

# **A Study of the MRO Supply Chain for Paper Mills**

## Final Research Report

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## ABSTRACT

The primary objective of our research was to study and understand the key characteristics of the portion of the supply chain focused on maintenance, repair, and operating supplies (MRO) for paper mills. More specifically, in the context of the MRO supply chain for paper mills, our goals were: 1) to develop an understanding of current practices including the challenges of integrating supply chains across organizations; 2) to gather information on the primary drivers of supply chain performance 3) to identify areas providing opportunities to improve the effectiveness and efficiency of the supply chains; and 4) to identify specific initiatives to improve supply chain performance.

To achieve the above goals, we collected data from field site visits as well as a comprehensive mail survey. The site visits provided valuable insights that enabled us to understand current MRO supply chain practices. Moreover, the site visits helped us to hone in on the appropriate measures of supply chain performance and the primary drivers of MRO supply chain performance. With much effort, we have collected a limited number of responses from the survey. It is not as big a sample as we would hope, however, it gives us a statistical foundation to glean insights from the survey and field data on several important dimensions.

In general and based on this research, we see promising trends for the management of the MRO supply chain in the paper and pulp industry. One key insight we have is that firms are both reducing the number of suppliers *and* increasing contract length. It is interesting that, at this time, we do not find strong evidence of close buyer-supplier relationships. However, we expect that the reduction in suppliers and lengthening of contracts will, in the near future, lead to closer buyer-supplier relationships. For example, using IT system linkages, we expect to see better information exchange between the paper mills and their suppliers regarding inventory

and production schedules. As those relationships grow and supplier-buyer trust increases, it is possible that mills will consider relying more on supplier managed inventory to reduce the inventory management burden at the mill and to increase the supplier's stake at the mill.

Competitive pressure has forced paper mills to reduce costs while maintaining or improving quality and delivery reliability. Therefore, it is not surprising that procurement managers overwhelmingly responded that the three most important criteria for choosing suppliers were cost, quality, and on-time delivery. The fourth criteria, the suppliers' ability to offer solutions to a mill's problems, reflects management's recognition that changes in current MRO supply chain practices are needed.

The usage of information technology may provide an opportunity for improved performance. Paper mills follow a regular maintenance schedule and on average adhere to the schedule and budget. Moreover, the mill manager relies heavily on IT to help plan the maintenance process. In contrast, IT is not heavily used in the management of the procurement process and MRO inventory system. IT usage in these domains represents a possible opportunity for paper mills to improve efficiency and effectiveness.

## 1.0 INTRODUCTION

Firms are increasingly recognizing that the effective management of supply chains is a primary driver of value creation and long-term performance. The importance of Supply Chain Management (SCM) has emerged as a consequence of the current business environment of global competition, globalization of supply chains, short product life cycles, rapid changes in technologies, the need to provide higher levels of customer service, and the constant pressure to reduce costs and improve asset utilization. Hendricks and Singhal (2000) underscore the importance of effective SCM by empirically showing that firms pay a significant price in terms of shareholder value when supply chains do not work effectively. Their study, which is based 861 announcements of supply chain glitches (i.e., production and shipment delays), indicates that non average glitch announcements are associated with a reduction in shareholder value of \$120 million, which represents almost a 9% decrease in stock price. The economic consequences of supply chain glitches are even worse when stock price performance is examined from a quarter before the formal announcement of the glitch to a quarter after the formal announcement of the glitch. During this period, glitches are associated with an average loss in shareholder value of about 20%.

While many firms in the automotive, consumer goods, and electronics industries have exploited the value creation potential of SCM, firms in the pulp and paper industry are just beginning to recognize the vast scope of the potential opportunities that exist. McLean (1999) argues that SCM is a critical business issue in the pulp and paper industry that offers tremendous potential for improving customer satisfaction, lowering operating costs, reducing inventory investments, and improving fixed asset utilization. He indicates that current SCM approaches and initiatives in the pulp and paper industry have significant gaps in the areas of demand planning, production planning, scheduling, inventory management, and transportation and

distribution planning. However, rather than a comprehensive and systematic analysis of SCM, firms in the pulp and paper industry have reacted to competitive forces by pursuing actions that may be detrimental. For example, as a result of the fierce competitive environment, significant pressure has been placed on suppliers to cut costs. In response, some suppliers are reducing their investments in research and development, equipment upgrades, and quality improvement initiatives. Needless to say, these supplier actions may have a devastating impact on the long-term performance of the pulp and paper industry.

The supply chain of the pulp and paper industry can be segmented into the following four sub-chains: 1) fiber procurement which includes all the activities that are required to deliver wood chips to a pulp and paper mill; 2) pulp and paper manufacturing; 3) customer fulfillment which spans order taking, production, and delivering of products to customers; and 4) non-fiber procurement which includes the activities required to manage maintenance, repair, and operating (MRO) supplies.

While opportunities exist to improve all four components of the supply chain, our focus in this research was to study the MRO (or non-fiber) supply chain for paper mills. Typical MRO supplies in the paper and pulp industry include bearings, power trains, pipe valves, electrical components, lubricants, clothing (felt and wires) and office supplies. We selected the MRO portion of the supply chain as the focus of our research since many in the industry have identified this as a critical area for which very limited research has been accomplished. According to Kapoor and Gupta (1997), business specific purchases (includes MRO) account for 15% to 20% of a company's indirect purchases while indirect purchases account for roughly 24% of the company's total purchases. From discussions with Jim McNutt (2001), a paper mill spends approximately \$60 to \$80 per ton of paper on MRO supplies.

When we examined current MRO practices, we found that, in response to severe competitive forces, paper mills place substantial pressure on suppliers to

reduce costs. Instead, we suggest that paper mills consider partnering with suppliers to develop processes and products that benefit both the paper mills and the suppliers. Through working with their supplier for mechanical seals, Boise Cascade's International Falls mill realized savings over \$200,000 (Williamson, 1999). The Finnish mill, UPM-Kymmene Kuusanniemi invited their supplier, Tamfelt, to help solve paper machine problems. Through collaborative efforts, a fine bottom fabric and dense surface top fabric were introduced which enabled the mill to run the machine at its target speed and to improve the paper quality (Shaw, 2000). Thus, through the development of strong relationships with key suppliers, substantial improvements may be realized in the MRO supply chain performance.

We thought it important to examine both the hard and soft factors that drive supply chain performance. We explored how hard attributes such as existing production capacity and location, existing process technologies, investments in new technologies, and the information technology (IT) infrastructure impact SCM. Many have argued that one of the keys to increasing the effectiveness of supply chains is better utilization of information regarding supply and demand. We examined how this information is captured, analyzed, shared, and made visible in a timely manner among the various participants of the MRO supply chain for the paper mill.

On the soft side, we studied organizational issues such as the integration across various supply chain partners, collaboration among partners, sharing of information and plans, existing practices for coordination and control of the supply chains, incentives issues, performance metrics used, and how those metrics influence decisions and behaviors. Davis-Blake and Uzzi (1993) show that several factors play a role in determining the use of temporary (internal) workers and independent contractors (external), and significantly impact employee relationships. Carrillo and Gaimon (2001) demonstrate the importance of linking organizational issues to the behavior of operations managers by showing that organizations pursue different

strategies for investment in resource-based core capabilities (which includes the design and operation of a firm's supply chain) depending on their organizational structure and managerial incentives. Economic models of SCM that incorporate organizational issues have recently appeared in the literature including Fisher and Raman (1996), Cachon and Fisher (1997), Fisher (1997), Raman (1977), Lee and Whang (1998), Gavirneri, Kapuscinski and Tayur (1999), and Lee, So, and Tang (2000). While some anecdotal evidence of the impact of certain organizational practices on supply chain performance is available, limited objective evidence exists. Furthermore, little research has been done that rigorously links organizational practices in the pulp and paper industry to supply chain performance. A key objective of our research was to develop these linkages and to identify best practices based on data analysis.

Our research approach included data collected from field site visits and a comprehensive mail survey. The site visits served to develop a better understanding of the issues faced by paper mills and their associated MRO suppliers, the supply chain initiatives that are being pursued, and the impact these initiatives are likely to have on performance. The information gathered from these site visits was quite useful when we developed the mail survey, which was designed to give us a more comprehensive view of drivers of supply chain performance across the paper industry.

The purpose of the mail survey was to gather comprehensive information from a larger number of paper mills about their supply chain management practices. The survey data would facilitate a deep understanding of MRO supply chain practices. Leveraging that understanding, we would perform analysis that would enable us to recommend initiatives to improve the performance of the supply chain and to develop a baseline against which the future performance can be compared. The mail survey would have also allowed us to develop economic models to project the operational and financial benefits from supply chain management initiatives. Unfortunately, as

discussed later, the response rate to our mailed survey was not sufficient to enable us to perform a rigorous statistical analysis of the above issues. Instead, the limited response to our mailed survey was used to highlight trends seen in the data.

The next section describes our research strategy and methodology. In section, 3 we present our results and finally we conclude the paper with a summary in section 4.

## **2.0 RESEARCH STRATEGY AND METHODOLOGY**

### **2.1 OVERVIEW**

Our research employed methods, where each method was selected to best exploit the problem domain under investigation while also enabling the development of generalizable results and managerial insights. We followed a classic research approach wherein the researchers 1) gained an in-depth understanding of the phenomenon to be studied, 2) conducted an empirical and analytical investigation of the phenomenon, and 3) combined the qualitative understanding with the empirical and analytical results to advance the field's knowledge concerning that phenomenon.

Phase 1 of the study involved qualitative data gathering and analysis through field studies. Based on the field investigations, we developed a better understanding of the nature of the MRO supply chain relationships for the paper mills. These relationships provided the necessary foundation to conceptualize a framework which was the basis for a survey instrument. The survey design reflects the relationships uncovered in Phase 1 as well as state-of-the-art knowledge of supply chain management principles. This latter feature is desirable so that we may leverage our knowledge of best practice supply chain approaches in other process industry domains. Phase 2 of the study focused on data collection and the development of prescriptive recommendations to improve performance of the MRO supply chains for the paper mills.

### **2.2 PHASE 1: QUALITATIVE INFORMATION GATHERING THROUGH FIELD STUDIES**

Prior to conducting interviews, we gained a basic knowledge of the paper industry through a review of the existing academic and practitioner literature and identified and contacted three mills for case studies. We interviewed the purchasing manager, maintenance manager, buyers and maintenance schedulers at each mill to

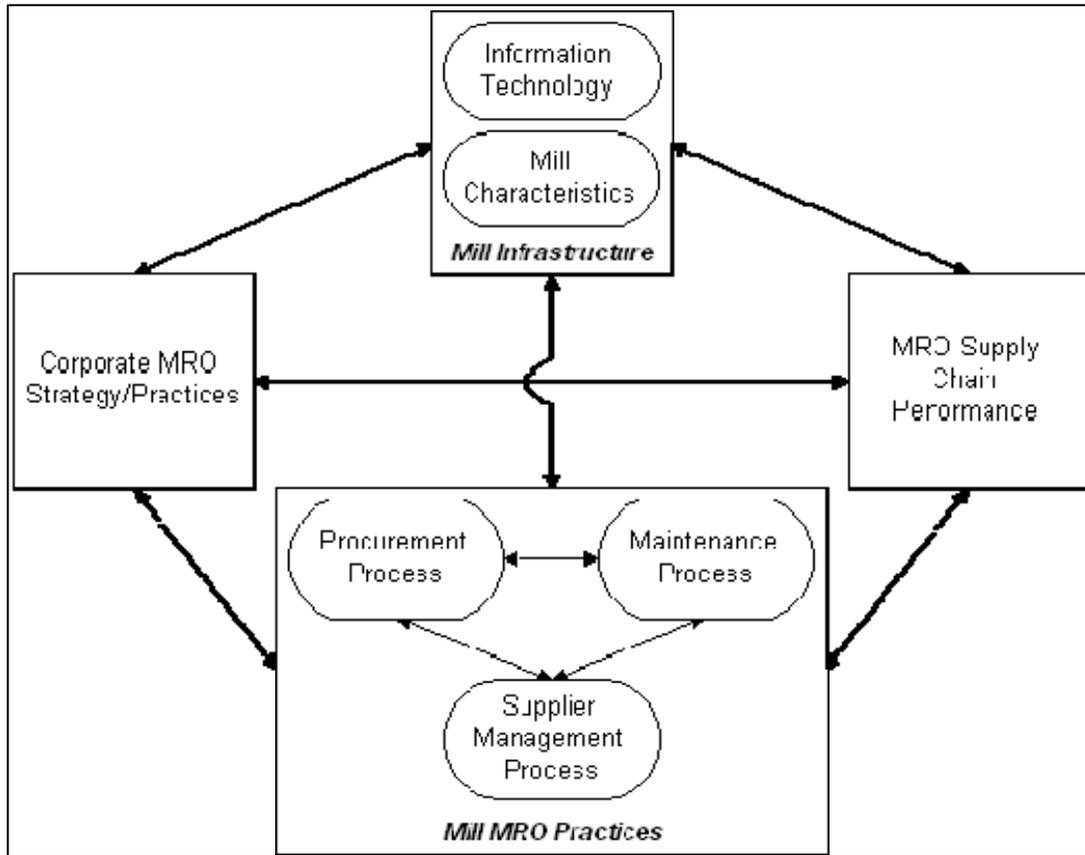
hear their perspectives on the issues involved in the MRO supply chain. Each employee was asked for key performance metrics and historical performance metric data in his area. Additionally, we asked how and how often procurement and maintenance interacted and coordinated activities, how the department forecasted demand for maintenance activities and parts, and key recent or future MRO improvement initiatives. Finally, we asked about other critical issues or challenges that hadn't been discussed yet. Through these open-ended questions we formed a general picture of industry progress to date, terminology, and critical areas for improvement for the three case study mills. Key characteristics of the mills we visited can be found in Table 1.

