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Maintenance: From Total Productive Maintenance to World Class Maintenance

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ABSTRACT:

Literature on maintenance management practices evolution from total productive maintenance to world class maintenance has so far been very limited. This paper reviews a large number of papers in this field and suggests the retrospective growth in this field. Subsequently, the need of maintenance, TPM attributes with it's different pillars, shortcoming of TPM are discussed in details then the world class maintenance system with its components, modules, factors for success and how to implement the world class maintenance system in any industry are discussed. A survey of CMMS Implementation is discussed by considering factors affecting implementation success, important aspect of CMMS implementation and benefits obtained from CMMS implementation. The paper provides many references and case studies on maintenance management. It gives useful references for maintenance management professionals and researchers working on maintenance management.

KEYWORDS: Maintenance, Manufacturing industries, Performance measures.

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1. INTRODUCTION

Since the beginning of industrial era, people have realized the need for the maintenance of equipment. But at earlier times people thought of maintenance as an added cost to the plant which did not increase the value of finished product and traditionally maintenance was only done when it was no longer possible to run it. Maintenance does not mean to eliminate the failure only, but to identify the cause and to understand the consequences.

The recent competitive trends and ever increasing business pressures have been putting maintenance function under the spotlight as never before. The maintenance function in an organization is confronted with the challenging task of affecting significant reductions in cycle time; set-up time, cost; facilitating quality improvements; capacity expansions, and affecting improvements in organizational working environment. Thus, an effective maintenance program can make significant contributions towards enhancing production efficiency, plant availability, reliability and organizational profitability[7].

Maintenance is also responding to changing expectations. These include a rapidly growing awareness of the extent to which equipment failure affects safety and the environment, a growing awareness of the connection between maintenance and the product quality, and increasing pressure to achieve high plant availability and to contain costs.

The changes are changing attitudes and skills in all branches of industry to the limit. Maintenance people have to adopt completely new ways of thinking and acting, as engineers and managers. At the same time the limitations of maintenance systems are becoming increasingly apparent, no matter how much they are computerized.

Strategic investments in the maintenance function can lead to improved performance of manufacturing system and enhance the competitive market position of the organization[11]. Thus, as a significant contributor towards organizational endeavors of growth and development, there is an utmost need to improve efficiency of maintenance function in the organization.

According to Mourbay, following categorized the evolution of maintenance philosophies over the past 60 years into three generations starting from the 1930s as summarized in Table 1

Table: 1: The development of maintenance philosophies [13]

Generation	Background and characteristics of equipment	Maintenance techniques and philosophy
First Generation (Before the Second world war)	Equipment simple, over designed, easy to repair	Basic and routine maintenance Reactive breakdown service ("fix it when it is broke)
Second Generation (Second world war- Late 1970s)	More complex, greater dependence of industry on machinery Higher maintenance cost relative to other operating cost	Planned preventive maintenance Time tested approach
Third Generation (1980s)	Continued growth in plant complexity and accelerating use of automation Downtime very costly Just in time systems more common Rising demand for standard of product or service quality Tightening legislation on safety	Condition monitoring, hazard studies, failure modes and effect analysis Reliability centered maintenance as corner stone Computer aided maintenance management information system Workforce with multi-skills and team working Emphasis on reliability and availability Proactive and strategic

The recognition of maintenance as a potential profit generator, however, is a fairly recent development. have also traced these recent developments of maintenance in a time perspective as shown in Table 2.

Table 2: Maintenance in a time perspective

<1950	1950-1975	>1975	2000 onwards
Manpower (Simple)	Mechanization (Complex)	Automation (More complex)	Globalization (crossing boundaries)
"Fix it when it breaks"	"I operate- you fix" Availability, longevity, cost are the main focus Preventive maintenance and work order management	Reliability, availability, maintainability with emphasis on safety, quality and environment Condition based maintenance, condition monitoring, multi-skilling, maintenance management information system and asset management	Optimal concept, outsourcing Information and communication technology is stressed
Maintenance is "a production task"	Maintenance is "a task of maintenance department"	Maintenance is (may be) "not an isolated function" Integration efforts	Maintenance is "external and internal partnerships" Maintenance meets production
"Necessary evil"	" Technical matter"	"Profit contributor"	"Partnership"

1.1 Maintenance definition

The two most common definitions of maintenance are:

1. All actions necessary for retaining of a system or product in, or restoring it to a serviceable condition
2. Maintenance is defined in Australian standard as the process of retaining or restoring an item to a condition in which it is capable of performing, and is consistently fit for purpose.

