RELIABILITY BASED ASSET MANAGEMENT
FOR OIL AND GAS PRODUCING PROPERTIES

by
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Abstract

Market competition, shareholder returns, declining product price, technology, safety and environmental legislation continually challenge the oil and gas industry. *An* additional challenge faced by many oil and gas producers is effectively maintaining equipment to acceptable levels in order to sustain production targets.

Asset reliability has become a focal point of discussion both domestically and internationally. Asset reliability can become a significant liability to the owner if the equipment is not in a state of production readiness or if an unforeseen catastrophic safety or environmental event occurs.

Many industry leaders are successfully meeting the challenge by adopting reliability based asset management.

Today, industry organizations have successfully aligned their business plan with reliability management. The results are very impressive.

This paper will examine common threads, which tie reliability asset management with corporate business goals.

Introduction

A number of changes have occurred in the oil and gas industry in the last ten years.
The oil and gas industry has experienced some of the lowest prices in history for their product. The industry has also been charged with complying with an ever-increasing number of federal and state laws for worker safety and environmental regulations. Compliance within the industry has been costly, however the cost of non-compliance has been even more costly for some.

A number of companies were unable overcome the challenges of the last ten years. Many of the surviving companies have hurriedly re-engineered, right-sized, down-sized and aggressively marketed marginal

operating properties. The changes made within many of the companies will only provide temporary relief from the anticipated onrush of future changes.
The challenges presented during the last ten years have influenced industry leaders to study the cost of maintaining their assets, Many industries have discovered the existence of significant opportunities to improve equipment reliability while reducing annual maintenance expenditures. Industry's long held belief of maintenance as being a cost issue, is now a profitability issue for many.

Many leading industries have invested heavily in reliability and maintenance improvement programs. Large numbers of organizations have completely restructured their engineering and maintenance organizations to meet the future challenges of the 21st. Century.

Industry surveys indicate U.S. industries spend more than 200 billion dollars annually on maintenance related activities. Maintenance expenditures typically rank either as the second or third largest expenditure for an operation. Industry experts estimate one out of every three dollars spent on maintenance activities is wasted. Results from a recent benchmark study conducted by the Society of Maintenance Reliability Professionals indicate reactive maintenance activities cost seven to ten times the cost of an effectively managed maintenance strategy. Additionally, industry surveys indicate the loss of revenue due to equipment failures and subsequent downtime may cost as much four to 15 times the cost of the maintenance repair.

Global challenges and external bench marking has convinced many within the oil and gas industry to adopt successful practices and key learning's of industries outside of oil and gas industry.

Many corporations in the manufacturing industry are trendsetters in reliability based management programs. Corporations such as E. I. du Pont de Nemours & Co. Alumax, Dofasco, Proctor and Gamble, Imperial Chemical Industries, Boeing and Ford Motors are all global maintenance trendsetters. Others, such as the United States Postal Service are successfully applying many of the same successful reliability practices commonly used by the manufacturing industry.

Du Pont conducted a 1986-benchmark study of "world class maintenance" performance indicators and discovered a significant gap between themselves and their competitors in reliability and maintenance management. The benchmark study began Du Pont's journey for global improvement. Du Pont's pre 1986 annual maintenance expenditures were $1.7 billion. By 1992, Du Pont's maintenance improvement program had captured savings of over **$420** million dollars per year.

Benchmark studies conducted within the oil and gas industry commonly uncover significant opportunities for improvement. In many instances, opportunities mirror those of the manufacturing industry. Savings of 20 percent to 40 percent on annual maintenance budgets are not uncommon. Moreover, industry studies indicate there are significant opportunities to increase revenues by improving equipment reliability and thus avoiding unnecessary equipment failures.

In some instances, revenue losses attributed to unnecessary equipment failures can often exceed the annual maintenance budget for many operations.

Many industry leaders have adopted reliability based maintenance improvement programs anticipating improved financial returns. Many have also redesigned their entire reliability and maintenance management processes while incorporating the fundamentals of continuous improvement.