**Table 1 - Characteristics of Mills Visited**

Characteristic	Mill 1	Mill 2	Mill 3
<i>Age of mill</i>	Original part built in 1954	Machine 1 built in 1962	Built in 1995
<i>Number of paper machines</i>	2	3	1
<i>Number of employees</i>	~800		<50, outsourced maintenance
<i>Annual amount of paper (tons) produced</i>	~472,000 per year	1450 tons/day of kraft paper, 900 tons/day of TMP, and 760 tons/ day of market pulp	275K tons/year
<i>Amount of capital investment</i>		\$66 Million in 2002	
<i>Type of paper produced</i>	Kraft brown paper	Coated and uncoated paper, kraft paper	Linerboard
<i>Source of paper fiber (wood chips or recycled paper)</i>	Wood chips	Wood chips	Recycled paper
<i>Union or non-union maintenance employees</i>	Union		Non-union

Based on our interviews and literature search, we created four separate categories to investigate within each paper mill: corporate MRO strategy/practices, mill infrastructure, MRO supply chain performance, and mill MRO practices. Each of

the four categories affect the other categories, as shown in Figure 1.



**Figure 1 - MRO Process Influences**

To take advantage of economies of scale, some large corporations have unified MRO practices throughout the firm under the umbrella of corporate MRO strategy/practices. These corporations have standardized part usage and part descriptions, implemented national or global procurement contracts and in the process reduced supplier base and centralized major decision making to the corporate office. These actions are survey items used to measure the overall corporate MRO strategy. Decisions made in a firm's headquarters regarding MRO strategy will affect how a specific mill handles the procurement, maintenance and supplier management processes since a mill has to follow corporate policy. Therefore, we posit that corporate MRO strategy affects MRO supply chain performance.

Each mill runs a procurement, maintenance, and supplier management process, which together make up mill MRO practices. These practices define how a specific mill obtains and stores MRO items and manages the maintenance function. The collection of mill practices within a firm will influence the corporate office's MRO strategy since corporate will want to make decisions that help the mills and the company as a whole. A mill obtains MRO items through a procurement process, characterized by how MRO items are categorized, the extent of forecasting used to predict MRO requirements, the use of reorder points to maintain optimal inventory levels, and the overall value of inventory kept at the mill. These specific tasks are measured within the survey in order to give an overall picture of the procurement process.

Closely related to procurement is the supplier management process, characterized by the extent of communication process with suppliers, identification of preferred suppliers, a process to reduce supplier base, and ability to evaluate and track supplier performance. The maintenance process is characterized by the extent of planned and emergency maintenance, production and procurement input, and parts standardization and criticality sorting. All of these specific attributes of procurement, maintenance and supplier management practices combined yield a mill's MRO supply chain practices, a key influencer of supply chain performance.

Each mill has a specific infrastructure which influences strategy, specific MRO practices and supply chain performance. This infrastructure includes mill characteristics and information technology (IT). Included in mill characteristics are: overall production capacity, age and condition of equipment, whether or not a mill has union employees, and number of employees. The general category of information technology includes hardware, software, and the ability to use both to analyze data to make better decisions. Infrastructure influences strategy, practices and performance because decisions are partly based on the basic characteristics of a mill. For

example, a very small mill will have a different inventory system than a large mill, just as a mill with sophisticated information technology will manage a supply chain differently than a mill with minimal automated inventory tracking and ordering.

Finally, we look at MRO supply chain performance. We measure this through MRO and maintenance budgets, unscheduled maintenance and downtime, and MRO inventory value and turns. All of the decisions a firm makes with regard to MRO items will affect supply chain performance in some manner.

Each task in phase 1 built MRO knowledge within the paper industry. As a result of these mill visits, we came to understand the different roles played within the maintenance and purchasing groups. Because of the different roles and knowledge base within each group, it became clear that we needed to design two separate but complementary surveys to gather relevant information: one for the maintenance manager and one for the procurement (purchasing) manager.

## **2.3 PHASE 2: QUANTITATIVE DATA COLLECTION AND ANALYSIS**

The goals of this phase were to complete survey development, collect and analyze survey data, and develop recommendations and insights based on the survey analysis. To achieve this, we developed two standardized and psychometrically sound research survey instruments: one instrument is to be completed by the maintenance manager and the other by the procurement manager (see Appendix B for actual surveys). The research instruments reflect the in-depth understanding developed in Phase 1 of MRO supply chains based on site visits. Data was collected via a survey of pulp and paper mills in the US and Canada. The unit of analysis was a single pulp or paper mill.

With the help of the Center for Paper Business and Industry Studies (CPBIS) and the contacts developed in Phase 1 of the research study, an appropriate large-scale sample of papers mills and MRO suppliers were identified for administering the survey instruments. We collected data in two phases. The first phase started in August 2003 when we sent out the survey instruments, along with letters of support for this research from Paper Management Industry Association (PIMA) and CPBIS, to over 500 mills listed in the Lockwood database. Each mill received two surveys in each envelope (one survey for procurement, one for maintenance), so we sent out a total of over 1000 surveys. As an incentive for filling out the surveys, we offered a free copy of the completed report. After sending out reminder cards two weeks later, we received 12 surveys back from 10 unique mills – a 1.2% response rate.

We started a second data collection effort in January 2004, with the goal of improving the response rate. We combined the Lockwood database with two other databases from CPBIS for an updated mailing list with contacts at 709 separate mills. Instead of mailing out all of the surveys at once, we called each contact, informed him/ her of the nature of the survey and asked him/ her to fill out or help find the appropriate person to fill out the surveys. We made a maximum of two attempts to

reach each potential recipient. On the second attempt, we left a voicemail message about our research effort and mailed the surveys. Since some contacts requested we not send them a survey, a total of 616 envelopes were mailed to mills, with two surveys in each envelope for a total of 1232 surveys. From this effort, we received 27 completed surveys. Nine mills completed both the procurement and maintenance surveys, which accounts for 18 of the 27 surveys. Additionally, 5 more mills completed the procurement survey and another four mills returned the maintenance survey. All told in the second mailing, 18 unique mills returned a total of 27 surveys for a response rate of 2%.

During the two data collection efforts, we mailed 2232 surveys. We received back 39 surveys from 28 unique mills for a 2% response rate.

### 3.0 RESULTS

Our respondents come from a wide range of mill sizes and ages. Although we received responses from 28 different mills, some of those mills did not provide complete information. Hence, some of the data item averages are based on less than 28 responses. The average respondent worked at a mill with 430 employees that produced 377,000 tons of pulp and paper. The average machine age was 36 years. The average mill had nearly 22,000 MRO items on their books worth \$6.5 million. We summarize these and other descriptive statistics in Table 2.

**Table 2 Descriptive statistics for survey respondents<sup>1</sup>**

	<b>N *</b>	<b>Mean</b>	<b>Median</b>	<b>Standard Deviation</b>	<b>Range</b>
<i>Annual Production (tons)</i>	14	377,000	219,000	364,000	49,400 – 1,200,000
<i># of Employees at mill</i>	28	430	400	368	53-1750
<i>Capacity (tons)</i>	18	365,000	175,000	394,000	12,000 – 1,200,000
<i>Average machine age (years)</i>	17	36	35	17.7	9-84
<i>Capital Investment (2002)</i>	16	\$8,476,000	\$5,200,000	8,676,000	\$100,000 - \$30,000,000
<i>Operating Cost (\$/ton)</i>	12	\$362	\$285	206	\$113 - 790
<i># of MRO items in inventory</i>	17	18,860	15,000	19,880	500 – 80,000
<i>MRO inventory value</i>	19	\$5,763,000	\$4,200,000	4,872,000	\$ 7 – 20,000,000
<i>% of obsolete items in MRO inventory</i>	19	6.3%	4	5.5	0 – 20 %

\* N= Number of respondents

The results in this report focus on nine factors that we predicted would impact MRO supply chain performance. These nine factors are:

- Corporate Practice
- Supplier Management

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<sup>1</sup> Mean= average. Median= middle number, after ordering answers from highest to lowest. Standard deviation= a measure of the dispersion around the mean for all data collected. Range = lowest and highest answers.

- Criteria for MRO Suppliers
- Maintenance Activities
- MRO Inventory
- IT for Maintenance
- IT for Procurement
- IT for MRO Management
- Maintenance Performance

Each of the nine factors assesses a different lever that impacts the MRO supply chain performance. For example, the "Maintenance Activities" targeted general maintenance practices that increase preventive maintenance and maintenance effectiveness and impact maintenance costs. For each factor, we developed 6-12 specific questions which, taken together, measure the factor.

We will present each factor and the questions used to measure them, then the responses to the questions. We will present average results for each question within a factor, and then average these across questions to get the overall factor scores (as shown in the tables that follow). To give some idea about the variability in factor scores, we also present the factor score for each of the responding mills (as shown in the graphs that follow). Respondents answered questions based on the extent to which they engaged in each activity, on a 1 (None) to 5 (Very High) scale.

Since many mills answered only one survey, there are some significant gaps in the graphs. Firms numbered 1-12 answered both surveys, so for most of the graphs there are responses for firms 1-12. Firms numbered 13-20 answered the maintenance survey only and left blank all questions that appeared in the procurement survey. These unanswered questions (which appear as gaps in the graphs) include everything in Corporate Practices, Supplier Management, Criteria for Suppliers, and IT for Procurement. Similarly, firms numbered 21–29 answered the procurement survey only and did not respond to questions in the maintenance survey. These firms will have gaps in the graphs pertaining to Maintenance Activities, IT for Maintenance, and

Maintenance Performance.

