The participants may point out an obvious issue, or make a point that was not raised during this process.

6
REFERENCES

1. Predictive Maintenance Guidelines EPRI TR-103374 August 1994

2. Predictive Maintenance Guidelines Volume 2 EPRI TR-103374-2 October 1994

3. Predictive Maintenance Assessment Guidelines EPRI TR-109241 November 1997

4. Smith, Anthony M., Reliability Centered Maintenance, McGraw Hill, 1993

5. Plant Performance Success Indicators for Predictive Maintenance Programs, Matusheski, paper published in the P/PM Technology magazine, July 1997

A
APPENDIX A – SPIDER CHART SELF-EVALUATION

B

APPENDIX B – STRENGTHS AND OPPORTUNITIES QUANTIFIERS

Score	Work Identification	Work Process		
	Work Identification	**Work Control**	**Work Execution**	**Work Close Out**
High 10	Integrated CBM Program	Priorities are set and approved	Zero Rework	Post Maint Testing Identified
	SRCM Has been accomplished	Work packages are prepared	Good Metrics	As Found and As Left captured in CMMs
	Highly planned Work Load (30%CM/70% PM/PDM)	Parts Availability	Planned hours vs. actual within 10%	Maintenance Histories Updated
	Strong RCA	Clearances/Blocking Timely - Work Packages	Task benchmarking has been performed	Initiator gets feedback
	Work Order review process	A multi-week scheduling process is being used		Good Housekeeping
		Scheduling Compliance is greater than 95%		Work Reviewed by supervisor
		Parts unavailable		
		Priorities are not reviewed	No benchmarking	
Low	Large Backlog of PM and PDM work	Work Packages are not prepared	Planned hours vs. actual not tracked	Limited learning from work performed
0	Highly Reactive Work Environment	No scheduling process	Large Percentage of Rework	No feedback

Technologies

Work Management System	Maintenance and Diagnostic Technologies	Information Integration Technologies
Great Metrics - Global and Component Specific	All know what and where info is	All decisions driven by integrated info
RCA identified from Histories	E&CI Optimized	Easy access to all information
Good Maintenance Histories	Technologies (Oil Analysis, IR, Vibration, Leak	System and Component based info
High percent of work uses CMMS	detection On-line and periodic data, leak detection)	Integration Tools exist
User friendly		LAN Exists
		CMMS - Financial System - Dispatch info
		DCS or Plant Process Computer
Do not have a CMMS		
Very Limited use	Reactive not taking advantage of Condition Info	No integration tools exist

Management and Work Culture

Continuous Improvement	**Accountability**	**Organization**	**Leadership**
Good process in-place yielding results - learning org.	All are held accountable for performance	Everyone is responsible to PMO	Walks the Talk - Direction and Discipline
Team Problem Solving	Good metrics provide clarity	Process Teams	Provides resources - demands accountability
Periodic self appraisals	Owners exist - Process, Technology, Equipment	Process Owners - Equipment Owners	Sets expectations - uses metrics effectively
RCA in place	Performance linked to plant success	Vertical Organizations Ops, Maintenance,	Reinforces by confirming why and
Employees solicited for ideas	Employees know roles and responsibilities	Technology, Engineering	provides rewards
Must be recreated for further improvement			
		Does not promote good communications	
"Program of the Month"	Empowerment incorrectly has halted accountability	Org limits workers from getting right thing done	Program of the Month
Too reactive for betterment	No Ownership until reaching Plant Manager	Heavy functional boundaries - turf battles	Incongruent Behavior
Global Metrics	**Communication (Inter)**	**Setting Goals**	**Benchmarking**
Mgmt Initiatives linked to Metric Improvement	Mgmt Issues are understood by workforce	Plant Goals linked to various plant org goals	Benchmarked Best Practice knowledge exists at Workforce
Creative Global goals have focused improvement	Communication paths exist	Good alignment of Goals (pers - org - plant)	Studies have been performed recently
Plant Strategies linked to Goals with Metrics	No boundaries between operations, maintenance, technology, engineering	Good local metrics	
Work linked to Metric Improvement		Workforce know plant goals and strategy	
HR, O&M Costs, EFOR, System Availability		Workforce is business literate	
Overall Plant Goals Tracked and Posted		Workforce participates in setting goals	
		Employees have current expectations	
	Turf Battles prevent good communication		"We're the Best" prevention
Goals seem unrelated to work ongoing at plant	Workforce and Management have different belief systems	Workforce unsure of plant objectives	Unaware and unconscious to best practice