In his book, "Out of the Crisis," Dr. W. Edwards Deming identified fourteen elements necessary to improve philosophies within industry's management. One primary element is to improve constantly and forever every process for planning, production and service. Improved quality and productivity and constantly decreased costs are the goals of the process.

Today, elements of Deming's philosophy are widely accepted and in many instances institutionalized within industry.

Many industry reliability improvement programs incorporate Deming's continuous improvement loops whereby, "plan, do, measure and change" is the foundation for improving reliability and maintenance management.

There are numerous improvement programs available to industry. Consultants from Ernst and Young, Price Waterhouse Coopers, A. T. Kearney, Stern Stewart & Co. and others have successfully implemented improvement processes. Many improvement programs are known as the following:

- Asset Management
- Reliability Based Manufacturing
- Total Productive Maintenance
- Total Planned Quality Maintenance
- Profit Centered Maintenance
- Reliability Management
- Total Quality Management and Manufacturing Excellence
- Enterprise Asset Management

A significant number of companies within the oil and gas industry have also developed and successfully integrated their own hybrid improvement programs. Many of the hybrid improvement programs have shown marked improvement in equipment reliability and have positively impacted shareholders returns. The most successful industry organizations share a number of common threads. The common threads are not unique to the industry. However, their application to each individual organization makes the common threads unique.

Mental models of maintenance management are now giving way to change.
Industry pacesetters routinely integrate corporate business objectives and reliability efforts into aligned business strategies. The aligned strategies are evergreen in nature and aligned with short and long term business goals.

Senior managers of "world class maintenance organizations" view reliability based maintenance management as an asset. Many pacesetters view reliability based management programs as profit centers.

As with any viable asset, reliability based programs require effective and efficient management in order to be sustained.

Reliability based asset management programs require a comprehensive master plan. The master plan typically includes sufficient funding, legitimate staffing levels, suitable skill sets, purposeful training programs, technology applications, work control and finally-- specific, and measurable goals.

Managers are continuously measuring shareholders return value. The single most important element of a reliability improvement program is measurement. If an organization is charged with making significant improvements, the rule is measure, measure and measure.

Corporate managers routinely review the profit and loss column of the financial statement. However, those which have incorporated reliability management strategies into their business plans also routinely include cost reviews of maintaining corporate assets.

The cost reviews of asset management usually occur in the form of economic reviews such as Economic Value Added and Estimated Replacement Value. Other measurement reviews may include Total Cost of Ownership, Life Cycle Costing and Equipment Unreliability Cost. Whether it be the measure of Economic Value Added or Equipment Unreliability Cost, cost reviews are consistently performed to determine the effectiveness of the organization's reliability and maintenance strategy. Meaningful measurements initiate change.

Change Management

Industry leaders accept with certainty that change management is fundamental to the success of repositioning their organizations from a reactive maintenance mode to a proactive maintenance mode. Change is unavoidable in new reliability improvement programs. Ideally, change allows for measurable improvements within the organizations. Personnel in management, engineering, operations, maintenance, material management, contract labor and finally the organization's customers are all affected by the changes.

Change has become known by psychologist as the "cycle of loss." The cycle of loss can be best described as denial, anger bargaining, depression and finally acceptance.

A change management plan must take into account the cycle of loss. Change management plans require an investment of time, money and people. A successful change management plan must be conceptualized, personalized and customized to meet the benefits of the organization. Change management isn't solely top-driven or grass-roots driven. Senior management, supervisory levels, and personnel within the operating and maintenance organization all champion change.

Leadership and employees must mutually develop the change management plan. Employees have to be actively engaged in the process and understand the tangible benefits of change. The change management plan establishes the need for change, expected benefits, accounts for prevailing paradigms, work processes, personnel roles and accountabilities, and finally the time required for change to occur.

For change to occur there are three levers which can be pulled.
1. Increase the force of the enablers
2. Decrease the force of resistance
3. In some instances the combination of 1 and 2

Measuring the rate of change is paramount. Measurements affect the timing and amount of energy required for pulling the levers.