1.2 Objectives of Maintenance

- Dictated by the nature of enterprise
    - i. Airline → reliability
    - ii. Hospital → customer satisfaction
    - iii. Mining → cost/ton of ore
- What does maintenance has to achieve?
    - i. Ensure maximum availability of plant, equipment, and machinery
    - ii. Increase the life span of plant, equipment,
    - iii. Provide management with information on the cost and effectiveness of maintenance
    - iv. To achieve the objectives economically (maintenance cost + production cost)

1.3 Characteristics of Maintenance

Certain aspects of maintenance set it apart from other industrial function

1. Maintenance is a composite function
2. The less the demand the better the service
3. Immeasurable and intangible benefits (improved morale,
4. A necessary evil
5. The “time lag” effect
6. Is maintenance “a bottomless pit” for expenses?

1.4 Needs of Maintenance Planning

- long life of machining

- increase plant utilization
- prevent waste of spares, tools, and materials
- control of maintenance labor force
- maximize utilization of labor and other resources
- ensure adequate technical information for maintenance
- record expenditure and estimate the cost of work
- control of maintenance costs and establish records

1.5 Functions of maintenance department

- Develop maintenance policies, procedures, and standards for company wide incorporation
- Design practicable and implementable schedules of maintenance work (master process sheet)
- Ensure the availability of production plant and equipments for planned/preventive maintenance
- Calibration, lubrication
- Documentation of maintenance work
- Standardize equipments
- Proper spare part inventory
- Safety standards
- Recruitment and training

2. TOTAL PRODUCTIVE MAINTENANCE

Originally the thought of TPM emerged in the year 1951 in Japan. The first implementation of this concept was done in-group Nippon Denso (a subsidiary of the Toyota Group). The conceptualization of this ideology was due to the gradual modifications in the 'Preventive maintenance; maintenance prevention & maintainability improvement' over the years under with the help from the production operators and the maintenance crew. The present shape of the TPM emerged in 1970. The basic requirement of the idea of TPM emerged due to a need of such a process, which coordinates all the production processes for the consummation of common goal.

It involves the newly defined concept for maintaining industrial plants and equipments. TPM is productive maintenance (maintenance of the production system not just maintenance of machines) carried out by all employees through team activities.

TPM means productive maintenance (activities in which all workers of corporations are required to participate) and stands for total productive maintenance.

2.1 Necessity of TPM

1. The economic environment surrounding corporations become severe, and total elimination of waste is required for the survival of the corporation. Therefore, wastes generated due to the failure shutdown of facilities which have been built with huge investment and wastes such as defective products should be absolutely eliminated.
2. Requirements for product quality become stringent, and not even one defective product would be allowed. Quality assured delivery of total quantity is now taken granted.
3. The small lot production of various kinds of products and shortening of production lead time have been strongly required to meet diversified customer needs. That is to say, TPM to reduce the 8 major equipment losses to zero has been recognized as necessary for corporate survival.
4. Avoidance of the three Ds (Difficulties, Dirty and Dangerous), workers preference for employment in the service industry and shorter working hours can be seen as spreading tendency, making the acquisition of a sufficient work force more difficult. Increases of the aged and higher educated in our society have also contributed to making the maintenance of conventional production facilities difficult.

2.2 Definitions and distinctive features of TPM

TPM is often defined as “productive maintenance involving total participation”. Frequently, management misconstrues this to mean workers only and assumes that PM activities are to be carried out autonomously on the floor. Unfortunately, some firms abandon TPM because they fail to support workers fully or involve management. The complete definition of TPM involves five elements:

1. TPM aims to maximize equipment effectiveness (overall effectiveness)
2. TPM establish a thorough system of PM for the equipment’s entire life span.
3. TPM is implemented by different various departments (engineering, operations, maintenance).
4. TPM involves every single employee, from the top management to the workers on the floor.
5. TPM is based on the promotion of PM through motivational management: autonomous small group activities.