People

Training	Utilization	Communication (intra)	Qualifications
Training driven off Existing/Required Matrices	System work grouping - Good Metrics	People learn from each other	Clear and Concise Roles and Responsibilities
Manage skill/knowledge of organization	Good Planning - Scheduling - Schedule adherence	People work well within Teams	No rework - people are well qualified
PMO Awareness is well understood	Multi-discipline capability	Team to team communication free-flows	Qualifications measured - Re-qualified
Training performed as requested	FIN approach	Proactive behavior	Written Job Descriptions
Training Budget exists			
		Compliant behavior	
		Resistance exists	Rework not measured
Training budget cut with no plans	Frequent trips to storeroom or parts unavailable	People are fearful for their jobs	No qualification tracking

C
APPENDIX C – MAINTENANCE OPTIMIZATION ASSESSMENT

Name: ____________________ Position: ______________ Date: ___________________

Work Identification

1 Work Identification

1. What is your overall maintenance strategy?
2. What is the current mix? ____%CM ____%PM ____%PDM ____%PAM
3. How do you categorize repair activities?
4. What is your definition of Predictive Maintenance?
5. What is your understanding of your company's Predictive Maintenance efforts?
6. Do you think PDM could be or has been effective in reducing O&M cost, increasing availability, or decreasing plant heat rate.
7. On what are you basing your belief?
8. Do you think that better control of the plant's temperatures, pressures, flows (Such as main steam temperature, main steam pressure, coal and combustion air flows) would eliminate unnecessary stresses and would be effective in reducing O&M costs, increasing availability and decreasing plant heat rate?
9. On what are you basing your belief?
10. What is the plant's actual heat rate? How does it compare with industry benchmarks?
11. Do you track EFORs or Peak EFORs? How do they compare with industry benchmarks?
12. Are there any technologies additional that would be beneficial to the plant that should be or will be implemented in the near future?
13. Are you considering the addition of Control Valve Diagnostics or Valve Leak Detection technologies?

14. What are the most troublesome equipment or component in the plant?

15. What, if any, monitoring or diagnostics have been applied to these systems?

16. Do you keep a running list of the top 10 or 12 problems? Could we get a copy of the list?

17. Do you track costs on individual pieces of equipment? Can you? Would this be useful?

18. Do track individual availability on major components? Can you? Would this be useful?

19. Do repairs recommended reflect the actual "as found" problem?

20. Describe the plant control system. DCS or analog? Year installed? Plans for upgrade?

21. What is the physical condition of the Control Valves and Control Dampers used to control the Plant's Processes? Do they operate smoothly and provide precise control of the processes?

22. Are any of the plant's process (DCS) controls run routinely in manual instead of automatic?

23. Is it necessary to place DCS controls temporarily in manual due to processes becoming unstable? Is priority given to correcting these problems and eliminating their negative effect on equipment reliability.

24. What key process data points are used for plant control?

25. Are there any process data points that are often used for identifying equipment problems or troubleshooting?

26. Are techniques such as performance testing employed to verify the accuracy of installed plant instrumentation? Are you confident that the installed instruments are accurate and presenting and accurate picture of actual plant operating conditions?

27. Are installed plant instruments checked for accuracy and calibrated on a regular basis?

28. What portable diagnostic tools are regularly used by operators?

29. Is the plant adequately covered with monitoring systems? Yes/No. What monitoring technologies would you like to see applied and to which equipment?

30. Do you track running hours on individual pieces of major equipment? Is it possible?

Work Process

2 Work Control

1. Is there a Work Planning Group? What are their responsibilities?

2. How is work scheduled? Is "performance to schedule" tracked?

3. Is operations (or the customer) involved in the scheduling process?

4. What performance metrics are used to assess Work Execution? Is that data taken from CMMS?

5. Are documents controlled (i.e., latest revision entered, used by worker, tracked, serialized)?

6. Describe, step by step, how a maintenance work order is initiated, reviewed processed and closed out. Are operators involved in evaluating the equipment condition? If not should they be, and how?

7. Is there a standard Work Order format? What data from the Work Order is entered into CMMS?

8. Are workers required to record (on the Work Order) :

- -work performed?
- -conditions found?
- -failure codes?