Ideally, the change management plans have measurable milestones which are utilized to compare actual progress against anticipated progress. Interventions are often brought about based measured results of the plan.

Within industry, many change management programs are typically the results of either a maintenance assessment or corporate benchmark study.

Maintenance Assessments

A growing number of corporations either internally perform or contract external resources to conduct annual maintenance assessments to determine the position of the maintenance and reliability management program. The primary focus of a maintenance assessment is to evaluate and compare the operating site's reliability and maintenance practices with known industry benchmarks or with "best in class industry practices." Secondly, the maintenance assessment will identify potential financial opportunities if reliability improvements or process changes occur.

Assessment information is typically gathered at the operating site by using a collection of predetermined data requirements and employee-input surveys.

The informational elements, site practices and management policies are included in the assessment format for review. Each topic element response is modeled by a series of questions. The responses of the questions are structured to determine the strengths and weaknesses of each topic element.

Elements which are typically reviewed:

- Work Control
- Maintenance Mission and Vision
- Change Management Plan
- Technology Applications such as vibration analysis, oil analysis, infrared imaging, Compressor and engine analysis, borescope, non-destructive testing, data collection
- Planning and Scheduling

- Use of Computerized Maintenance Management Systems
- Utilization of Reliability Centered Maintenance Analysis
- Utilization of Root Cause Failure Analysis
- Personnel Training Records
- Environmental and Safety Records and Audits
- Equipment Downtime Records
- Documentation of Vessel and Piping Inspections and results
- Technical Library including Electronic Data Systems
- Project Management including capital investments and turnaround/outage management
- Equipment Overhaul Management
- Inventory Management
- Process Optimization
- Key Performance Indicators such equipment uptime, unreliability cost, downtime, reliability, Preventive Maintenance compliance, Corrective Maintenance compliance manpower utilization, planned versus actual work completed, overtime, reactive maintenance man-hours, Predictive Maintenance value, Economic Value Added and Estimated Replacement Value for equipment
- Customer Survey Results
- Data Analysis Collection and Trending Tools

The results of maintenance assessments commonly identify a number of opportunities. These opportunities are typically improved reliability and facility optimization. In many instances, identified improvements include work processes and documentation. The resulting opportunities are ranked either in a priority matrix or pareto chart based on the identified economic benefits to be derived.

Typically, after the review process, organizations will develop an "evergreen" maintenance strategy to capture the opportunities. The strategy is evergreen in as much as the reliability strategy will be flexible to accommodate changes based on product pricing, product demand and operating requirements. Required planning takes place much like a project execution plan. The following elements are normally listed in the plan.

- Reliability Mission and Vision
- Reliability Strategies and Tactics
- Reliability Centered Analysis Reviews and schedules
- Root Cause Failure Analysis Reviews and schedules
- Required Resources
- Training requirements
- Procurement and installation of technology applications
- Inspection Schedules for piping and vessels
- Selection of Performance measures (Key Performance Indicators)
- Work Control plans and documentation
- Drawings
- Outage plans

- Timeline for the plan of execution

The development of maintenance strategy tactics is essential to the success of the improvement plan. Tactics are developed to include work processes, tools, technology applications and personnel. For instance, tactics may include alignment of roles and accountabilities of the operating staff. In other instances roles and responsibilities are clearly detined for contract support staffing particularly where contract support is essential for daily operations. In some organizations, contract organizations are actively involved in the planning of tactics. Other items of concern are also often developed during the strategy planning to manage or improve alliance agreements or Quality Control plans for the procurement of materials and equipment repairs.

Maintenance assessments commonly identify equipment reliability analysis tools used to develop the scope of reliability and maintenance care for equipment. The most popular reliability tool is Reliability Centered Maintenance.

Reliability Centered Maintenance Analysis is proactively utilized in a vast majority of reliability improvement plans. Reliability Centered Maintenance (RCM) was developed originally for the wide bodied 747 jets in the late 1960's. Reliability Centered Maintenance is proactive in nature. RCM addresses potential equipment failures before they actually occur.