2.3 Business Environment and Necessity for TPM

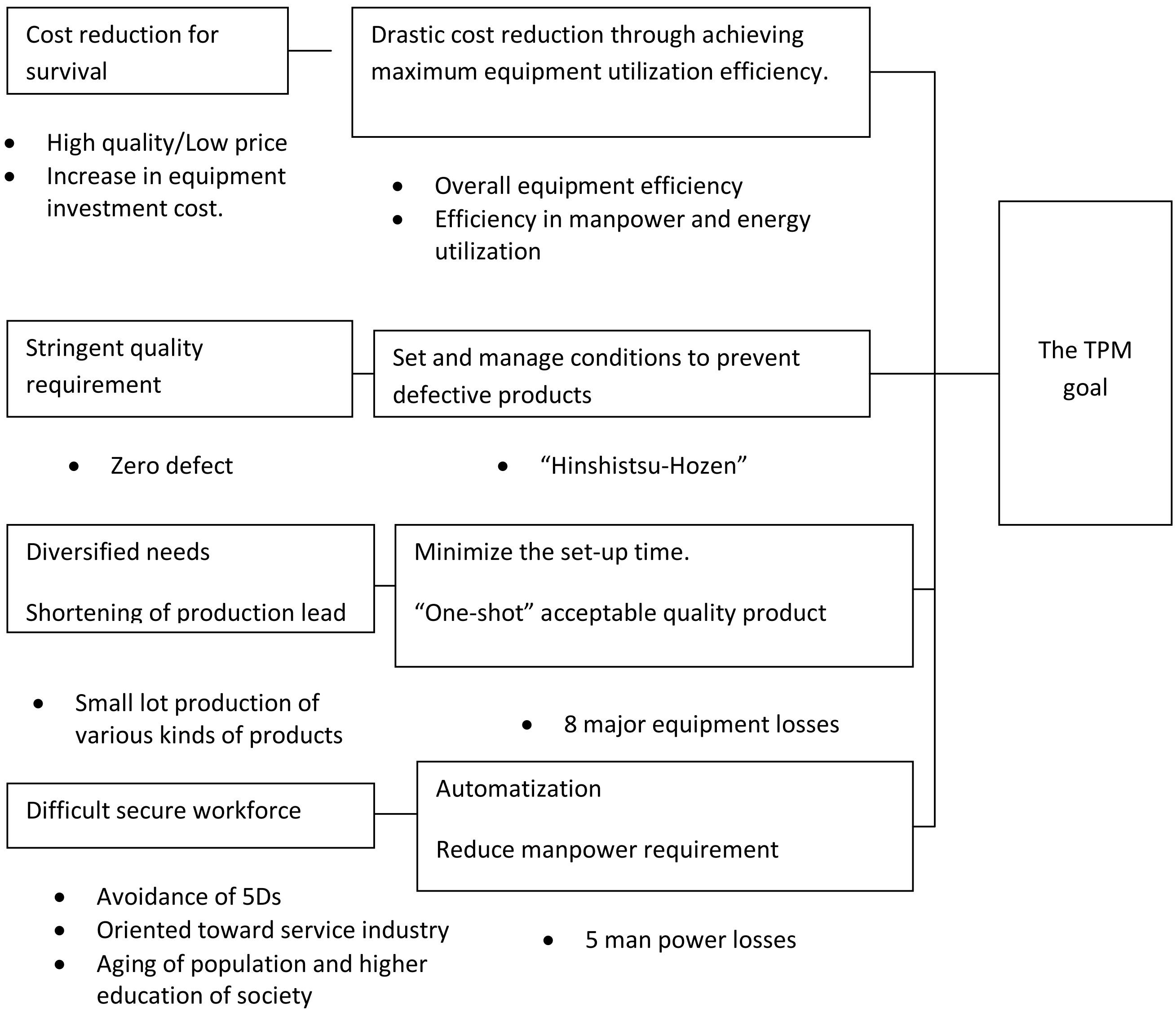

Figure 1: Business Environment and Necessity of TPM

2.4 *Outline of the 12 Steps of TPM development programme:*

Table 3: The Twelve Steps of TPM Development

Stage	S.No.	Step	Details
Preparation	1	Announce top management decision to introduce TPM.	Statements at TPM lecture in company; articles in company newspaper.
	2	Launch Education and campaign to introduce TPM.	Seminars/retreats according to level and slide presentations.
	3	Create organizations to promote TPM.	Form special Committees at every level to promote TPM; establish central headquarters and assign staff.
	4	Establish basis TPM policies and goals.	Analyze existing conditions; set goals; predict results.
	5	Formulate master plan for TPM development.	Prepare detail implementation plans for the five foundational activities.
Preliminary Implementation	6	Hold TPM kick-off.	Invite clients, affiliated and subcontracting companies.
TPM Implementation	7	Improve effectiveness of each piece of equipment.	Select model equipment; from model teams.
	8	Develop an autonomous maintenance program.	Promote the seven steps; build diagnosis skills and workers certification procedures.
	9	Develop a scheduled maintenance program for the maintenance department.	Include Periodic and Predictive Maintenance and management of spare parts, tools, blue-prints, and schedules.
	10	Conduct training to improve operation and maintenance skills.	Train leaders together; leaders share information with group members.
	11	Develop early equipment management program.	MP design (maintenance prevention); commissioning control; LCC analysis.
Stabilization	12	Perfect TPM implementation and raise TPM levels.	Evaluate for PM prize; set higher goals.