9. Does anyone check to see if the Work Order is a duplicate?

10. Does anyone verify the correct priority code on the Work Order?

11. Who sets the priority for work requests/work orders? Who should?

12. What % of work orders are planned? How far in advance?

13. How much does it cost to process a work order?

14. On the average, how many maintenance orders do you receive per year?

15. Who assigns resources (people and materials)?

16. Are there existing work packages or are they developed as needed?

17. Are there any existing procedures or processes that you consider to be highly efficient and cost effective? (i.e. quality program, heat recovery, etc...)

18. Are there any old processes or procedures that should be brought back?

19. In your opinion, are current resources adequate for operating and maintaining the plant, safely and efficiently?

20. How much of your plant maintenance is done on overtime? Do you track this by employee? By component?

21. Is your company planning to reorganize or down-size anytime soon?

22. Will personnel reduction resulting from down-sizing cause problems maintaining or operating in the future?

23. Will personnel reduction result in reduction of safety? Will personnel reductions result in reductions in plant efficiency or reliability?

24. What steps should be taken to relieve some of these difficulties?

25. Are you aware of any other programs for cost reductions either at the plant level or at the corporate level?

26. Are you aware of programs to increase plant efficiency? To increase reliability? To reduce emissions?

27. Do you have a "performance group" or process experts on staff?

28. What are the risks involved with reducing these costs?

29. How do seasonal variations effect plant maintenance workload.

30. Does management support you when requesting investment in maintenance?

31. As a result of post maintenance testing, how is any rework justified? Do you track rework?

32. Spare Parts

- What is your spare parts policy?
- What is the basis for the policy?
- Where are spare parts kept?
- Has your store-room been recently purged for overstocked or obsolete parts?
- Who orders spare parts?

33. How are Spare Parts tracked? Is material staged for scheduled work?

34. How are jobs awaiting parts/material tracked?

35. Are procedures used? Is there any written guidance as to how and when?

36. Are spare parts generally available when needed? Give an overall percentage availability

37. Is parts control in the CMMS or is it a separate system? Manual or computerized?

38. Does the plant have any problems with regulatory mandated emission or discharge systems?

3 Work Execution

1. What types of preventive activities are carried out on a regular basis?
2. On which equipment?
3. Do the maintenance crews capture the "as found" condition of the components that were repaired or replaced during these preventive procedures?
4. Are there any written schedules for performing these activities?
5. How is outage scope derived?
6. Are diagnostic results used to direct outage maintenance?
7. Is there an outage planning group? If so, do they have formal guidance/procedures?
8. Is outage work prioritized in advance (1 day, 1wk plans)? Who sets the priority for work?
9. How are jobs in the planning process tracked?
10. Is material staged for execution? How?
11. Is there an outage scheduling group? Is operations (customer) involved?
12. Are contractors used for outage work?

- How are they managed?
- What procedures do they use?

13. What performance metrics are used to assess outage performance? How do you know if the overall duration and cost of your outage is competitive?
14. Are documents controlled?
15. Is there a formal "lessons learned" file for future outage planning/execution?
    What services does the plant use on a regular basis from Central corporate or contractor support? *Check all that apply(either Central or Contractor)*

    ____Diagnostic Testing (including NDT Inspections)

    ____Laboratory

    ____Engineering Design

    ____Troubleshooting

    ____Outage Maintenance

16. What is the current maintenance order backlog? Is this normal? (in worker-weeks)

17. Is the backlog increasing, decreasing or staying the same?

18. Do you periodically purge the backlog for duplicates or outdated work requests?

4 Work Close-Out

1. Is post maintenance testing done?

- By whom?
- What tests are done,
- On which machines?
- How is it documented?

2. Are PMT acceptance criteria identified?

3. What action is taken if PMT acceptance criteria is not met?

4. Does anyone check to ensure that the Work Order is filled out properly after job completion? Who does this?

5. How do systemic (repetitive) failures get identified? Is action assigned to conduct Root Cause Failure Analysis, etc. to determine long term resolution of these problems? If so, who is action assigned to?

6. Are the following failure causes identified and dealt with:

- Improper performance of work by the worker
- Defective Spare Parts
- Non-calibrated test instruments
- Improper operation of equipment by the operator
- Unsatisfactory product quality or rate

7. Are "as-found-as-left" data identified? How/where is it recorded? Is it used for future maintenance planning?

8. Is there any guidance/procedures for the workers with respect to documentation of completed work?

9. Is there an equipment "tag-out" procedure? How is equipment transferred to operations after maintenance is complete? Is there a procedure?