Reliability Centered Maintenance provides an analytical approach to potential equipment failures known as Failure Modes Effects Criticality Analysis. The analysis provides the user with an in-depth review of equipment criticality, failure probability, and failure consequence.

The analysis is structured to assist maintenance personnel in determining the maintenance tasks, task frequency and tactics to economically maintain equipment at prescribed reliability, safety and environmental goals.

One of the many benefits provided by performing RCM analysis is maintenance cost reduction. John Moubray, author of Reliability Centered Maintenance RCM II reports that potential savings of 30%-40% in maintenance expense can occur if the results of the Reliability Centered Maintenance analysis are fully implemented. Industry case studies substantiate savings of 30% and greater on annual maintenance expenditures.

Since its development Reliability Centered Maintenance has been sucessfully implemented in all industries. The use of Reliability Centered Maintenance in the oil and gas industry began a number of years ago. The methodolgy is actively utilized for onshore and offshore gas and oil production and product transportation.

Many oil and gas producers routinely utilize the classical approach to Reliability Centered Maintenance. However, many industry users have also actively developed and streamlined their own versions of the RCM methodology. The streamlined versions allow the user to analyze multiple pieces of equipment within predetermined systems. The streamlined version of Reliability Centered Maintenance has proven to be very beneficial in time and expense.

The Electric Power Research Institute (EPRI) in the 1980's developed the Streamlined Reliability Centered Maintenance Analysis for use in fossil fuel plants. The plan called for a streamlined approach, which captures the major benefits of Reliability Centered Maintenance with far less resources being consumed. EPRI's streamlined version produced very promising results for electric power generating plants.

Another useful tool to analyze sporadic **or** chronic failures is Root Cause Failure Analysis (RCFA). Root Cause Failure Analysis is used extensively in all industries. Root Cause Failure Analysis is reactive in nature. The Root Cause Failure Analysis is primarily utilized after a failure event. However, if acted upon, the resulting recommendations of a Root Cause Failure Analysis can be utilized proactively to eliminate undesired events.

There are a number of variations of Root Cause Failure Analysis. One variation of Root Cause Failure Analysis identifies not only the root cause but the analysis also identifies the human root cause and the latent root cause. This particular analysis is extremely helpful in identifying the human root cause and the latent deficiencies in work processes and policies.

Industry studies indicate a vast majority of failures are human induced and in many instances undesired events occur due to the absence of adequate procedures and governing policies.

There are also other variations of Root Cause Analysis, which can be utilized proactively before a failure event. One well-known process is known **as** the positive tree process. For instance, the National Aeronautics and Space Administration uses positive tree diagrams to prevent design oversights in the manned space flights and within industry many organizations use the fault tree analysis in Change Management programs.

Root Cause Failure Analysis is used to methodically investigate a failure event and determine the root cause of the failure. The failure investigation is conducted much like a homicide investigation. Evidence is gathered from many sources. Each piece **of** evidence is thoroughly examined for its value in determining and supporting **a** failure hypothesis.

In the vast majority of failures, the root cause can be identified. However, there are some instances where the investigation team is unable to positively determine the root cause. In these cases, a degree of certainty will **be** assigned to one or more probable root cause.

Subsequent recommendations are complied and submitted for management review. Reviews typically occur with a cross section of personnel who determine the priority of the recommendations and commit the required resources to implement the recommendations. The most successful Root Cause Failure Analysis programs incorporate a tracking process to document and measure the value of the recommendations.

Practitioners of Root Cause Failure Analysis indicate returns on investment of over 500%.

Industry best practices include documenting the results of the Reliability Centered Analysis and Root Cause Failure Analysis in a computerized maintenance management system for future referral and management.

Computerized Maintenance Management Systems

Most successful maintenance organizations recognize the Computerized Maintenance Management System **as** being the one of the key building blocks of any successful reliability improvement program. The computerized maintenance management system is designed to be the central repository for all maintenance procedures, analysis activities and repair documentation. The system provides the user with the capability to control work and to document all required maintenance activities. Most systems have the capability to schedule labor and materials, procure materials, track inventory and provide performance reports.