Many corporate headquarters have decided to ensure corporate initiatives have a strong influence on mill practice. Therefore, we thought it valuable to examine *Corporate Practices* – the extent to which mills use the following corporate control procurement practices:

- Reduce number of MRO items
- Categorize MRO items into commodity groups
- Pursue commonality/standardization of MRO items across mills
- Use long-term corporate wide supplier contracts
- Create production schedules for all mills
- Use a centralized distribution center for MRO items

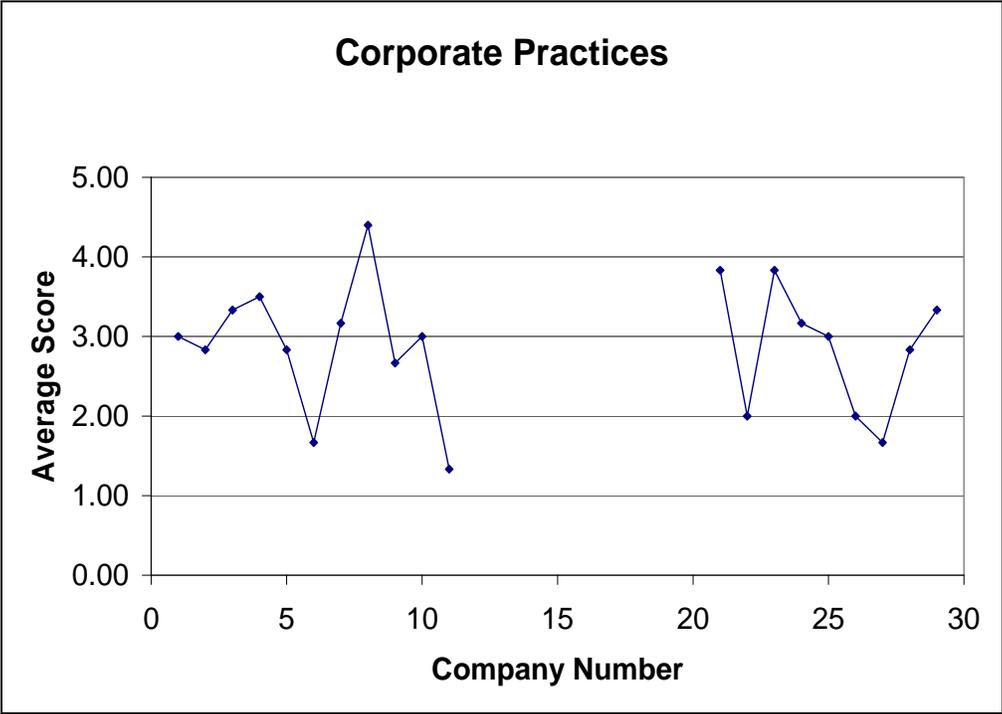
**Table 3 - Corporate Practices scores by question**

	<b>N*</b>	<b>Mean</b>	<b>Median</b>	<b>SD</b>
<b>Corporate Practices</b>				
Reduce # of MRO suppliers	20	3.35	4.00	0.88
Categorize MRO into commodity groups	20	3.20	3.50	1.24
Standardize MRO across mills	20	3.00	3.00	1.26
Use long-term contracts corporate wide supplier contracts	20	3.50	4.00	1.15
Create production schedules for all mills	19	2.21	2.00	1.23
Use centralized distribution center for MRO items	20	1.85	1.50	1.14
<i>Average Corporate Practices Score</i>	<i>20</i>	<i>2.87</i>	<i>3.00</i>	<i>0.80</i>

\* N = number of respondents, SD = standard deviation

The respondents' average overall score for corporate practices (2.87, see Table 3) suggests that corporate headquarters is not closely engaged in the MRO supply chain process of its mills. However, it is important to note that two trends exist regarding the management of MRO supply chains. First, the results in Table 3 suggest that corporate headquarters has actively reduced the number of suppliers (average score of 3.35 out of 5) that service its mills. Second, corporate headquarters has adopted long-term contracts for corporate wide suppliers. Reducing the number

of suppliers and increasing the length of supplier contracts is a key precursor for a firm interested in building strong partnerships with its suppliers. Through those partnerships, the MRO manager hopes to improve performance through improved communication problem solving. However, not many firms are pushing towards corporate headquarters controlling more mill practices, such as remote production scheduling (2.21) and use of a centralized distribution center (1.85). Figure 2 illustrates a company by company look at corporate practices. We see that there is a wide range of corporate control, from very little (company # 11) to strong corporate influence (company #8).



**Figure 2 - Corporate Practice scores by company**

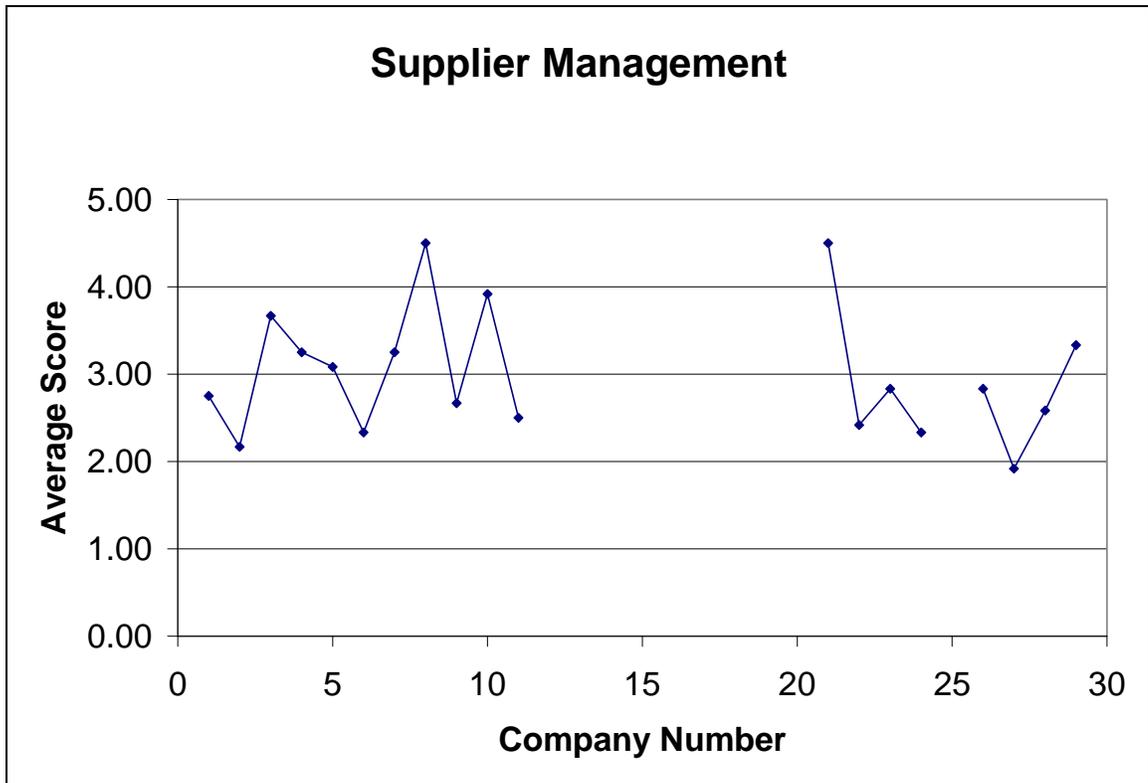
Mills develop supplier relationships over time through incentives and threats, collaboration and communication. We examine these relationships through the *Supplier Management* factor - an assessment of how each mill manages MRO suppliers using the following practices

- Use on-site MRO supplier representatives
- Use long term MRO supplier contracts
- Use single sourced contracts for MRO items
- Use preferred MRO supplier lists
- Employ supplier selection criteria
- Track and provide supplier performance feedback
- Share MRO material forecasts with suppliers
- Conduct periodic visits to MRO supplier sites
- Conduct periodic meetings with MRO suppliers at mill
- Collaborate within the firm to consolidate MRO purchase volume
- Participate in corporate MRO related decision
- Provide training for procurement/ inventory management mill personnel

**Table 4 - Supplier Management scores by question**

	<b>N*</b>	<b>Mean</b>	<b>Median</b>	<b>SD</b>
<b>Supplier Management</b>				
Use on-site supplier representatives	19	3.05	3.00	1.22
Use long-term MRO supplier contracts	19	3.11	3.00	1.15
Use single source contracts for MRO items	19	2.95	3.00	1.27
Use preferred MRO supplier lists	19	3.74	4.00	0.87
Employ supplier selection criteria	19	3.32	3.00	1.06
Track and provide supplier performance feedback	19	2.89	3.00	0.99
Share MRO material forecasts with suppliers	19	2.84	3.00	1.17
Conduct periodic visits to MRO supplier sites	19	2.26	2.00	0.87
Conduct periodic meetings with MRO suppliers at mill	19	2.95	3.00	0.91
Collaborate with other mills within firm to consolidate MRO purchase volume	19	2.63	3.00	1.16
Participate in corporate MRO-related decisions	19	3.32	3.00	1.11
Provide training for procurement mill personnel	19	2.84	3.00	1.01
<i>Average Supplier Management Score</i>	<i>19</i>	<i>2.99</i>	<i>2.83</i>	<i>0.74</i>

\* N = number of respondents, SD = standard deviation



**Figure 3 - Supplier Management scores by company**

From Table 4, we observe that the management by the mill of its suppliers is (in our rating scale) average (2.99). Specifically, mills share information with their suppliers only to a limited extent. The score of 2.84 for “share forecasts with suppliers”, 2.95 for “conduct periodic meetings with suppliers at mill” and of 2.84 for “sharing MRO material forecasts” demonstrate the relatively limited communication between the mill manager and suppliers. This lack of information sharing could be due to the recent establishment of long-term relationships through long-term contracts. As firms gain trust in their suppliers through successful partnerships, greater information sharing could lead to substantial benefits. As a mill manager entrusts more business to fewer suppliers (as seen in *Corporate Practices*), s/he will be better able to track supplier performance. During the contract interval, the information gleaned from the tracking should be shared with the supplier with the expectation of improving performance. In the long-term, information from tracking would be valuable when the mill decides whether or not to renew a contract. Our

firms do not track and provide feedback to suppliers consistently (2.89). On some dimensions, however, positive indications exist indicating recognition of the value of a strong relationship between the MRO supply chain manager and his/her suppliers. Specifically, managers are relying on-site supplier representatives in their mills (3.05) and mills are using preferred MRO supplier lists (3.74).

We look at how each capability of a supplier factors into buy/don't buy decision in *Criteria for MRO Suppliers*. We asked the procurement manager at each mill to tell us the importance of each of the following criteria when selecting suppliers from 1 (none) to 5 (very high).

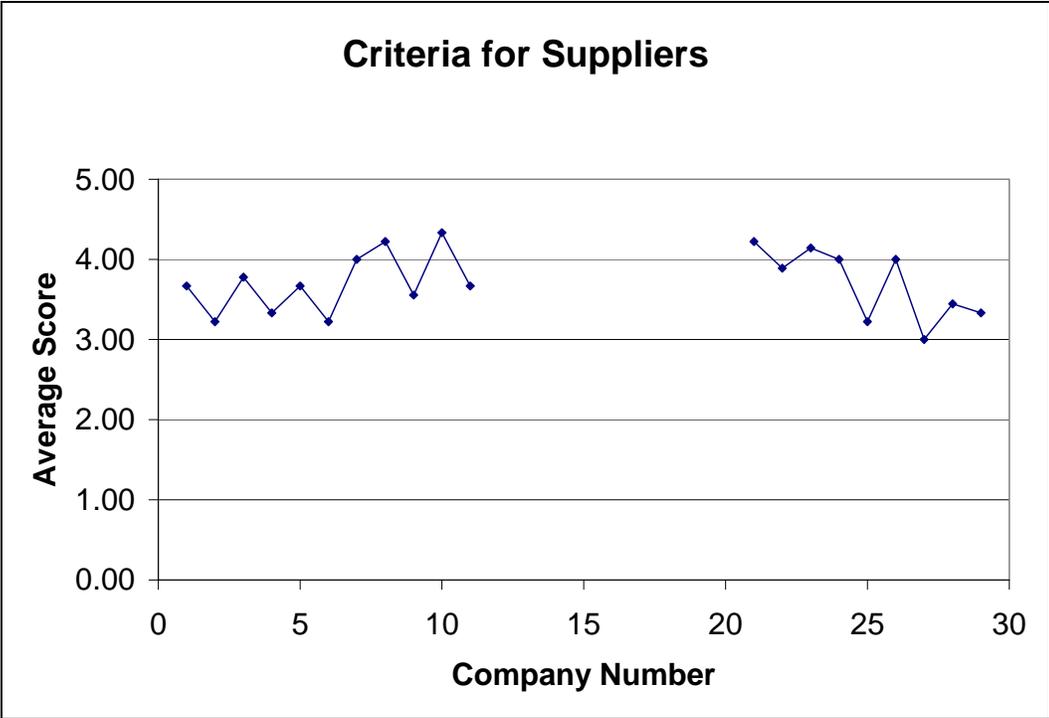
- Cost of MRO items
- Quality of MRO items
- Supplier on-time delivery performance of MRO items
- Supplier's ability to change order quantities
- Supplier's ability to change delivery lead-time
- Accessibility of MRO supplier for problem resolution
- Importance of mill purchases to MRO supplier's total sales base
- Ability of MRO supplier to provide an on-site representative
- Ability of MRO supplier to offer solutions to mill problems