2.5 PILLARS OF TPM

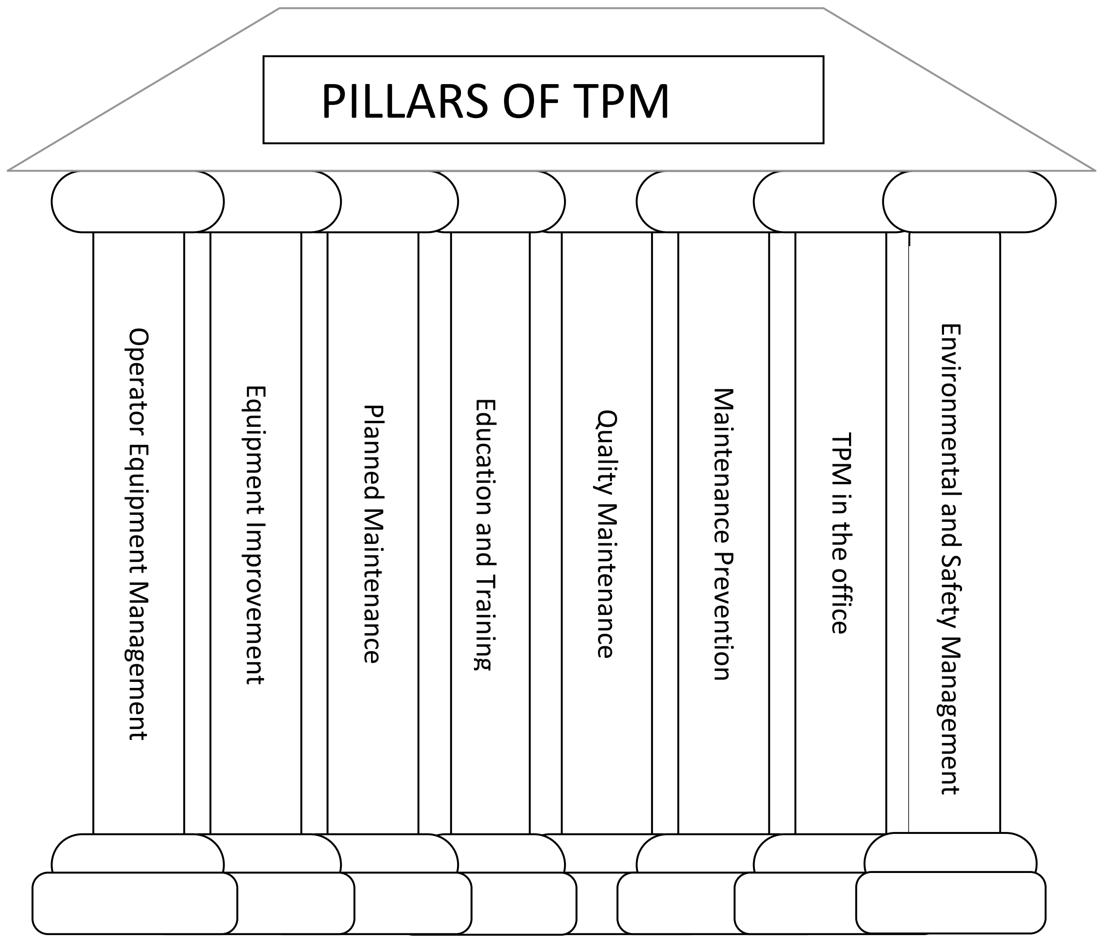

Figure 2: Pillars of TPM

1. Operator Equipment Management (Autonomous Maintenance)

2. Equipment and Process Improvement (Equipment Improvement)

3. Planned Maintenance

4. Educations and Training

5. Process Quality Management (Quality Maintenance)

6. New Equipment Management (Maintenance Prevention)

7. Administration System Improvement (TPM in the office)

8. Environmental and Safety Management

3. COMPUTERIZED MAINTENANCE MANAGEMENT SYSTEM

CMMS techniques become more necessary than ever to ensure productivity, quality, timely delivery, and availability, low cost, safety particularly in lean manufacturing. CMMS are increasingly being used to manage and control plant and equipment maintenance in modern manufacturing industries. Developing and implementing a maintenance programme is a difficult process that suffers from many problems. Its often suffers from lack of a systematic and consistent methodology. In addition, since the process of developing the programme relates to different parties with interests in maintenance, it becomes difficult to achieve all round satisfaction of these parties and at the same time achieve the objectives of the company. In deriving these objectives maintenance managers usually try to achieve multiple, and sometimes, conflicting objectives such as maximizing throughput, availability, and quality subject to constraints on production plan, available spares, manpower, and skills[3].