Many computerized management systems independently provide financial data or can **be** directly tied to independent financial packages.

High performing maintenance organizations recognize the full capabilities of a computerized system can not be fully realized until work control is implemented. Additionally, it is clearly understood that poor work processes will not improve data collection and trending within a computerized maintenance management system. In most instances, a computerized maintenance management system will force an organization to improve its work processes.

Work control is the key competitive edge for many best in class reliability organizations.
Planning and scheduling provides industry accepted work controls. Planning and scheduling also provides high performing maintenance organizations with quality work standards and governing policies. Quality standards and policies provide the cohesive element for the maintenance tactical plan. Reliability improvement hinges on quality. If quality is not demanded, embarking on a reliability improvement program is meaningless.

John Dixon Campbell, of Price Waterhouse Coopers indicates a **20%** increase of **MTBF** resulting **from** a successful implementation of CMMS can be achieved. Additionally, the effective use of a CMMS often can mean savings of ***5%*** to 15% of total maintenance cost. Other industry recognized consultants indicate a well managed planning and scheduling process can reduce 20% to 30% of the time to complete the job. Additionally, the results of a well managed planning and scheduling process will produce higher quality results with *30%-50%* fewer people and expenses.

Many high performing maintenance organizations practice the policy of only performing "value added maintenance." The strategy is to simply use maintenance resources only on tasks where monetary value supplements the business strategy.

Work control of maintenance activities begins when corrective maintenance work requests are initiated. Many best in class maintenance organizations utilize a methodology called rank in maintenance expense for determining the priority of maintenance activities. Work requests are typically reviewed and prioritized based on equipment criticality and operational requirements. Additionally, many organizations also include profit calculations into the final equation.

During the review process, many work requests are purged from the system because the request provides little or no value to the organization. In many instances, work request screening and subsequent purging can result in reducing the number of requests by 20%-30%.
The remaining work requests become work orders that are formally planned and scheduled. The final outcome of the process includes a list of prioritized work orders based on profit criteria rather than perceived needs. The list of work is then planned and scheduled based on priorities and operational opportunities.

An industry norm of the planning and scheduling typically conforms to a six or seven step process.

1. Identify work by work request
2. Prioritize or purge work request
3. Plan work order
4. Assign work order
5. Schedule work
6. Execute the work
7. Analysis of the completed work

All corrective maintenance and specified preventive activities which require labor, tools, transportation materials and equipment downtime are proactively planned in advance to eliminate waste and to accommodate maintenance activities during windows of opportunity. In most instances this occurs when production equipment is taken out of service.

Effective planning and scheduling encourages effective communication. One of the planner/scheduler's roles is to effectively communicate with production department personnel. In most cases, the planner/scheduler and production personnel will review methods to eliminate unnecessary equipment downtime during maintenance activities.

Another recognized benefit work control provides, is the process of planning and scheduling predictive and preventive maintenance activities. Effective planning and scheduling will insure maintenance activities, which were developed during the Reliability Centered Maintenance Analysis are completed per the tactical strategy plan. This step includes the activity frequency whether it is calendar or runtime based and who performs the task, whether onsite personnel or contract service providers.

If the organization over maintains equipment, unnecessary resources are wasted. If the maintenance activity is not performed per the plan frequency, the discovery of a failure in progress may go undetected. If the failure occurs without warning, the maintenance repair activity may result in reactive activities occurring. It is of significant importance that all preventive maintenance activities are executed per the plan.

Technologies

Throughout industry, technology is impacting the speed, quality and the effectiveness of reliability and maintenance management.
In the **book** entitled Business at the Speed of Thought, by Bill Gates, CEO of the Microsoft Corporation, he proposes a twelve- step approach that will enable companies to use digital tools to reinvent the way people competitively work.

Many reliability and maintenance organizations have developed their strategy for competing with technology tools. Their strategies often include budgeting for the purchase of new or updating existing equipment.