**Table 5 – Criteria for Suppliers scores by question**

	<b>N*</b>	<b>Mean</b>	<b>Median</b>	<b>SD</b>
<b>Criteria for Suppliers</b>				
Cost	20	4.15	4.00	0.59
Quality	20	4.30	4.00	0.66
On-time delivery	20	4.15	4.00	0.67
Change order quantity ability	19	3.05	3.00	0.91
Change order leadtime ability	19	3.42	3.00	1.02
Supplier problem resolution	20	3.90	4.00	0.85
Importance of mill purchases to MRO supplier's total sales base	20	2.85	3.00	0.99
Ability of supplier to provide an on-site rep	20	3.40	4.00	1.05
Ability of supplier to offer solutions to problems	20	3.95	4.00	0.69
<i>Average Criteria for Suppliers Score</i>	<i>20</i>	<i>3.70</i>	<i>3.67</i>	<i>0.40</i>

\* N = number of respondents, SD = standard deviation

In general, we see from Figure 4 that responding firms are demanding high performance from their suppliers. As firms have been forced by competitive pressure to reduce costs while maintaining or improving quality and delivery reliability, it is not surprising that procurement managers overwhelmingly responded that the three most important criteria for choosing suppliers were cost (4.15), quality (4.30), and on-time delivery (4.15) (Data from Table 5). Moreover, suppliers are being expected to offer solutions to problems faced by the MRO manager (3.95). In order to offer solutions, suppliers must be willing to become involved in MRO activities at the plant level. This is more likely as mills move to long-term contracts with fewer suppliers (i.e., each contract has greater dollar value) as seen in the *Supplier Management* factor.



**Figure 4 - Criteria for Suppliers scores by company**

In general, we see from Figure 4 that responding firms are demanding high performance from their suppliers. As firms have been forced by competitive pressure to reduce costs while maintaining or improving quality and delivery reliability, it is not surprising that procurement managers overwhelmingly responded that the three most

important criteria for choosing suppliers were cost (4.15), quality (4.30), and on-time delivery (4.15) (Data from Table 5). Moreover, suppliers are being expected to offer solutions to problems faced by the MRO manager (3.95). In order to offer solutions, suppliers must be willing to become involved in MRO activities at the plant level. This is more likely as mills move to long-term contracts with fewer suppliers (i.e., each contract has greater dollar value) as seen in the *Supplier Management* factor.

The important factor, *Maintenance Activities*, assesses the extent to which a mill manages the maintenance of its equipment. General activities such as preventative maintenance and daily walk-throughs can help to prevent breakdowns from ever taking place. As a result, both the mill realizes less in repair cost (parts and labor) and mill downtime due to broken equipment. We asked maintenance managers to rate the extent to which their mill undertook each of the following practices from 1 (None) to 5 (Very High):

- Use maintenance work orders to drive planned maintenance schedule
- Schedule planned downtime
- Follow equipment manufacturer's suggested preventative maintenance schedule for planning MRO activities
- Use vibration analysis to identify needed maintenance of equipment
- Perform daily walk-through inspection of mill
- Collaborate with procurement personnel on MRO material requirements
- Collaborate with production personnel on maintenance/repair activities
- Provide training for maintenance personnel
- Participate in corporate MRO-related decisions
- Collaborate with MRO supplier on maintenance activities
- Use monitoring systems to improve process performance
- Use outsourced services for maintenance activities

- Participate in hiring process of employees at supplier for outsourced maintenance services
- Participate in performance evaluation of employees at supplier for outsourced maintenance services
- Participate in training of employees at supplier for outsourced maintenance services

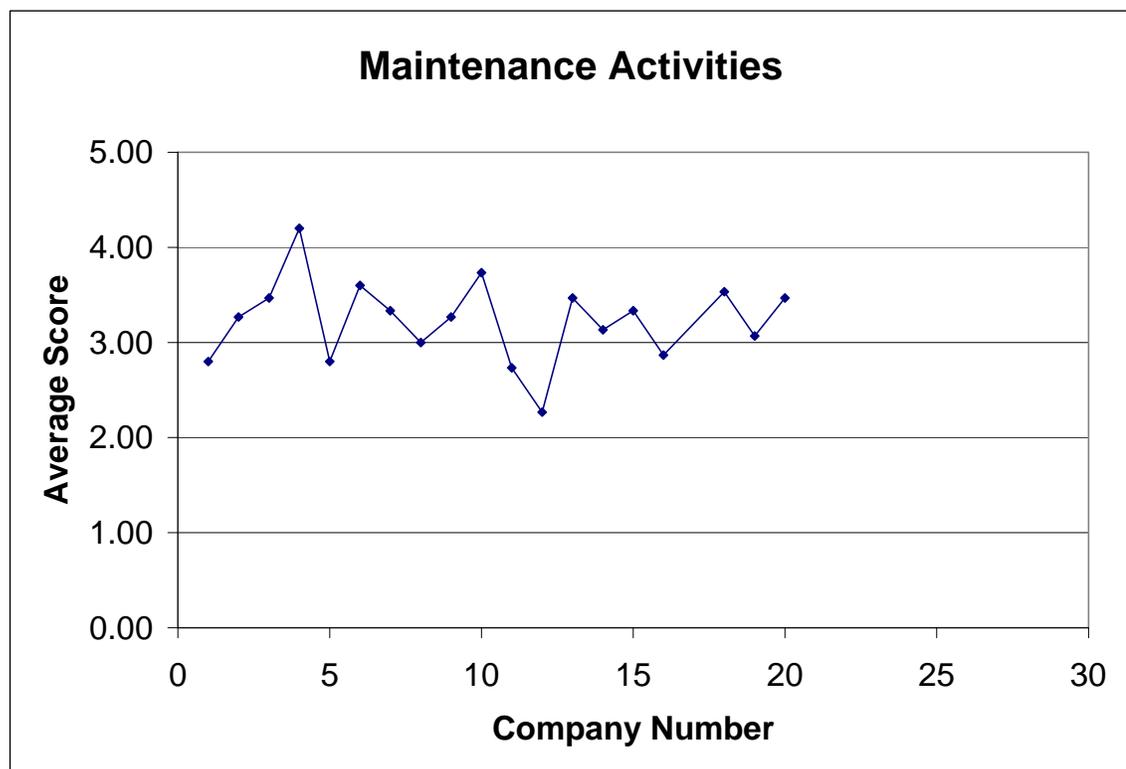
**Table 6 – Maintenance Activities scores by question**

	<b>N*</b>	<b>Mean</b>	<b>Median</b>	<b>SD</b>
<b>Maintenance Activities</b>				
Use work orders to drive planned maintenance schedule	19	4.00	4	0.75
Schedule planned downtime	19	4.47	4	0.51
Follow equipment manufacturer's suggested preventative maintenance schedule for planning MRO activities	19	3.32	3	0.82
Use vibration analysis to id needed maintenance	19	4.21	4	0.79
Daily walk thru inspection of mill	19	4.00	4	0.75
Work with procurement on MRO material requirements	19	3.58	4	0.61
Work with production on maintenance/repair activities	19	4.11	4	0.81
Provide training for maintenance personnel	19	3.32	3	0.67
Participate in corporate MRO decisions	19	2.95	3	1.03
Work with MRO suppliers on maintenance activities	19	3.16	3	0.69
Use monitoring systems to improve process performance	19	3.37	3	0.90
Use outsourced services for maintenance activities	19	2.74	3	0.81
Participate in hiring process of employees at supplier for outsourced maintenance services	19	1.74	1	1.15
Participate in performance evaluation of employees at supplier for outsourced maintenance services	19	1.84	1	1.12
Participate in training of employees at supplier for outsourced maintenance services	19	1.63	1	1.01
<i>Average Maintenance Activities Score</i>	<i>19</i>	<i>3.23</i>	<i>3.27</i>	<i>0.43</i>

\* N = number of respondents, SD = standard deviation

Table 6 indicates respondents believe their mills have strong maintenance programs, with an overall score of 3.23. Mills proactively plan for maintenance by both using work orders to drive planned maintenance schedules (4.00) and scheduling planned downtime (4.47) to work on equipment. This scheduled maintenance could be a result of regularly running diagnostics to identify needed maintenance with activities such as vibration analysis (4.21) and walk-through inspections of mill (4.00), which the mills are doing with regularity as evidenced by the high scores. The maintenance groups seem to be working well with production

personnel (4.11) to schedule these activities, but may want to increase communication with procurement (3.58) to ensure the right items are ordered at the right times for maintenance activities. Finally, some mills use outsourced services for maintenance activities (2.74). Surprising, very few of the mills that outsource maintenance participate in the hiring (1.74), evaluating (1.84), or training (1.63) of the maintenance personnel who actually working in their mills. We believe that maintenance managers would find it beneficial to play a more active role in the hiring and development of these maintenance employees who play an integral role in the maintenance process.



**Figure 5 - Maintenance Activities scores by company**

The maintenance and procurement departments both have a stake in effectively managing MRO inventory. Hence, we assess the extent to which practices for managing *MRO inventory* are used on a scale from 1(not at all) to 5 (very high):

- Plan MRO material requirements using planned maintenance work orders
- Plan MRO material requirements using supplier leadtimes

- Categorize and manage MRO items according to criticality
- Categorize and manage MRO items according to ABC classification
- Maintain MRO items as stocked inventory items
- Manage MRO items using a formal inventory control system
- Purchase MRO items on a Just In Time basis
- Use supplier managed inventory

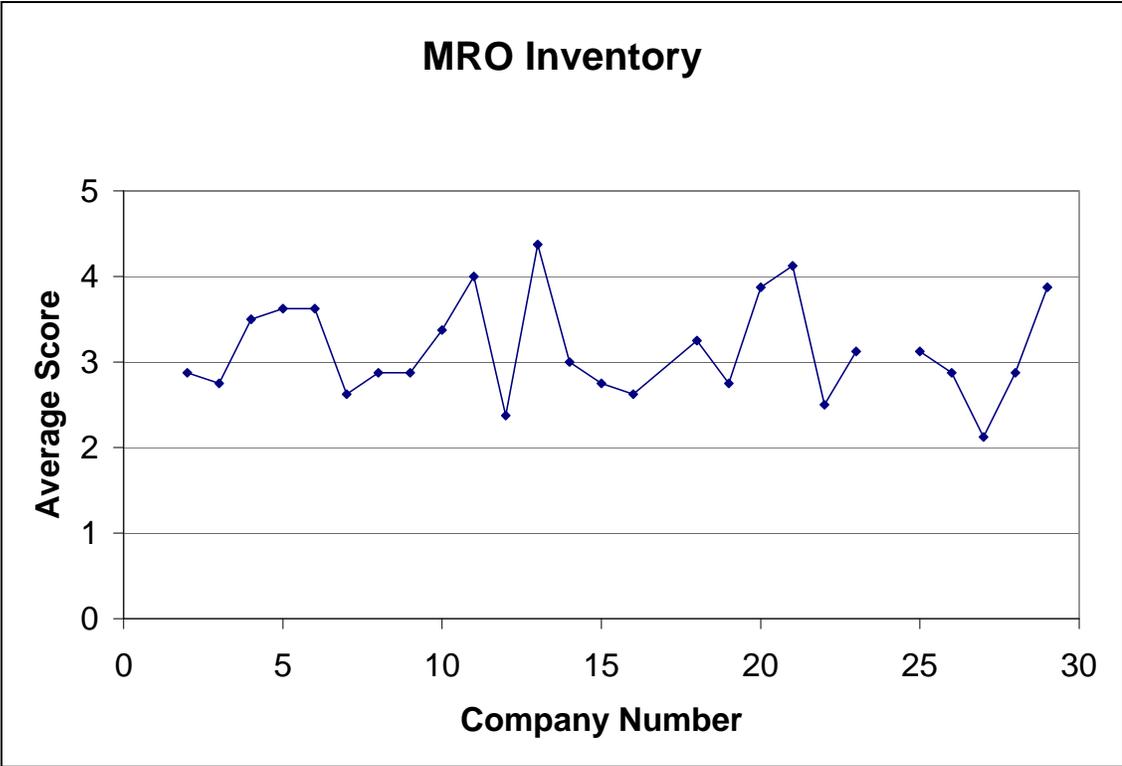
**Table 7 – MRO Inventory scores by question**