3.1 CMMS Definitions

The following are various definitions given by different authors and organizations. They are:

A computerized maintenance management system (CMMS) provides historic information for various types of work; availability of materials; costs by job, facility or type of work, and much more. It can increase effectiveness of planning, scheduling, and cost tracking by as much as 50 percent. In addition, it will establish an electronic information warehouse, which will be available for many other queries and reporting, at no additional cost[4]. CMMS is a centralized repository for maintenance related information. Ideally, a CMMS provides an easy to use interface to modules tying together purchasing, work requests, work orders, equipment records, labor resources, inventory, and history of work orders. The effectiveness of a CMMS depends on how well the software accomplishes this integration, the acceptance of the user community, and the quality of the maintenance data loaded into the CMMS[5]. A CMMS is a powerful tool that simplifies day-to-day activities in maintenance, planning and scheduling, inventory control and purchasing. It also provides event and history tracking facilities that will enable the overall performance to be monitored and optimizes the equipment and personnel resources.

3.2 Need for CMMS

Maintenance departments are under tremendous pressure to provide more information faster, and at a lower cost to the company. At the same time many companies have reduced the staff to the bare minimum. Maintenance professionals are presented with more difficult challenges today than at any previous point. The biggest obstacle of all confronting maintenance professionals is being forced to do more with fewer resources. Maintenance departments must deliver superior service, comply with regulatory requirements and provide detail financial accountably all within the confines of limited and/or reduce budgets. In order to meet challenges, maintenance professionals are arming with economical computerized maintenance management systems (CMMS). Maintenance organizations can improve their agility and cost effectiveness through implementing and deploying a latest generation CMMS[6]. CMMS are now a necessary part of managing and controlling assets, plant and equipment maintenance in modern manufacturing facilities management and service industries. CMMS are designed to provide today's maintenance professionals with the tools needed to reduce downtime, increase equipment life, maximize productivity, lower overall costs and simplify the maintenance process. The importance of CMMS has increased dramatically in the past few years, especially in resource-based companies such as mining, oil and gas, pulp and paper, utilities, and heavy manufacturing. This is because lean companies realize the enormous savings potential due to improved equipment reliability, lower spare parts inventory, and higher operator/maintainer productivity. The more sophisticated CMMS packages provide excellent analysis tools for lean manufacturers to identify problem areas, root causes, and actions required. Many problems can be avoided in the first place through various modules of CMMS.

The following characteristics should be in CMMS

- Minimal learning curve required.
- Quick easy to set-up.
- Easy to use with powerful features.
- Minimal time required for operating.
- Bulletproof software system that requires no computer experience to install or maintain even on a network.

3.3 Basic Components of CMMS

The following flowchart (fig.3) highlights the basic components of CMMS[7]. Work Order is the key feature of the system. It consists all of the labour data, materials data, contractor data, preventive maintenance data that is written against a piece of equipment (or a facility or a building etc). The information collected is then stored in a database called the equipment history. It is here that all of the data is drawn to reproduce all of the reports needed by the organization to manage the equipment or assets. The CMMS most basic function is to organize all equipment information into a workable database.