Technology applications have provided quantum leaps to the reliability and maintenance professionals. Technology has moved many maintenance organizations from the least desired state of reactive maintenance management to the most desired state of proactive reliability based maintenance.

Advanced technologies are being introduced to the industry on almost a daily basis.
For instance, communication links through cell phones, computers, Internet connections and palm computing applications are fast becoming common maintenance tools within the industry. For many reliability organizations, technology and its effective utilization serves as a competitive advantage. In many instances, effective uses of technology may be the difference between winning and losing to your competitor.

Honeywell developed the “heads up” technologies for the pilots in the
United States Army attack helicopter units. The availability of this technology to the industry has allowed maintenance organizations to cost effectively apply the same technology while working or overhauling process equipment. Operations personnel also have the same ability to use the technology for process data collection and comparison. In both examples personnel have the ability to access information such as drawings, procedures and process data.

Moreover, equipment expert systems or equipment health managers are in use throughout industry. The expert systems automatically collect maintenance and operations data from numerous databases or data points while providing guidance for decision making to industry reliability and maintenance professionals. In many instances, expert systems automatically initiate work request based on rule based inputs.

Many maintenance organizations have installed inexpensive fixed vibration monitoring systems. The systems capture data at almost real time allowing maintenance organizations to remotely access the data resulting in quicker decision making for equipment repairs and reduced travel time to locations.

Many corporations utilize popular hand held computing tools to effectively collect or receive data. Bar coding is very popular in warehouse and inventory management sites. Bar code technology is widely applied throughout industry. Inexpensive bar coding technology has become an excellent tool for capturing equipment or process data where traditional data gathering systems are too expensive to install and maintain.

Commonly found technology applications in high performing reliability and maintenance management programs include, but are not limited to, the following technologies.

- vibration analysis
- used oil analysis
- infrared imaging
- borescope
- bar coding and automatic data collection
- electronic measurement
- electric motor and component testing
- laser alignment
- non destructive testing
- precision balancing
- steam trap monitoring
- compressor and engine analysis
- expert systems
- neural networks

Industry surveys indicate advanced technologies provide substantial returns for the user. There are many industry case studies that further document savings. These case studies are easily accessible in industry publications or on Internet web sites.

- Return on investments ranging from **4** to 30 times, with a median return of 11 times program cost.
- Reduction of maintenance cost ranging from **7** percent to sixty percent with a median of **27** percent
- Productivity gains ranging from 2 percent to 40 percent with a median of **21** percent
- **40** percent reduction in unscheduled downtime with a median ranging from 33 percent to **45** percent
- **74** percent of equipment breakdowns eliminated with a median range of 50 percent to 98 percent
- additional savings in parts and spare inventories and power consumption

Key Performance Indicators

Key Performance Indicators (KPI) are widely accepted benchmark standards within industry. High performing or best in class maintenance organizations routinely utilize key performance indicators to determine the state of their reliability and maintenance programs. The results of the measurements drive the reliability programs.

The most successful industry reliability programs routinely measure the results of their strategies. Reliability measurements are typically aligned with key business goals. For example, critical equipment uptime may be a significant factor of financial success.

Common industry key performance indicators include:

- Equipment Reliability
- Equipment Downtime
- Equipment Availability
- Equipment UN-reliability
- Equipment Utilization
- Schedule Compliance
- PM Compliance
- Work Backlog in man-hours
- Percent of Reactive Maintenance Activities
- Percent of Corrective Maintenance Activities
- Inventory Stock Turns
- Economic Value Added
- Overall Equipment Effectiveness
- Ratio of Supervision Support to Personnel
- Percent of Emergency Maintenance
- Productivity Performance

A point to remember when improving reliability and maintenance performance is,
"What gets measured, gets managed, and what gets managed gets improved."

Knowledge Management

John Moubray, author of Reliability Centered Maintenance II indicates maintenance concepts currently exist in a third generation of development. Moubray describes third generation maintenance as higher plant availability and reliability, greater safety, longer equipment life and finally greater cost effectiveness.