	<b>N*</b>	<b>Mean</b>	<b>Median</b>	<b>SD</b>
<b>MRO Inventory</b>				
Plan MRO material requirements using planned maintenance work orders	26	3.35	3.50	1.13
Plan MRO material requirements using supplier leadtimes	26	3.12	3.00	1.03
Categorize and manage MRO items according to criticality	26	3.62	4.00	0.80
Categorize and manage MRO items according to ABC classification	26	2.12	2.00	1.14
Maintain MRO items as stocked inventory items	26	3.54	4.00	0.76
Manage MRO items using a formal inventory control system	26	3.65	4.00	1.06
Purchase MRO on JIT basis	26	3.12	3.00	0.77
Use supplier managed inventory	26	2.65	3.00	0.89
<i>Average MRO Inventory Score</i>	26	3.14	2.94	0.58

\* N = number of respondents, SD = standard deviation

While responding mills rated their MRO inventory practices at 3.14 (Table 7), formal inventory control of MRO items is a high priority (3.65) indicating that mills know their inventory. However, the underlying processes used to sort and control this inventory could be improved. ABC sorting breaks items into three categories: A, B, and C. Items fitting into the A category are used on a daily or weekly basis, B items are used less frequently (possibly on a monthly basis or less) and C items may be used once a year or less. In contrast, criticality sorting means that a mill ranks an item as critical (1) or not (0). From our survey we observe that mills tend to use the criticality sorting more often (average score of 3.62) than ABC sorting (average score

of 2.12). However, the ABC classification allows more range in sorting for the management of inventory items and may be a tactic for MRO managers to consider.



**Figure 6 - MRO Inventory scores by company**

The 3.35 rating for “plan MRO material requirements using planned maintenance work orders” represents an area of potential improvement. Earlier, in the Maintenance Activities factor, we observed that the communication between maintenance and procurement could be strengthened. This additional result on the link between MRO material requirements and planned maintenance is another indication of a lack of communication. As discussed earlier, most of the maintenance work is planned through work orders. It would be straightforward to use those same work orders to communicate maintenance item needs. Lastly, mills use supplier managed inventory slightly less than average (2.65). Using a trusted supplier to manage inventory can reduce the burden on the mill and increase opportunities for

suppliers to provide solutions. Mills may want to consider trying supplier managed inventory.

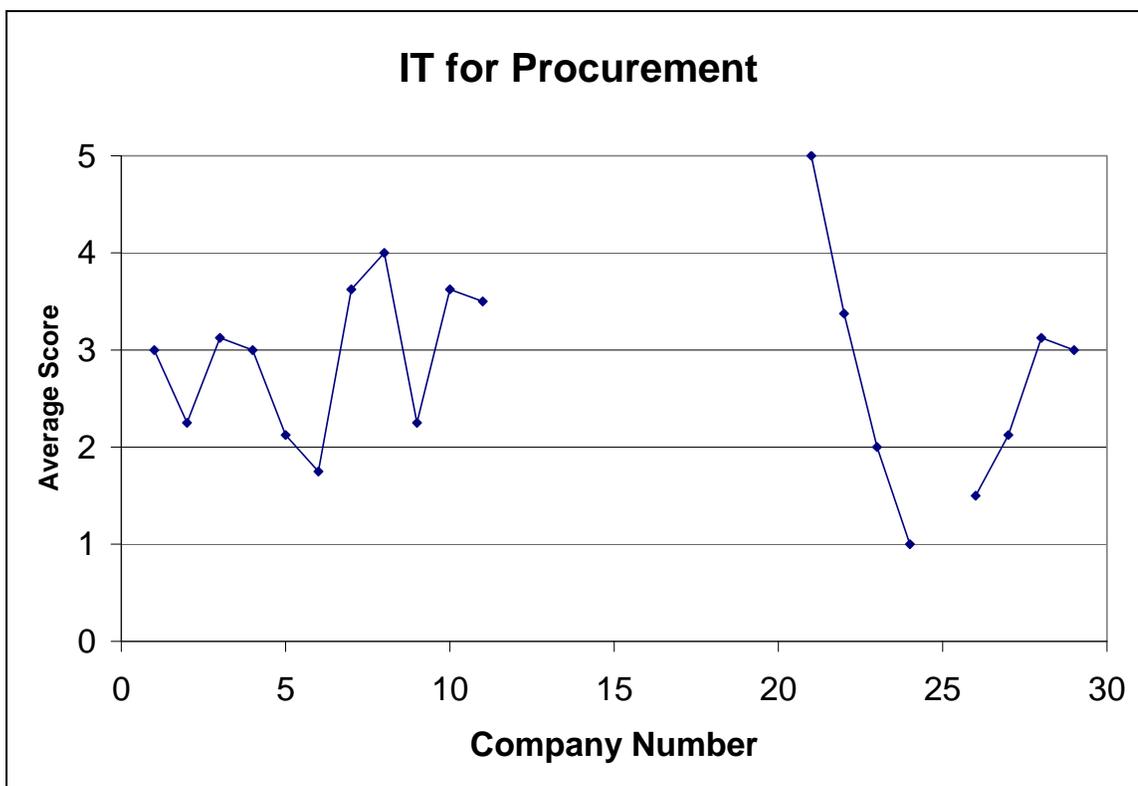
Information Technology can enable greater supplier-buyer communication, immediate notification of changes in production, paperless purchase orders, etc. We asked procurement managers the extent to which they undertook each of the following actions in our assessment of *IT for Procurement*:

- Share MRO material requirement plans with suppliers
- Share inventory status with MRO suppliers
- Send purchase orders to MRO suppliers
- Verification of MRO material transactions with supplier
- Access MRO supplier's material planning system
- Monitor MRO supplier performance
- Track MRO supplier delivery status
- Provide performance feedback to MRO suppliers

**Table 8 – IT for Procurement scores by question**

	<b>N*</b>	<b>Mean</b>	<b>Median</b>	<b>SD</b>
<b>IT for Procurement</b>				
Share MRO material requirements with suppliers	19	2.37	2.00	1.12
Share inventory status with MRO suppliers	19	2.74	3.00	1.10
Send purchase orders to MRO suppliers	19	3.53	4.00	1.26
Verification of MRO material transactions with suppliers	19	3.11	3.00	1.20
Access MRO supplier's material planning system	19	2.00	2.00	1.05
Monitor MRO supplier performance	19	2.74	3.00	1.24
Track delivery status	19	2.95	3.00	1.22
Provide performance feedback to MRO suppliers	19	3.05	3.00	1.18
<i>Average IT for Procurement Score</i>	<i>19</i>	<i>2.81</i>	<i>3.00</i>	<i>0.97</i>

\* N = number of respondents, SD = standard deviation



**Figure 7 - IT for Procurement scores by company**

While procurement groups use some IT for procurement, there remains have significant opportunity for improvement, as shown by the average score of 2.81 in Table 8. Mills have made the first step with supplier communications through information technology by sending purchase orders electronically to MRO suppliers (3.53). However, mills are behind in terms of using the more advanced forms of electronic communication such as accessing suppliers' material planning systems (2.00), tracking delivery status (2.95), and sharing material requirements with suppliers (2.37). While most respondents felt their mills were about average with respect to their usage of IT, there was one clear IT leader (firm # 21) and one clear laggard (firm #24) as evidenced in Figure 7.

In addition to enabling communication, information technology can simplify routine tasks and help to ensure that tasks are completed on schedule. We asked

maintenance managers the extent to which they undertook each of the following actions in our assessment of *IT for Maintenance*:

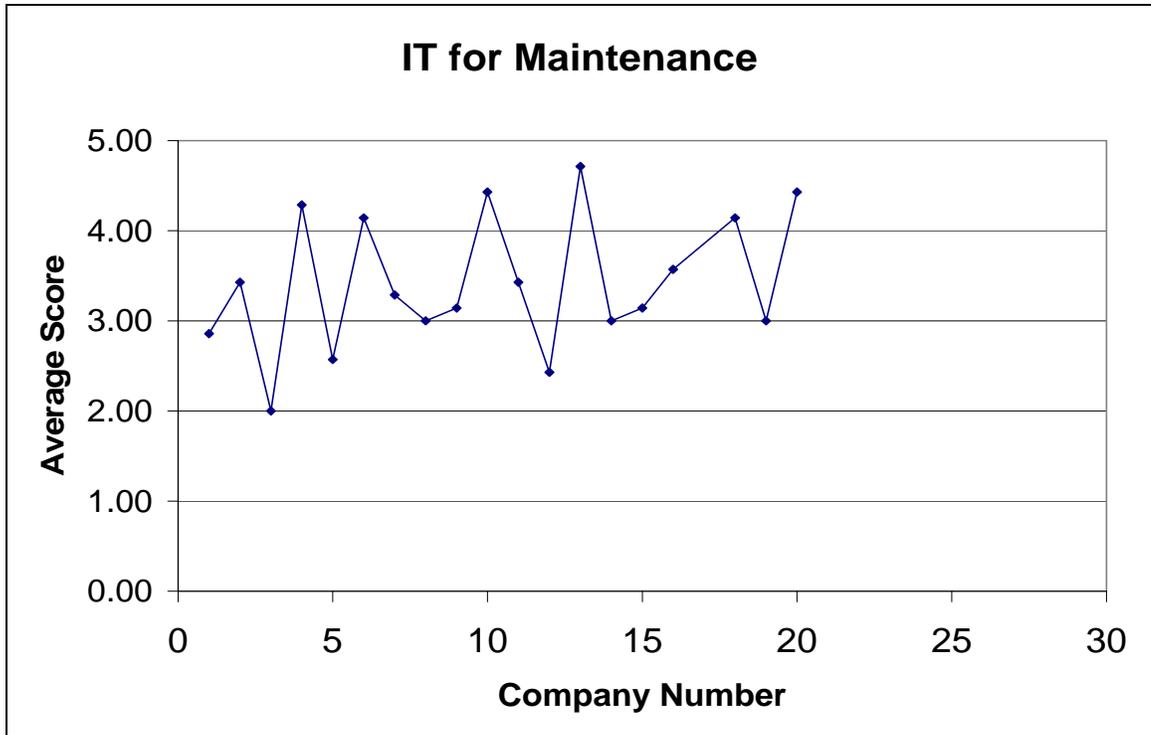
- Plan maintenance activities
- Generate maintenance work orders
- Schedule maintenance activities
- Track maintenance activities
- Monitor maintenance performance
- Increase maintenance effectiveness during planned line shutdown
- Identify opportunities to improve performance by changing MRO practices

**Table 9 – IT for Maintenance scores by question**

	<b>N*</b>	<b>Mean</b>	<b>Median</b>	<b>SD</b>
<b>IT for Maintenance</b>				
Plan maintenance activities	19	3.84	4	0.83
Generate maintenance work orders	19	3.63	4	1.01
Schedule maintenance	19	3.68	4	1.06
Track maintenance	19	3.42	3	1.02
Monitor maintenance performance	19	3.21	3	0.92
Increase maintenance effectiveness during planned shutdowns	19	3.37	3	0.96
ID opportunities to improve performance by changing MRO practices	19	2.79	3	0.85
<i>Average IT for Maintenance Score</i>	19	3.42	3.29	0.76

\*N = number of respondents, SD = standard deviation

Responding mills use IT in maintenance regularly. Specifically, participants use IT to: plan maintenance activities (3.85), schedule activities (3.65), track activities (3.35), and generate work orders (3.65), as seen in Table 9. Mills scored consistently higher using IT for maintenance than they did in using IT for procurement (see the average score in Table 9 of 3.42 versus the average score in Table 8 of 2.81). This observation could be due to the fact that maintenance is a function within the mill itself so that the maintenance IT system is fully controllable within the mill. In contrast, to use IT for procurement, the mill IT system must communicate with suppliers whose IT resides outside the mill domain.