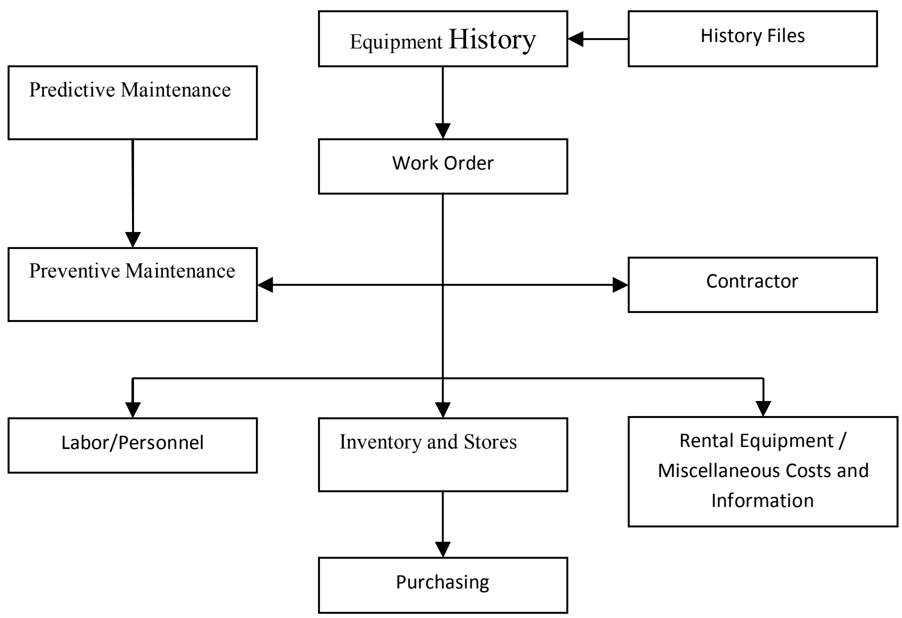

Figure 3: Basic Function of CMMS

3.4 Implementation

The actual implementation of the CMMS was performed in two parts: warehouse and procurement process, and work control process. During each conversion, a partial changeover was not considered. This total conversion worked only because of the modifications made to the system by each team prior to implementation and because all training was conducted prior to the actual implementation. Implementing a CMMS is a systematic process of evaluating the correct order of application implementation. This process can be conducted if the knowledge base of the new CMMS is well known along with the knowledge of current and future maintenance operations. Therefore, the first step in implementing a CMMS is to take all-available training (user and system administrator) to become an "expert" on how the system works and can potentially be modified. Next, a phased implementation has to be developed, reviewed, modified, and accepted by management. The following phased implementation:

1. **Test and validation:** The CMMS was tested against all established requirements to assure that it would perform all maintenance processes. The entire work control process (with all appropriate data loaded) was tested to understand how the new CMMS administered work from one application to another.

2. **Decisions:** After a thorough understanding of the system (through training) and a general understanding of how the CMMS administers work were achieved, decisions had to be made to merge the old system and set up the new system. The biggest decision was how to define and set up the equipment assemble structure (EAS). The EAS is the foundation of a CMMS, and a good deal of time was spent defining maintenance tracking levels. All installed facilities systems were defined to the lowest level of equipment maintenance that was to be tracked. This defined what equipment records. The greatest contribution of the EAS is the ability to track maintenance costs at the equipment level (then roll-up them to the system level) in order to perform optimal replacement analysis.

3. **Modifications:** Every application in the CMMS was reviewed for its applicability to the existing work control process. Each team learned every application, evaluated its functionality, and made recommendations to modify the application (field modifications or additional table requirements) to better fit. Modifications were then made to the application. This approach insured that the existing work control process was included in the CMMS prior to implementation.

4. **Training:** Training of all users was developed and conducted by in-house personnel because they had the system knowledge combined with the work control process knowledge (both current and future). The training program was broken into two groups: inventory and purchasing, and work control. The inventory and purchasing group consisted of all users responsible for procuring and storing maintenance materials (excluding work control flow through the CMMS). The implementation team trained all planners and supervisors on work order flow through the CMMS (excluding inventory and purchasing). Users learned the application and then learned how the application was going to be used.

5. **Warehouse and procurement:** The Materials management and purchasing modules were the first to be implemented because the CMMS is set up to check for materials before a work order can be moved to in-progress status. All stored material data was converted into the inventory database and procurement personnel started submitting purchasing orders to the Purchasing Department. Most inventories "bugs" were worked out prior to full implementation of the work control process.

6. **Work control:** The work control implementation consisted of a comprehensive use of most of the applications in the CMMS. Work control flow through the CMMS consisted of work order generation, receivable of new work order, detail of work order, assignment of work order, posting of craft daily time, completion of the work order, and closing of the work order.

7. **Equipment:** The equipment application is the foundation of a CMMS and great care should be taken to correctly set up this application. Each piece of equipment was then placed into the correct location of the defined EAS with the appropriate priority assigned to it. Then the correct equipment specification screen was assigned to the equipment for additional name plate data acquisition.

8. **Job plans:** Generic preventive maintenance (PM) job plans were written for all equipment types that require PM. These job plans would serve as a template when the PM Masters were to be created. The objective was to build a library of job plans that could be used in future PM development.

9. **Preventive maintenance:** Preparing a PM Master in a CMMS takes a great deal of effort, but yields many benefits. A PM Master will automatically generate work orders when they are due and specify appropriate operations, materials, labor, and specialty tool requirements. The warehouse will always know what materials are needed for PM and when they are needed.

10. **Failure analysis:** Tracking why equipment failed and how to fix it is the final leg of the implementation project.