However, because of the rapid development of information management systems, the Internet and predictive technologies, reliability based maintenance management has entered into a fourth generation.

Although industry has been involved in the information age for about thirty years, many corporate managers readily accepted the absence of timely information as a given for most situations.

Today, competitive industries require rapid information retrieval and dissemination. The absence of information is totally unacceptable. Moreover, many successful corporations have turned to mining nuggets of data. Many recognize the implications of data gathering, analysis and trending. For many, data will become the single most powerful source of competitive advantage.

Bill Gates, Chief Executive Officer of the Microsoft Corporation, has stated that business will change more in the next ten years than it has over the last fifty years.
He further comments that the 1980's were defined by quality initiatives, the 1990's were defined by re-engineering and the 2000's will be defined by velocity.

Honeywell is likely the largest supplier of software tools for knowledge management and reliability management within the oil and gas industries. Others include Fisher Rosemount and Provox.

Within the retail market, large corporations continue to make large investments in knowledge based information systems. The most successful retailers utilize knowledge information to either surpass or close the gap between their competitors.

When comparing sizes of knowledge based information databases, Wal-Mart retail stores are second only to the United States government. Wal-Mart has long realized the value of information and has created a process to utilize the knowledge to its competitive advantage.

Amazon Books also utilizes knowledge based information systems to individually profile the buying habits of it customers. Profiling customers gives Amazon Books a distinct advantage over its competitors.

As early as 1969, Peter Drucker suggested that workers of the future would become "knowledge workers." Drucker defined the knowledge worker as a person who has formal education but may need manual dexterity skills to perform the job.

The traditional role of maintenance personnel has changed. Maintenance personnel are now more responsive to equipment needs due to knowledge networks. Reliability and maintenance personnel rely upon knowledge networks to assist in making more informed business decisions. Their decisions affect equipment downtime, repair cost, inventory management and revenue.

For instance, HSB Reliability Technologies, a division of Hartford Steam Boiler utilizes the Internet to further develop an industrial equipment reliability database for subscriber companies.

Subscriber companies use the database for entering data via the Internet and for benchmarking equipment reliability. The database also affords the subscriber companies the ability to purchase solution tools for implementing and managing corporate reliability strategies.

Machinery Information Management Open Systems Alliance (MIMOSA) is a non- profit organization, which advocates an open exchange of information. A MIMOSA open system allows for automatic communication and transfer of data between multiple equipment software packages without proprietary or supplier specific interface protocols. Corporate technology providers such as Computational Systems Inc. sponsor the organization, Entek IRD International, Predict/ DLI, **SKF,** Siemens **AG,** Erlangen and others.

Knowledge based decisions will undoubtedly become very profitable for those in industry that adapt to change. Information management and technology solutions are the next industrial revolution for maintenance management.

Conclusion

The **2** 1st Century will continue to present challenges to the oil and gas industry.
In order for the oil and gas producers to successfully compete in the future, producers **will** have to adopt many of the common threads of Reliability Based Asset Management.

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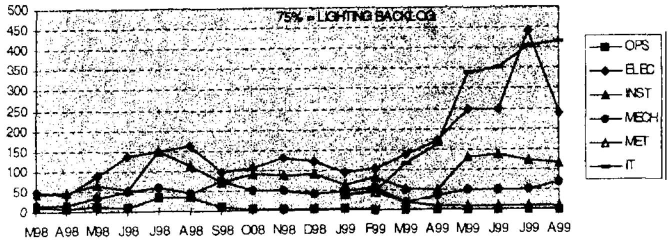

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Figure 1 - Manhours Backlog - Corrective Maintenance

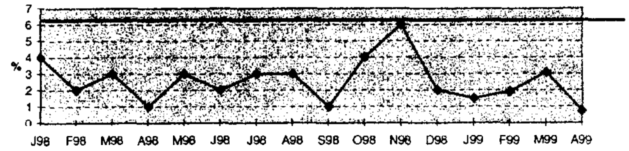

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Figure 2 - % of No. unplanned jobs v No. of planned jobs
Target = <5%