10. Who is responsible to clean up the work site? Recommend evaluator tour some work sites to get a feel for overall plant cleanliness

11. What performance metrics are used regarding Work Orders? For example, backlog of PMs and Reactive Maintenance Tasks, open actions discovered upon review of completed work such as Root Cause Failure Analysis, improper vendor performance, PM revisions required, Drawing Revisions required, etc.

Technology

5 Work Management System (CMMS)

1. Does your facility have a computerized maintenance management system? How is it used?
2. Do you use this system? Who Does?
3. Is there a training program in place for the use of the CMMS? Who is trained?
4. Who is responsible for the CMMS system?
5. What CMMS modules are used (planning, scheduling, electronic work orders)?
6. Is CMMS tied to the warehouse parts management system?
7. How are min/max spare parts levels determined?
8. Are spare parts identified on each PM tasks?
9. Is there a formal scheduling process? Describe?
10. Are Spare Parts requirements tied to the work scheduling process?
11. Is there a continuous improvement process in place (e.g., failure trending, action item tracking, worker suggestions, PM revision status, etc.)?
12. What are the most frequently recurring problems faced by your maintenance department? Does your system flag these recurring problems automatically?
13. Do you know your plant's production costs?
14. Are you aware of any sort of equipment trouble list? Who keeps it?

6 Maintenance and Diagnostic Tools

1. What diagnostic technologies are used in your plant's maintenance program?
2. What diagnostic technologies are used your maintenance craft personnel?
3. Are there any technologies that are used by operations?
4. Are any technologies conducted by plant technical staff or outside organization?

5. Are there any contracted services that have been effective?

6. What condition monitoring diagnostic technologies do you know of that your company is not using?

7. To what equipment problems would you apply them?

8. Which diagnostic system, on-line or periodic, is utilized in the PDM program?

9. Do you have reporting responsibility to a specific plant person or group?

10. Are there any existing procedures for condition based testing which you perform for the plant? (i.e. lube oil sampling, vibration, etc...)

7 Information Integration Tools (Financial, Budget, Schedule, Dispatch, Tech Equip)

Work Culture and Management

8 Continuous Improvement

1. Do you have a formal root cause analysis process? Are people trained in the process? Is there a dedicated root cause team? How often is a root cause assessment performed? *(Management question)*

2. How do you use root cause information to prevent recurrence of a problem? Is the effectiveness of this process tracked? How? *(Management question)*

3. Do you apply root cause analysis to process and management issues? *(Management question)*

4. Do you capture the "as-found" condition of equipment when you do maintenance? Where is this data captured? In the CMMS? Is this information used to make changes in the operation and maintenance processes? Is this information reviewed before planning or performing maintenance on the same piece of equipment?

5. Are "as-left" conditions noted on the work order or in the CMMS? Is this information reviewed during planning or prior to working on the equipment the next time?

6. Is the effectiveness of these interventions or changes to work practice tracked or periodically measured to assure that the changes had a positive effect on the process by extending equipment life and optimizing time-based maintenance?

7. Periodic plan review

8. Team Problem Solving

9 Accountability

1. What meetings are held regularly to address plant equipment problems or other O&M issues?
2. Who attends these meetings?
3. What reports are you aware of (paper, electronic, voice mail) are currently available to you? Who produces these reports?
4. What mechanisms are in place to hold employees accountable?
5. Is a formal action item system/report used to document and track action to completion? Does management review/status open actions items?
6. Is management involved in progressing overdue actions?
7. Is operations required to be accountable to maintenance for the proper operation of equipment? How is this done?
8. Are support organizations (Engineering, Stores, I.S.S., others) held accountable to ensure all work on hold is made "ready to work" as soon as possible? How?
9. Is there a formal performance evaluation process in place?
10. Does each level of management set goals for their subordinates? If so, are employees evaluated based upon their performance to the goals?
11. Who are the customers? (Evaluator ask the customers if maintenance is accountable to them for product quality, rate, safety, etc.)
12. Are performance metrics used to assess levels of accountability? For example, are overdue action items tracked and trended? When a particular organization (engineering, stores, operations) has excessive overdue action items, what steps are taken to resolve?

10 Organization (Vertical, Process Teams, Component Ownership, Process Ownership, Fix-it-Now)

Are performance metrics used to assess levels of accountability? For example, are overdue action items tracked and trended? When a particular organization (engineering, stores, operations) has excessive overdue action items, what steps are taken to resolve?

11 Leadership (Management Support)

1. Is management committed to remaining in the generation business? Will they invest in improvements that enhance plant reliability and operations?
2. Does plant management support Predictive Maintenance philosophy?