3.5 How to avoid the pitfalls

Most mistakes are made when the basic information is entered into the system. Basic information answers such questions as "What is a piece of equipment?" "What is a part?," and "How is preventive maintenance handled?". More importantly, "How much detail gives us the information necessary to run the department?" What is a piece of equipment? Is it the cost, the critical nature, or a life/safety issue that determines that the piece needs to be set up in the system as a unique entity? Is it anything over $500 or maybe the cost is less but it would have a significant impact on the operation (like the lock on the front door) or a fire extinguisher for safety? A policy needs to be created defining what a piece of equipment is Parts vs. equipment. Parts are typically items that make up a piece of equipment and are replaced, not repaired. Disposable filters are typically parts. Electric motors can be both. Smaller electric motors are replaced as parts. As an example, a ¼ hp motor most likely would be a part, while a 25 hp motor probably would be a piece of equipment. Generally, setting up a ¼ hp motor as a piece of equipment would create a cumbersome situation for maintenance history. Preventive maintenance. The caution with setting up PMs is again the amount of detail you need. As an example, an air handling unit can be set up as a number of pieces of equipment (fans, motors, condensers, etc.) with each having a separate PM or it can be set up as one piece of equipment with a number of PM tasks. Typically setting the unit up as one piece of equipment reduces the number of work orders or pieces of paper the system generates. I have been at sites where the volume of paper generated for PM work orders stalled or exterminated the project. An option to reduce some of the paper yet get the detail is to set up the PMs on the larger unit (the air handling unit) but then do the corrective work against individual pieces of equipment (fans, motors, condensers, etc.). People are very good at their jobs and now are being asked to change; how do you get them as comfortable with the new process as they were with the old one? Training and practice is the only way they will overcome the natural human resistance to change. There is no magical solution, but the correct timing and quality and quantity of training is crucial.

3.6 Shortcomings of TPM

The TPM concept is simple and obvious, but there are some reported shortcomings. Managers tend to focus on early results rather than activities aimed at reducing losses in the long run[15]. Improving personnel and changing the corporate culture is more easily said than achieved. The traditional cultural division between operator and maintenance, "you bend it, we mend it", must be altered by mutual consent. Continuous improvement means data analysis. Often data are collected but not analyzed. There is a need to find a less time-consuming method that is also precise. While its philosophy is sound, its implementation lacks focus, and a systems approach that is compatible with different environments. Hence, an appropriate approach is presented. This approach is aimed at extending TPM in an effective and efficient model, rather than contradicting it. In addition, this approach addresses maintenance practice in both the strategic and operational domains. The trend in recent maintenance literature seems to emphasize the cultural difference between the Japanese culture and the Western[16]. pointed out the cultural differences between the Japanese and the West, stressing the Japanese affinity for small groups and consensus decisions[17]. It confirms this and emphasizes that the work ethic is very strong in Japan, coming before self and family. Also, in an article[18] about uses and limits of TPM, the authors of the article conclude that TPM succeeds not because of its systems or engineering techniques but because of its attention to the management of human factors.

Any TPM programme is supposed to go through four stages: self-development, improvement activities, problem solving and autonomous maintenance. However, it seems that most groups do not transit from stage two to stage three. They die before they are really grown up[9]. An analogy of adopting TQM and TPM is of having a good brain and strong muscles. It seems, however, that a nerve system (data and decision analysis) is missing in this analogy. Through personal experience, industrial collaboration, and research, the author has formulated the opinion that while TPM is obviously a step in the right direction, it is clear that there is a need for a revised, ``appropriate", approach regarding TPM. There is also need for a more appropriate approach that is dynamic, practical, focused, adaptable, and integrated with other functions of the organization. Need for a revised, appropriate, approach the above literature survey shows that TPM in its pure form is not totally applicable to Western industry. TPM appears to be in danger of being just an activity-centred management theory rather that a result driven approach. Therefore, there is a need for a revised approach to TPM, an appropriate one. The revised approach is intended to be keyed to specific results, rather than to too large scale and diffused objectives: an approach that is a management thought process rather than a thing unto it. It is not intended to contradict TPM philosophy, but to complement it. The proposed approach is a further step that puts a concept into practice. This revised approach is intended to account for differences from the ideal case, which embodies ``best" practices yet, which can be ``tailored" to yield an appropriate system.