**Figure 8 - IT for Maintenance scores by company**

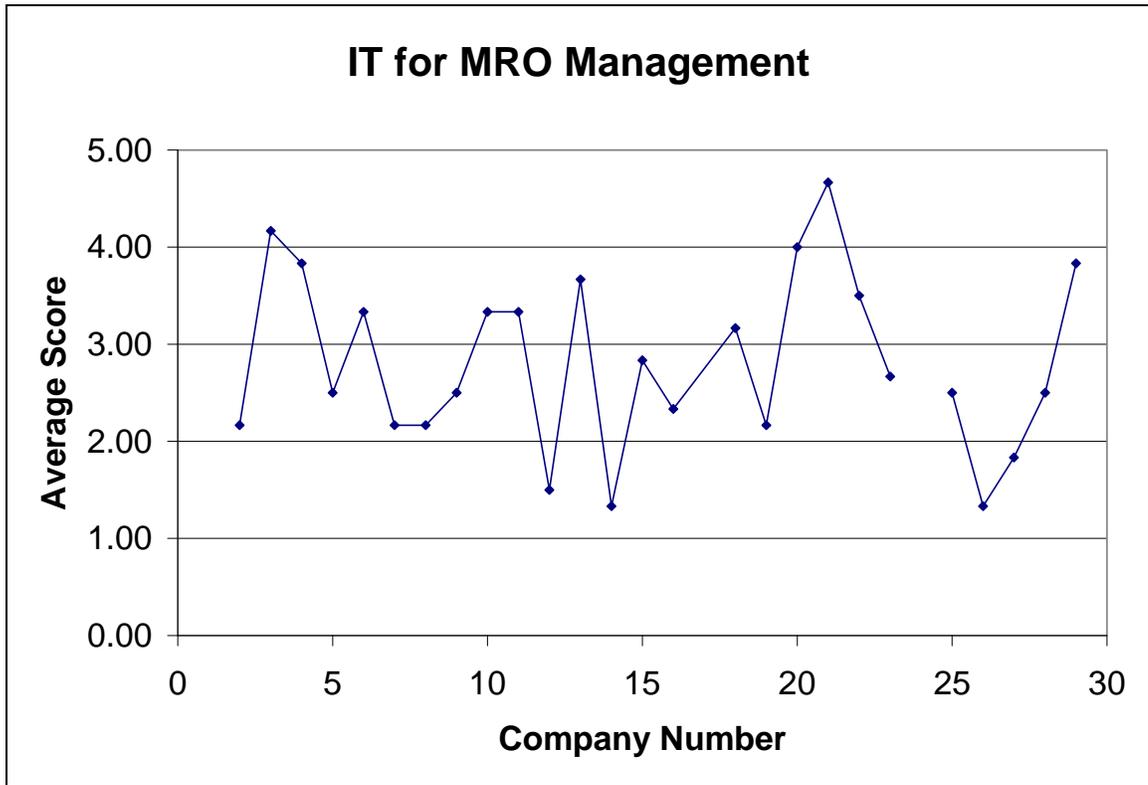
Information Technology can simplify tasks within the MRO inventory arena through tracking inventory and managing purchases. We asked both maintenance and procurement managers the extent to which they undertook each of the following actions in our assessment of *IT for MRO Management*:

- Forecast MRO inventory
- Manage purchase requisitions process
- Manage MRO inventory
- Track MRO inventory status
- Access MRO inventory data at other mills in your organization
- Coordinate corporate-wide inventory management

**Table 10 – IT for MRO Management scores by question**

	<b>N*</b>	<b>Mean</b>	<b>Median</b>	<b>SD</b>
<b>IT for MRO Management</b>				
Forecast MRO inventory	26	2.50	2.50	0.95
Manage purchase requisitions process	26	3.69	4.00	0.84
Manage MRO inventory	26	3.27	3.00	1.12
Track MRO inventory status	26	3.19	3.00	1.30
Access MRO inventory data at other mills within firm	26	2.23	2.00	1.21
Coordinate corporate wide inventory management	26	2.04	2.00	1.18
<i>Average IT for MRO Management Score</i>	26	2.82	2.58	0.90

\* N = number of respondents, SD = standard deviation



**Figure 9 - IT for MRO Management scores by company**

Firms showed a wide range of IT use in managing MRO items. As seen in Figure 9, firm #21 leads the respondents in IT use for MRO management. These mills use IT less for MRO management than for maintenance (2.82 versus 3.42, from Tables 10 and 9). Specifically, firms use IT very little for forecasting MRO inventory (2.48), accessing inventory data at other mills within a firm (2.22) or coordinating corporate wide inventory (2.00). Therefore, firms are missing the advantages offered

by IT systems that are built to support improved decision-making such as forecasting and sharing items across mills. Mills may want to consider ways to leverage the wealth of data contained within their IT systems.

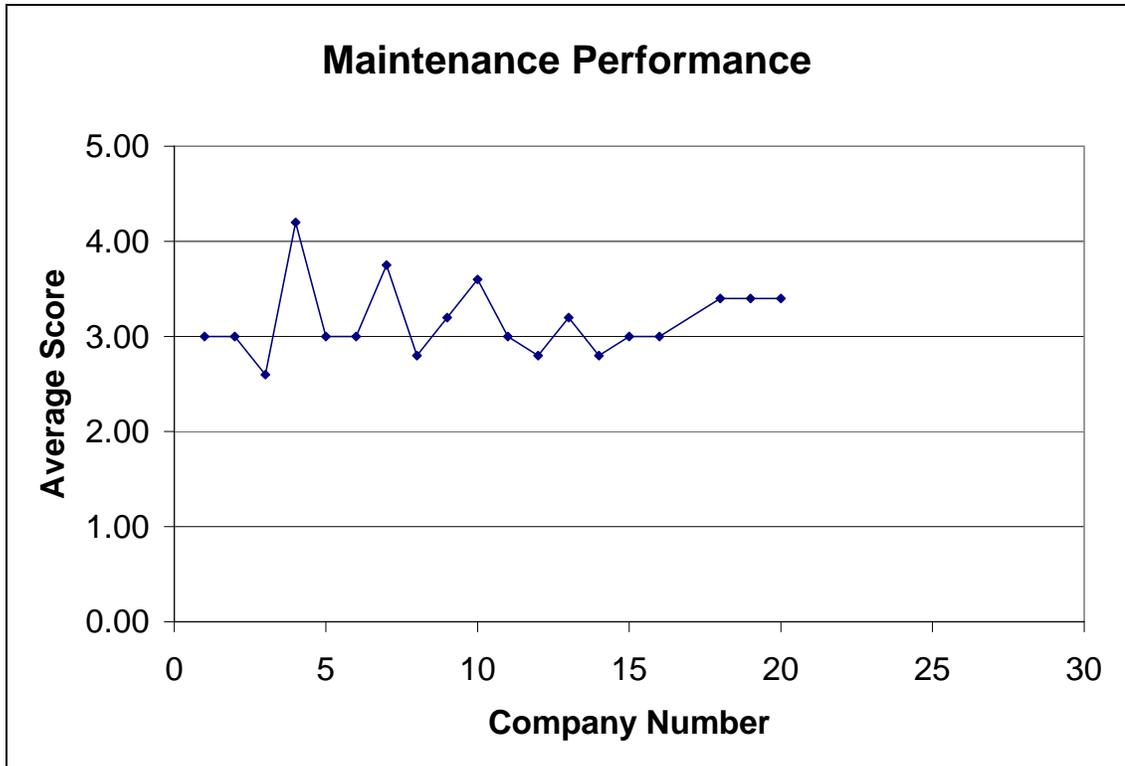
Lastly, we examined *Maintenance Performance* as measured by the following items, all measuring the mills' maintenance groups' performance, on a scale from 1 (None) to 5 (Very High):

- Adherence to planned preventative maintenance schedule
- Adherence to planned preventative maintenance budget
- Extent of unplanned repair maintenance
- Actual to budget spent for maintenance
- Extent of production downtime due to maintenance problems
- % of time that a paper line shut down due to MRO stockouts (This question was a write-in question where respondents wrote in the percentage of time that a paper line shut down due to MRO stockouts.

**Table 11 – Maintenance Performance scores by question**

	<b>N*</b>	<b>Mean</b>	<b>Median</b>	<b>SD</b>
<b>Maintenance Performance</b>				
Adherence to planned preventative maintenance schedule	19	3.58	4.00	0.61
Adherence to planned preventative maintenance budget	19	3.26	3.00	1.10
Extent of unplanned repair maintenance	19	2.74	3.00	0.93
Actual to budget spent for maintenance	19	3.58	4.00	0.77
Extent of production downtime due to maintenance problems.	18	2.61	3.00	0.78
% time line shutdown - MRO stockouts	22	0.50	0.00	1.25
<i>Average Maintenance Performance Score</i>	<i>19</i>	<i>3.17</i>	<i>3.00</i>	<i>0.39</i>

\* N = number of respondents, SD = standard deviation



**Figure 10 - Maintenance Performance scores by company**

Mills' maintenance performance results clumped mostly in the 3-4 range as shown in Figure 10, indicating that the responding firms perform similarly to their competitors. From Table 11, respondents rank themselves at 3.58 for actual to budget spent for maintenance, 3.58 for adhering to the planned maintenance schedule and 3.26 for adhering to planned maintenance budget. The firms reported that, on average, 0.5% of mill line shutdowns were due to MRO stockouts. The median measure for this same item is 0. From this we may conclude that, for over half of the responding mills, there were no line shut downs due to a MRO stockout in 2002. In conclusion, while there is always room for improvement in stocking and managing inventory, for the most part, the mills surveyed have the essential maintenance parts when they need them.

#### 4.0 SUMMARY

We see promising trends for the MRO supply chain in the paper and pulp industry. Table 12 lists the average responding mills' scores for each of the nine factors we measured. This table is a compilation of scores from Tables 3-11. Judging from these scores, we can say that responding mills' top strengths are: criteria for MRO suppliers, IT for Maintenance, and maintenance activities, as measured by our surveys.

**Table 12 - Average Scores for nine factors**

	<b>N*</b>	<b>Mean</b>	<b>Median</b>	<b>SD</b>
Average Corporate Practices Score	20	2.87	3.00	0.80
Average Supplier Management Score	19	2.99	2.83	0.74
Average Criteria for MRO Suppliers Score	20	3.70	3.67	0.40
Average Maintenance Activities Score	19	3.23	3.27	0.43
Average MRO Inventory Score	26	3.14	2.94	0.58
Average IT for Maintenance Score	19	3.42	3.29	0.76
Average IT for Procurement Score	19	2.81	3.00	0.97
Average IT for MRO Management Score	26	2.82	2.58	0.90
Average Maintenance Performance Score	19	3.17	3.00	0.39

\* N = number of respondents, SD = standard deviation

Outside of these 3 factors, there are many positive results within other factors. Within the Corporate Practices factor, we saw that firms are beginning to reduce the number of suppliers and increase contract length. This should eventually lead to closer buyer-supplier relationships, including better information sharing of inventory needs and production schedules through IT system linkups. As those relationships grow and supplier-buyer trust increases, mills may consider using more supplier managed inventory in order to reduce inventory management burden at the mill and to increase a supplier's stake at the mill.

As competitive pressures have forced firms to reduce costs while maintaining or improving quality and delivery reliability, it is not surprising that procurement managers overwhelmingly responded that the three most important criteria for choosing suppliers were cost, quality, and on-time delivery, closely followed by

suppliers' ability to offer solutions to a mill's problems. Mills follow a regular maintenance schedule and on average stick to their schedule and budget. They rely heavily on IT to help the maintenance process, but could probably improve performance by using IT more to facilitate the procurement process and MRO inventory system.