3. Who prioritizes work associated with PDM program findings?

4. Do you perform cost benefit analysis?

5. At your plant, has PDM effected the following:

   ___Component or plant availability?

   ___O&M costs reductions?

   ___Capital Expenses?

   ___Plant heat rate reduction?

   ___Safety or regulatory compliance?

6. How much extra cost does your company incur which your plant is not available to produce?

7. Are there incentives for plant managers who meet their goals for generation, control costs, personnel caps, others?

8. How did your current organization evolve, and do you see any changes in the near future?

9. Where does the PDM Group effort in your organization?

12 Global Metrics and Reporting

1. How do you define a forced outage?

2. What is your average forced outage average rate?*All units*

3. What is the goal for average availability for the plant as a whole, or by unit?

4. Is the plant meeting goals for production? How much room is there to improvement?

5. What is your current total plant budget? Fuel? O&M Labor? Expenses?

6. Is there a line item in the budget for PDM?

7. Capital Expenditures

- What is your typical expected payback period for investment in capital equipment?
- How are capital expenditures justified?
- Is there a written procedure?
- Have there been any major capital investments for plant equipment. Are any planned?

13 Communication Mechanism

1. On a scale of 1 to 10 (10 being perfect) how well does your company, within the plant and also with any central support group, communicate information regarding diagnostic testing or special testing related to a specific equipment problem?
2. On a scale of 1 to 10 _____DATA _____INFORMATION ____ACTION
3. Is your department involved in the process of evaluating component conditions?
4. If yes, how is this information transferred to other parts of the organization?
5. How do you make other plant personnel aware of diagnostics results?
6. Is there a standard procedure for reporting of anomalies?
7. Is the report by exception only or on all equipment tested?
8. Are there any hard copy reporting requirements? (get copy?)

14 Goal Setting

1. For the plant under study, prioritize the following:

   ___Availability Improvement

   ___Safety

   ___Equipment Life

   ___Operations Management

   ___Reduction of Maintenance Costs

   ___Emissions Reduction

   ___Heat Rate Reduction

   ___Increasing Capacity

   ___Reduce Start-Up Times

   ___Increase Unit Ramp Rates

2. What is the plant history? Ask only if we don't already have this information.

- Operating Profile
- Remaining Life. Any plans for life extension?

- Availability
- Forced outage rate
- Peak EFORs
- Heat rate
- Has the plant readily met goals for production, availability, emissions, forced outage, heat rate and budget?

3. Are there any existing corporate-wide initiatives for:

   ___quality improvement

   ___safety

   ___reliability improvements

   ___problem solving

   ___cost reduction

   ___other personnel development.

   ___emissions reduction

   ___heat rate reduction

15 Benchmarking

Have benchmarking activities been performed to allow a direct comparison of the organizational practices with the Best-in-Class, or at least against the standard practices within the power industry?

People

16 Training

1. Is the current training program adequate to meet the needs of plant Operations, Maintenance, I&C, Electrical, Engineering and Technical Staffs? What other courses should be offered? *(As a general Rule, power plant people (including management) think of the term "maintenance" as including only maintenance mechanics, welders, etc. The term doesn't usually include I&C, Electricians Engineering, etc. Basically you have Operations, Maintenance and "some other folks" that are not really necessary but that are sometime nice to have around. This thinking (culture) must be altered so that there is some realization of the importance of process control to the bottom line).*

2. Do you feel you need training? If so, in what areas?

- Program training
- Condition monitoring technology training
- Specific Equipment maintenance or operation training
- Plant Process Optimization, Efficiency Improvement, Emissions Reduction Training?

3. Do you have any experience using personal computers? Would training in this area be helpful?

4. Do you feel confident in previous craft oriented training or would some refreshers help?

17 Utilization (Wrench Time/Multitasking/Bargaining Unit)

1. Are you currently operating with a Multi-skilled work team?

2. How you determine who gets a work assignment?

3. How many shifts per week do the operators work?

4. How many operators per shift?

   ___Control Room

   ___Roving

5. Describe responsibilities of operations managers and shift supervisors.

6. Has this always been the same?

7. Is overall productivity of the workforce measured? How?

8. Is the number of jobs completed per person per shift measured? How?

9. Is the 1st Line Supervisor generally at the work site to assign and progress work performed? What percentage of the time (average) is the 1st Line Supervisor on the floor?