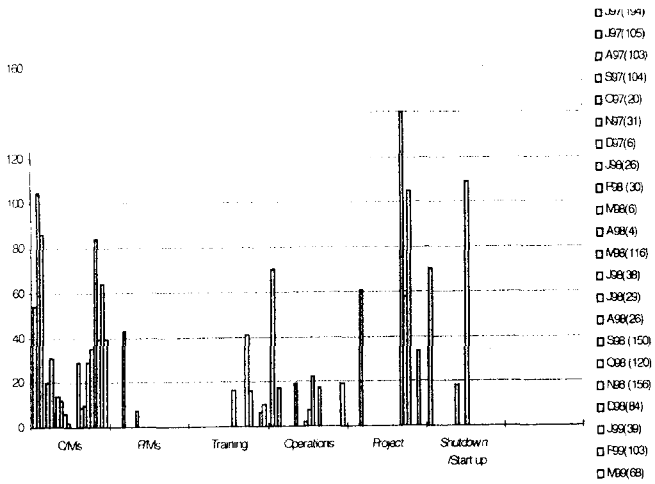

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Figure 3 - Overtime Hours -
Dayshift Maintenance Personnel

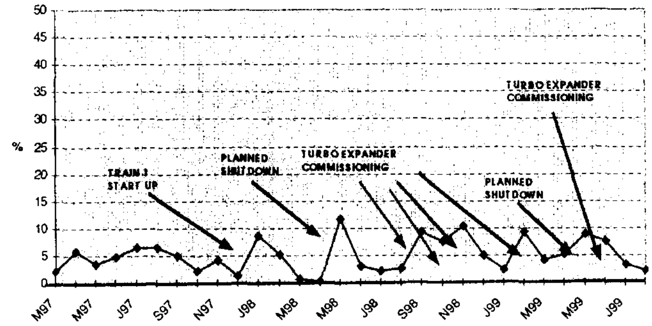

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Figure 4 - Dayshift Maintenance Overtime
Target <5%

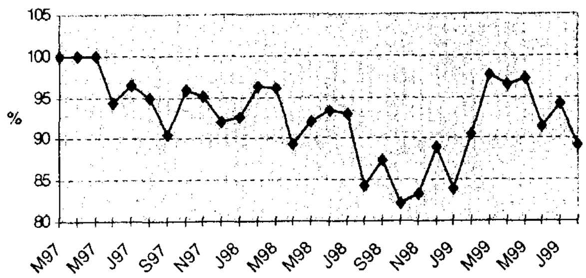

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Figure 5 - % of PM WOs completed
within time specified priority
(PM compliance) - Target =100%

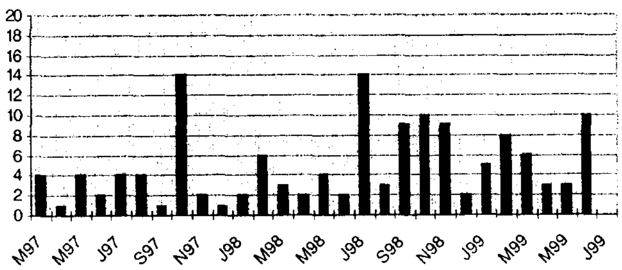

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Figure 6 - No. of Sub WOs (CM)
generated from PM WOs

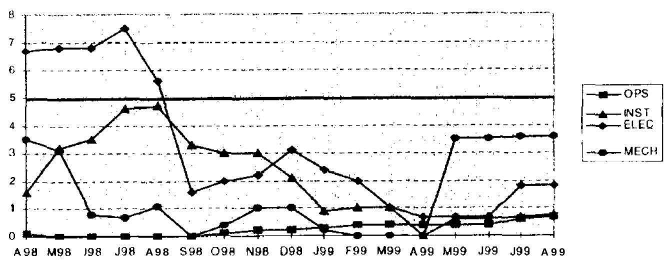

Figure 7 - % of PM Backlog Manhours v Total PM Hours