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## Appendix A

### Case Study Observations

Practices	Mill One	Mill Two	Mill Three
<b>Maintenance Process</b>			
Planned maintenance process	~30%, 2 weeks of job packets	45% of work orders with target of 75%, Maintenance is planned for at least 1 month ahead with 12 weeks of backlog job orders, Critical ranking are used when scheduling, As planned maintenance has increased, accidents have decreased	Maintenance manager and 2 engineers keep list of maintenance jobs in Excel (owner, frequency, use of crane, time to complete.etc.) Maintenance manager has 2 years of history in Excel. Maintenance is planned in Excel with 1 week look ahead. 1/3 of the jobs planned are in the backlog due to missing material.
Routine maintenance process	~50%		~33%
Emergency maintenance process	~20%		~33%
Input from production	Daily morning meetings with production, production can also create work requests		Routine meetings with production
Impact from production practices on maintenance	Maintenance work increased if production staff does not operate machine properly		Maintenance work increased if production staff does not operate machine properly
Use of criticality ranking of MRO items	1 to 5 scale used, set by production and maintenance	0/1 used with 1 indicating critical items	No formal system but currently identifying based on downtime implications, time to repair, and supplier leadtime
Coordination with procurement	Occasional meetings but not routine, phone and emails	No routine meetings so primarily phone and email, issue of accessibility to procurement people	Maintenance, procurement, and stockroom are in same department (small group)
Efforts to standardize MRO items within mill	Standardized control values, project initially started by maintenance	Yes, but primary problem is standardization is not consider in capital investment projects	Yes, when appropriate but driven by cost implications

Use of subassemblies and parts versus assemblies			Uses subassemblies and parts if there is a lower cost
Use of maintenance frequencies for jobs	Yes, initially set with consultant's help or recommendations from MRO supplier	Yes, an on-site representative assists with setting and maintaining frequencies	Yes, kept in individual excel spreadsheets
Use of preventative maintenance analysis (vibration analysis, walkthroughs)	Vibration analysis and walkthroughs	Standard walkthrough paths and instructions, sonic readings, vibration analysis, also set up 4 year apprentice program for maintenance personnel	Vibration analysis (2/month) and daily walkthroughs
Extent of outsourcing maintenance activities	\$1.17 million versus \$3.4 million actual (based on 12 month average)		All maintenance is outsourced with a supplier with whom there is a high level of coordination and interaction
Use of job packets	Contains material list, safety instructions, and technical instructions	Packets include material lists and instructions. Codes for job packets are P-Planned, B-Material available, S-Scheduled	No
<b>Procurement Process</b>	Procurement responsible for inventory	Maintenance responsible for inventory	Maintenance responsible for inventory (no procurement department)
Use of MRO item categories (commodity, critical, In-house)	Procurement identifies as standard in paper industry or non-standard. In these commodities are identified for national contracts. Maintenance identifies as stock or non-stock.	Classifications are reorder, direct, contract, consignment, and order on demand, Quotes are obtained for direct and order on demand items, no approval process for reorder point items, approval is given by maintenance	Just beginning to identify critical items
Use of forecasting MRO material requirements	2 weeks of planning for material if TSW has job packet or maintenance frequency for maintenance job, supplier leadtime for part used if in TSW	Material is planned using supplier leadtime and inventory information if maintenance work order is in MMS or frequency is set for maintenance activity	No, identification of material needs is responsibility of engineer who tracks and recommends maintenance activity
Use of reorder points	Yes, use history to maintain reorder point levels	Yes, use history to maintain reorder point levels, 20K-25K (~75% of MRO items) items on reorder	Yes, set based on previous experience. Expediting costs and usage may be used in the future

Amount of items (#,\$) in inventory versus purchased when needed

Controlled storeroom	Yes, separate building	Yes, inventory accuracy at 92% (up from 40% by limiting access and requiring all material requests be electronic using MMS)	No, currently have inventory problems which are partially due to not having 24/7 stockroom support
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**Supplier Management**

**Process**

Use of on-site supplier representative	Yes, for suppliers of bearings and motors, Created expectation document for on-site rep for motors.	Yes, with suppliers for bearings and vibration analysis, Created job description for on-site rep for vibration analysis	Maintenance engineer did work with felt supplier to assess actual felt life (service from supplier provided at no cost)
Means of communication/coordination with material suppliers	Phone for initial PO and follow-up, PO is faxed, quarterly meetings with some suppliers, no use of EDI	Phone/ fax	Phone/fax
Means of communication/coordination with service suppliers	Most are local so phone and face-to-face meetings	Phone/fax	Extensive communication/coordination with contractor for maintenance who is on-site
Identification and use of preferred suppliers	Yes, but do not use a contract	No	No
Strategy to reduce supplier base	Working to buy more MRO items from one supplier but emphasis is on having material, 80 vendors account for ~80% of spending	No, but occurred as result of national contracts	No, focus is on cost thus competition among suppliers is useful
Track/report supplier performance	TSW has information so can create reports, however reports are requested only when there is a problem, Also suppliers are requested to submit their performance reports	Do not track performance unless there is a problem. Primary metrics are price, stockouts, and delivery	No, however they will change suppliers if not satisfied with cost or delivery (may even break national contract if not satisfied)
Supplier selection criteria	ISO 9000 certification, on-time delivery, fill rates, quality, and importance of mill to supplier	Delivery performance to company mills, location, # of distribution centers, on-site rep., supplied managed inventory, and 24/7 accessibility	Cost and delivery

Vendor managed inventory	One supplier has bearings on reserve. If mill changes suppliers, then mill must buy these bearings	Purchasing moving away from vendor reserved inventory due to switching costs; however maintenance wants more consigned inventory, Maintenance is also considering a regional warehouse for MRO items common to company mills	One attempt with hardware but did not work
<b>Corporate</b>			
Efforts to standardize MRO usage across mills		No	Result of buying 3 identical paper machines from same supplier
Use of standard part descriptions and numbers across mills		Corporate directive given 2 years ago in order to identify usage and cost of commodity items	Result of buying 3 identical paper machines from same supplier
Use of national and/or global contracts	Corporate strategy for economies of scale in price negotiation, contract must project at least a 15% savings, did save \$1 million with chemical contract	Corporate directive started 3 years ago, Identified ~50 commodities, have 5-10 contracts under review at any given time, 10% cost savings and increased purchasing power; however suppliers were not as responsive at the beginning of contracts but more so towards the end of the contract	Use of national contracts was cost driven. There is 1 global contract for pressure screen baskets (50% price reduction). There are 5 national contracts for items such as bearings, starch, and felts. Contract duration is 1-3 years and can be broken due to price, quality or delivery.
Strategy to reduce supplier base	Tied to use of national contracts	No, result of national contracts	Result of national contracts
Centralized versus decentralized decision-making			Corporate emphasizes cost/ton and budget. Corporate also sets the production schedule for its US mills
Amount of participation from mill personnel in corporate decisions	Commodity teams consisting of mill personnel involved in supplier selection for contracts	Commodity teams consisting of mill personnel involved in supplier selection for contracts	Mill personnel involved in supplier selection but little input into production schedule
<b>Information Technology (extent of use)</b>		Bought MMS for \$300,000, spent \$1 million on modifications. Corporate is integrating all mills with a new system, INDUS	

Tracking MRO inventory information	TSW has on-hand, location, on-order information along with pick lists for scheduled maintenance job packets, however there is still a great deal of walk-up requests for parts at stockroom	MMS has on-hand, location, on-order information along with pick lists for scheduled maintenance job packets, and all material requests must come from MMS	MP2 has inventory and on-order information but not maintenance information. Currently working with person from Watkins to move maintenance history and information into MP2
Creating purchase requisitions	Maintenance planner creates requisition in TSW	Maintenance planner creates requisition in MMS	Anyone can create requisition in MP2 but maintenance manager has to approve it
Creating and managing purchase orders	Open requisition reports are printed daily from TSW for conversion to purchase orders	MMS has all purchase orders and information	MP2 converts approved requisitions to POs
Communication with suppliers	No IT link		No IT link
Planning MRO inventory	Only if job frequency is set or job packet is created in TSW	Only if work order is created or frequency is set in MMS	None except use of reorder points
Planning maintenance activities	Only if job frequency is set in TSW	Only if job frequency is set in TSW	Manual process using Excel and Microsoft project
Tracking maintenance activities	System tracks open or closed work order	System tracks open or closed work order	
Scheduling maintenance activities	Manual process	Manual process	Manual process using Microsoft project
Tracking performance	TSW can generate some performance reports on supplier performance and inventory, primary focus in on cost reports	MMS can generate performance reports	MP2 can generate cost reports
Sharing information among mills	No, different systems	Yes, this mill is last mill to implement INDUS system	No
<b>Mill Characteristics</b>			
Age of mill	Original part built in 1954	Machine 1 built in 1962	Built in 1995
Number of paper machines	2	3	1
Number of employees	~800		<50, outsourced maintenance
Annual amount of paper (tons) produced	~2000 tons/ day * (256-20 days shutdown) = ~472,000 per year	1450 tons/day of kraft paper, 900 tons/day of TMP, and 760 tons/ day of market pulp	275K tons/year
Amount of capital investment		\$66 Million in 2002	

Type of paper produced	Kraft brown paper	Coated and uncoated paper, kraft paper	linerboard
Source of paper fiber (wood chips or recycled paper)	Wood chips	Wood chips	Recycled paper
Union or non-union maintenance employees	Union		Non-union

**MRO Supply Chain Performance**

Extent to which performance is assessed	A number of maintenance and production measures are assessed	Procurement costs, inventory and maintenance metrics	Emphasis on cost/ton and budget
Extent to which performance is tracked	A number of maintenance and production measures are tracked for 12 months with a 12 month average	A number of maintenance metrics and cost metrics are tracked	Creates cost reports weekly and bi-weekly
Extent to which performance is used to drive practices			
Budget spent on MRO items	\$30-50 Million (5 for parts and 10-15 for services) Maintenance manager reports shows \$1.3 million per month (12 month average)	\$50 million/year (accounts for \$55/ton of paper produced)	65% of maintenance budget which is \$500,000/month (includes roll covers)
Budget spent on maintenance activities	\$3.4 million/month actual versus \$3/1 million/month (12 month average)	Do not know but currently 10-12% of maintenance budget is spent on premium overtime, also there are 10 to 12 maintenance planners	25% of maintenance budget for direct labor
Time spend in managing maintenance activities			
Budget spend on outsourced maintenance services	\$10-15 million	\$5 million	10% of maintenance budget
Amount of machine downtime due to maintenance problems	2.4% for machine 1 and .9% for machine 2 (12 month average)		Normally 3%
Amount of unscheduled maintenance	~10% per month (12 month average)		
Budget spent on expediting MRO items	Not tracked		Beginning to track
Budget spent on managing MRO inventory	11 people in the stockroom		2 people in the stockroom

MRO inventory value (\$)	\$16 million (\$1.6 million with no activity in last 10 years)	\$5 million (\$3 million in capital spare parts, \$2 million in repair parts)
MRO inventory turns	Procurement manager stated ~4 per year but report shows .48 per month	Not tracked since inventory is young, Maintenance manager did say that 1/2 moves quickly while 1/2 moves slowly
Cost/ton of paper produced	\$330 per ton (12 month average)	\$150/ton
Machine uptime (%)	97.6% for machine 1 and 99.1% for machine 2 (12 month average)	Target is 95 to 96% (includes scheduled downtime) In November, downtime was 5% of which 3% was maintenance



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If you have any questions, please contact:

Dr. Soumen Ghosh, Professor  
 DuPree College of Management  
 Georgia Institute of Technology  
 soumen.ghosh@mgt.gatech.edu

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MRO Study  
 Institute of Paper Science and Technology  
 500 10th Street, NW  
 Atlanta, GA 30318  
 or fax to 404-894-6030

Thank you in advance for your help.

Preparing business leaders for changing technological environments



In 2002, what was the approximate number of distinct MRO items in your mill? \_\_\_\_\_

At the end of 2002, what was the approximate value of your entire MRO inventory (in US \$)? \_\_\_\_\_

During 2002, to what extent did you engage in the following activities while managing your MRO inventory.

	None	Low	Average	High	Very High
Plan MRO material requirements using planned maintenance work orders	( )	( )	( )	( )	( )
Plan MRO material requirements using supplier leadtimes	( )	( )	( )	( )	( )
Categorize and manage MRO items according to criticality	( )	( )	( )	( )	( )
Categorize and manage MRO items according to ABC classification	( )	( )	( )	( )	( )
Maintain MRO items as stocked inventory items	( )	( )	( )	( )	( )
Manage MRO items using a formal inventory control system	( )	( )	( )	( )	( )
Purchase MRO items on a Just In Time basis	( )	( )	( )	( )	( )
Use supplier managed inventory	( )	( )	( )	( )	( )

Relative to your primary competitors, to what extent did you use information technology (ERP, MRP, email, EDI, internet-based or Project Management software) within your organization for MRO management?