10. Does the 1st Line Supervisor assign all work to the employees? If not, who does?

11. Is the General Foreman available to assist the workers in removing roadblocks to the performance of work?

12. Are daily meetings conducted to progress work? If not, how is work progressed?

13. What performance metrics are used to assess worker productivity (schedule performance, backlogs, number of tasks completed per person per shift, etc.)

14. When work is awaiting parts, engineering drawings, special tools, etc., is there a formal method to involve Engineering? Stores? Operations? Vendors?

15. How are relations between management and the union? Is the contract flexible? Discuss specific examples (e.g., utilization of overtime, skills vs. seniority, cross-crafting, etc.)

16. Is there any effort towards better utilization of resources, such as multi-disciplined workers, cross training and assignment, specialized teams, etc.?

17. Is the customer satisfied with worker performance? Evaluator talk to customer and rank satisfaction on a scale of 1-10.

18. How is the morale of the workers? Evaluator talk to at least 5 workers from different trades and shifts and rank from 1-10.

18 Inter-Departmental Communication

1. Are PDM capabilities and procedures well known among:

- Plant management
- Engineering staff
- Maintenance craft
- Operators

2. Are operators or maintenance supervisors and craft ever consulted before work orders are issued on PDM program findings?

19 Qualifications

1. What is your current function in the organization?
2. How long have you held this position?
3. What is your background?
4. Are you currently operating with a Multi-skilled work team?
5. How you determine who gets a work assignment?
6. Do qualifications reside in the CMMS, /does the individual craftsman maintain a “Qual Card”?
7. Does the company operate an apprentice program?

Target:

Work Process Improvement Guidelines & Techniques

About EPRI

EPRI creates science and technology solutions for the global energy and energy services industry. U.S. electric utilities established the Electric Power Research Institute in 1973 as a nonprofit research consortium for the benefit of utility members, their customers, and society. Now known simply as EPRI, the company provides a wide range of innovative products and services to more than 1000 energy-related organizations in 40 countries. EPRI's multidisciplinary team of scientists and engineers draws on a worldwide network of technical and business expertise to help solve today's toughest energy and environmental problems.

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EPRI • 3412 Hillview Avenue, Palo Alto, California 94304 • PO Box 10412, Palo Alto, California 94303 • USA
800.313.3774 • 650.855.2121 • askepri@epri.com • www.epri.com

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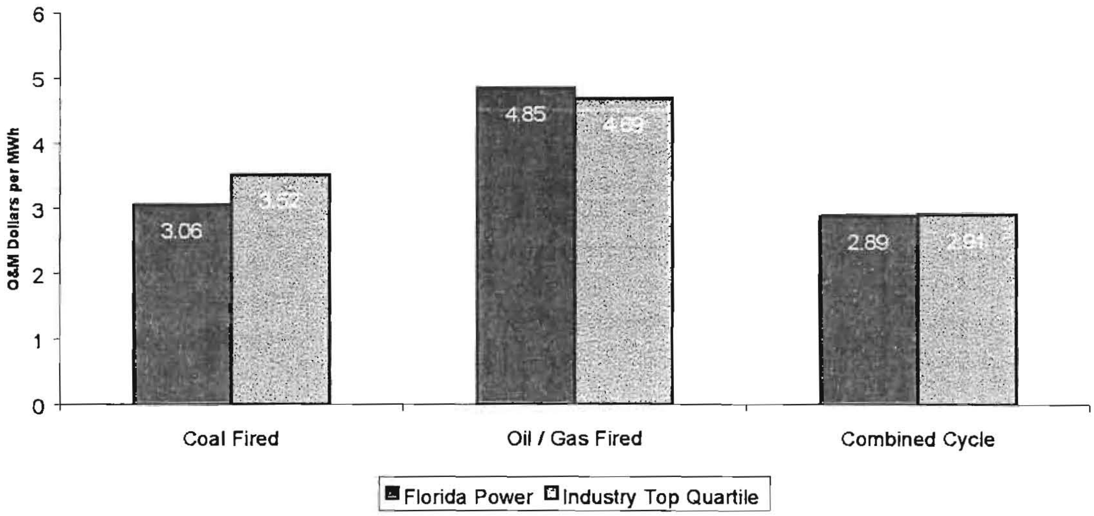

Notes: Data for coal and oil / gas fired plants is based on 1996 – 2000 5-Year average data.
Data for combined cycle plants is based on 1999 – 2000 2-Year average data.
Data for coal-fired plants includes Crystal River.
Data for oil / gas fired plants includes Anclote Bartow, and Suwannee.
Data for combined cycle plants includes Hines and Tiger Bay.

Source: RDI