	None	Low	Average	High	Very High
Forecast MRO inventory	( )	( )	( )	( )	( )
Manage purchase requisitions process	( )	( )	( )	( )	( )
Manage MRO inventory	( )	( )	( )	( )	( )
Track MRO inventory status	( )	( )	( )	( )	( )
Access MRO inventory data at other mills in your organization	( )	( )	( )	( )	( )
Coordinate corporate-wide inventory management	( )	( )	( )	( )	( )

Indicate MRO inventory management performance along the following dimensions:

What was your average annual MRO inventory turnover rate for 2002? \_\_\_\_\_

What was the average cost of MRO inventory at end of 2002? \_\_\_\_\_

What was the average age in years of MRO inventory at end of 2002? \_\_\_\_\_

What percent of MRO inventory at the end of 2002 was obsolete? \_\_\_\_\_ %

What was the percent of time that a paper line shut down due to MRO stockouts during 2002? \_\_\_\_\_ %

Thank you for taking the time to participate in our study.

In this section, we are seeking information pertaining to MRO and procurement related activities in your mill.

What is your current title? \_\_\_\_\_

How many years have you been in this position at this mill? \_\_\_\_\_

Approximately, how many people were employed at your mill at the end of 2002? \_\_\_\_\_

Where is corporate headquarters located? \_\_\_\_\_

Please fill in the table below based on 2002 data.

	Mill Employees	Subcontracted Employees	Union?	
			Yes	No
How many worked in maintenance/repair?				
How many worked in production?				
How many worked in inventory control?				
How many worked in purchasing/procurement?				

During 2002, how would you describe the decision making process for MRO procurement strategy and practices?

- Fully centralized at corporate
- Mostly centralized at corporate
- Fully decentralized to mills

	None	Low	Average	High	Very High
During 2002, to what extent did corporate pursue the following practices:					
Reduce number of MRO suppliers	<input type="checkbox"/>				
Categorize MRO items into commodity groups	<input type="checkbox"/>				
Pursue commonality/standardization of MRO items across mills	<input type="checkbox"/>				
Use long-term (2 years or more) corporate-wide supplier contracts	<input type="checkbox"/>				
Create production schedules for all mills	<input type="checkbox"/>				
Use a centralized distribution center for MRO items	<input type="checkbox"/>				
Relative to your primary competitors, to what extent did you practice the following supplier management activities for MRO items during 2002?					
Use on-site MRO supplier representatives	<input type="checkbox"/>				
Use long-term (2 years or more) MRO supplier contracts	<input type="checkbox"/>				
Utilize single sourced contracts for MRO items	<input type="checkbox"/>				
Use preferred MRO supplier lists	<input type="checkbox"/>				
Employ supplier selection criteria	<input type="checkbox"/>				
Track and provide supplier performance feedback	<input type="checkbox"/>				
Share MRO material forecasts with suppliers	<input type="checkbox"/>				
Conduct periodic visits to MRO supplier sites	<input type="checkbox"/>				
Conduct periodic meetings with MRO suppliers at mill	<input type="checkbox"/>				
Collaborate with other mills in your organization to consolidate MRO purchase volume	<input type="checkbox"/>				

Participate in corporate MRO-related decisions  None  Low  Average  High  Very High

Provide training for procurement/inventory management mill personnel  None  Low  Average  High  Very High

Please rate the level of importance of the following criteria when managing your MRO supplier relationships during 2002.

	None	Low	Average	High	Very High
Cost of MRO items	<input type="checkbox"/>				
Quality of MRO items	<input type="checkbox"/>				
Supplier on-time delivery performance of MRO items	<input type="checkbox"/>				
Supplier's ability to change order quantities	<input type="checkbox"/>				
Supplier's ability to change order delivery leadtime	<input type="checkbox"/>				
Accessibility of MRO supplier for problem resolution	<input type="checkbox"/>				
Importance of mill purchases to MRO supplier's total sales base	<input type="checkbox"/>				
Ability of MRO supplier to provide an on-site (at mill) representative	<input type="checkbox"/>				
Ability of MRO supplier to offer solutions to mill problems	<input type="checkbox"/>				
Relative to your primary competitors, to what extent did you use information technology (EDI, internet-based or email) to communicate/coordinate with your MRO suppliers during 2002?	<input type="checkbox"/>				

	None	Low	Average	High	Very High
Share MRO material requirement plans with suppliers	<input type="checkbox"/>				
Share inventory status with MRO suppliers	<input type="checkbox"/>				
Send purchase orders to MRO suppliers	<input type="checkbox"/>				
Verification of MRO material transactions with suppliers	<input type="checkbox"/>				
Access MRO supplier's material planning system	<input type="checkbox"/>				
Monitor MRO supplier performance	<input type="checkbox"/>				
Track MRO supplier delivery status	<input type="checkbox"/>				
Provide performance feedback to MRO suppliers	<input type="checkbox"/>				

Indicate procurement performance during 2002 for the following questions:

What was the total cost for MRO material? \_\_\_\_\_

What was the total expense incurred for expediting MRO item delivery? \_\_\_\_\_

What percent of the time was a paper line shut down due to quality problems of MRO material? \_\_\_\_\_%

What percent of the time was a paper line shut down due to late delivery of MRO material? \_\_\_\_\_%

If you are primarily responsible for MRO inventory management, please answer the questions on the following page.



In 2002, what was the approximate number of distinct MRO items in your mill? \_\_\_\_\_  
 At the end of 2002, what was the approximate value of your entire MRO inventory (in US \$)? \_\_\_\_\_

During 2002, to what extent did you engage in the following activities while managing your MRO inventory.

	None	Low	Average	High	Very High
Plan MRO material requirements using planned maintenance work orders	<input type="checkbox"/>				
Plan MRO material requirements using supplier leadtimes	<input type="checkbox"/>				
Categorize and manage MRO items according to criticality	<input type="checkbox"/>				
Categorize and manage MRO items according to ABC classification	<input type="checkbox"/>				
Maintain MRO items as stocked inventory items	<input type="checkbox"/>				
Manage MRO items using a formal inventory control system	<input type="checkbox"/>				
Purchase MRO items on a Just In Time basis	<input type="checkbox"/>				
Use supplier managed inventory	<input type="checkbox"/>				

Relative to your primary competitors, to what extent did you use information technology (ERP, MRP, email, EDI, internet-based or Project Management software) within your organization for MRO management?

	None	Low	Average	High	Very High
Forecast MRO inventory	<input type="checkbox"/>				
Manage purchase requisitions process	<input type="checkbox"/>				
Manage MRO inventory	<input type="checkbox"/>				
Track MRO inventory status	<input type="checkbox"/>				
Access MRO inventory data at other mills in your organization	<input type="checkbox"/>				
Coordinate corporate-wide inventory management	<input type="checkbox"/>				

Indicate MRO inventory management performance along the following dimensions:

What was your average annual MRO inventory turnover rate for 2002? \_\_\_\_\_  
 What was the average cost of MRO inventory at end of 2002? \_\_\_\_\_  
 What was the average age in years of MRO inventory at end of 2002? \_\_\_\_\_  
 What percent of MRO inventory at the end of 2002 was obsolete? \_\_\_\_\_ %  
 What was the percent of time that a paper line shut down due to MRO stockouts during 2002? \_\_\_\_\_ %

Thank you for taking the time to participate in our study.

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Thank you in advance for your help!

## Maintenance Practices for Managing your MRO Supply Chain

To be completed by person(s) primarily responsible for maintenance activities



Preparing business leaders for changing technological environments

Georgia Tech  
 DuPree College of Management

In this section, we are interested in gaining information pertaining to MRO and maintenance related activities in your mill.

What is your current title? \_\_\_\_\_

How many years have you been in this position at this mill? \_\_\_\_\_

Approximately, how many people were employed at your mill at the end of 2002? \_\_\_\_\_

Please fill in the table below based on 2002 data.

Number of Pulp/Paper Machines	Average Age of Pulp/Paper Machines (years)	Total Annual Capacity (tons)	Total Capital Investment during 2002 (US 000\$)	Total Annual Operating Cost/ton (US \$)	Total Annual Revenue (US 000\$)	Total Annual Production (tons)	Raw Material Used (percent)
							virgin fibers _____% recovered fiber _____% market pulp _____%

Please Circle Types of Products Produced :

Coated paper \_\_\_\_\_

Boxboard \_\_\_\_\_

Kraft paper \_\_\_\_\_

Market pulp \_\_\_\_\_

Newsprint \_\_\_\_\_

Tissue \_\_\_\_\_

Other (please specify) \_\_\_\_\_

Uncoated groundwood \_\_\_\_\_

Linerboard \_\_\_\_\_

Other groundwood \_\_\_\_\_

Comugating Medium \_\_\_\_\_

Relative to your primary competitors, to what extent did you practice the following mill maintenance activities during 2002?

	None	Low	Average	High	Very High
Use maintenance work orders (job packets) to drive planned maintenance schedule	( )	( )	( )	( )	( )
Schedule planned downtime (e.g. belt changes)	( )	( )	( )	( )	( )
Follow equipment manufacturer's suggested preventative maintenance schedule for planning MRO activities	( )	( )	( )	( )	( )
Use vibration analysis to identify needed maintenance of equipment	( )	( )	( )	( )	( )
Perform daily walk-through inspection of mill	( )	( )	( )	( )	( )
Collaborate with procurement personnel on MRO material requirements	( )	( )	( )	( )	( )
Collaborate with production personnel on maintenance/repair activities	( )	( )	( )	( )	( )
Provide training for maintenance personnel	( )	( )	( )	( )	( )
Participate in corporate MRO-related decisions	( )	( )	( )	( )	( )
Collaborate with MRO supplier on maintenance activities	( )	( )	( )	( )	( )
Use monitoring systems to improve process performance	( )	( )	( )	( )	( )
Use outsourced services for maintenance activities	( )	( )	( )	( )	( )

Participate in hiring process of employees at supplier for outsourced maintenance services

( ) ( ) ( ) ( ) ( )

Participate in performance evaluation of employees at supplier for outsourced maintenance services

( ) ( ) ( ) ( ) ( )

Participate in training of employees at supplier for outsourced maintenance services

( ) ( ) ( ) ( ) ( )

Relative to your primary competitors, to what extent did you use information technology for the following activities during 2002?

None Low Average High Very High

Plan maintenance activities

( ) ( ) ( ) ( ) ( )

Generate maintenance work orders (job packets)

( ) ( ) ( ) ( ) ( )

Schedule maintenance activities

( ) ( ) ( ) ( ) ( )

Track maintenance activities

( ) ( ) ( ) ( ) ( )

Monitor maintenance performance

( ) ( ) ( ) ( ) ( )

Increase maintenance effectiveness during planned line shutdowns

( ) ( ) ( ) ( ) ( )

Identify opportunities to improve performance by changing MRO practices

( ) ( ) ( ) ( ) ( )

Relative to your primary competitors, to what extent did you perform along the following dimensions during 2002?

None Low Average High Very High

Adherence to planned preventative maintenance schedule

( ) ( ) ( ) ( ) ( )

Adherence to planned preventative maintenance budget

( ) ( ) ( ) ( ) ( )

Extent of unplanned repair maintenance (e.g. failure)

( ) ( ) ( ) ( ) ( )

Actual to budget spent for maintenance (labor, material, training, etc.)

( ) ( ) ( ) ( ) ( )

Extent of production downtime due to maintenance problems

( ) ( ) ( ) ( ) ( )

Please indicate actual 2002 expenditures within the maintenance budget for following categories:

Mill employees \_\_\_\_\_

Subcontracted employees \_\_\_\_\_

Material (including that from subcontractors) \_\_\_\_\_

Overhead \_\_\_\_\_

Other (please specify) \_\_\_\_\_

During 2002, what percent of your maintenance budget was spent on outsourced services? \_\_\_\_\_%

If you are primarily responsible for MRO inventory management, please answer the questions on the following page.