4. WORLD-CLASS MAINTENANCE SYSTEMS

Optimize the maintenance contribution critical when striving to meet world-class competition for maintenance to make its proper contribution to profits, productivity and quality, it must be recognized as an integral part of the plant production strategy – an integral component of the overall plan by which the plant provides the products to the customer at the quality they want at the price they are willing to pay. Recent competitive trends have been pushing manufacturing executives to reconsider the contribution and importance of virtually every key business function involved in getting a quality product to the customer- manufacturing, procurement, distribution, marketing, product and process development and maintenance. It is now obvious that ability of a company to achieve world-class status depends largely on how well it can get all the various functions to work together simultaneously rather than sequentially, how well if manages to remove the walls (both figurative and actual) between departments and function that cause mistrust, rivalry and dysfunction, leading to waste, inefficiency and chaos. That means to accomplish the maintenance mission in a world-class organization requires more than maintenance just “doing its job” or “getting its act together”. It requires the cooperation of and the association with virtually all other departments within the plant but especially production, procurement, engineering, accounting and human resource. Not only must the roles and mission be well defined for maintenance it self they must be directly related to or a derivative of the largest set of roles mission and strategic objectives of the overall organization. But getting “beyond the boundaries” is what proves so difficult. It is relatively easy to encourage important within maintenance that has been the traditional approach. The challenge is to get other departments to adjust to work out new arrangements that shift territories and responsibility to get departments or group to recognize common goals or even accept each other’s ideas.

A world-class maintenance operation differs from a run-of-the-mill operation only by the degree to which it achieves its primary function to ensure that the right amount of equipment is ready and available without costing the operation an arm and a leg. An automobile runs most efficiently with better gas mileage, fewer breakdowns and smoother ride when it is well tuned and maintained. The same holds true with mining and quarrying equipment. Poor practices can bring productivity to halt and seriously affect the bottom line. Carrier cites fives key components for attaining world-class maintenance status as defined[19], author of world-class maintenance. The key components are:

- Quality equipment maintenance
- A positive attitude towards preventive maintenance (PM)
- Labour planning
- Inventory control and
- Using automation in the field to optimise the maintenance department’s ability to meet its goals.

4.1 Factors Influencing Implementation Success

According to the respondents, the most important factors in their success were obtaining Senior Management commitment, and effective training.

Table 4: Factors Influencing Implementation Success

What do you consider are the two most important aspects of your implementation that led to your success?			
	Responses		
Factor	**Most Important**	**Second Most Important**	**Total**
Senior Management commitment	15	17	32
Effective training	12	17	29
Choosing the right CMMS	10	7	17
Effective Change Management	10	5	15
Focus on business benefits	5	9	14
Adequate budget	6	8	14
Effective BPR	5	8	13
Effective Project Management	5	5	10
CMMS Vendor Support	7	2	9
Consultant support	4	2	6

Table 5: Most Important aspect of CMMS Implementation

In hindsight, what is the most important aspect of your implementation that you should have spent more time and effort on, in order to increase implementation success?		
Factor	**Responses**	**Percent**
Effective training	20	19.0%
Choosing the right CMMS	9	8.6%
Senior Management commitment	8	7.6%
Effective BPR	16	15.2%
Effective Change Management	12	11.4%
Effective Project Management	5	4.8%
Adequate budget	5	4.8%
Focus on business benefits	2	1.9%
CMMS Vendor Support	3	2.9%
Consultant Support	1	1.0%
Other/Not Applicable	24	22.9%

4.2 Benefits obtained from CMMS Implementation

Overall, most respondents reported that their CMMS implementation has led to some or significant benefits. Note that, in the following table, the large number of "Don't Know/Not Applicable" responses includes those from people who do not currently use a CMMS.

Table 6: Benefits obtained from CMMS Implementation

	Size of Benefits Obtained % of Responses			
Area of Benefit	**Significant**	**Some**	**None**	**Don't Know/Not Applicable**
Reductions in Labor Costs	5.7%	32.4%	29.5%	32.4%
Reductions in Materials Costs	11.4%	32.4%	22.9%	33.3%
Reductions in Other Costs	8.6%	36.2%	23.8%	31.4%
Improved Equipment Availability	9.5%	37.1%	21.9%	31.4%
Improved Equipment Reliability	13.3%	41.0%	15.2%	30.5%
Improved Cost Control	35.2%	23.8%	16.2%	24.8%
Improved Maintenance History	30.5%	37.1%	9.5%	22.9%
Improved Maintenance Planning	30.5%	36.2%	8.6%	24.3%
Improved Maintenance Scheduling	28.6%	39.0%	6.7%	25.7%
Improved Maintenance Schedules	29.5%	35.2%	9.5%	25.7%
Improved Spare Parts Control	21.9%	35.2%	12.4%	30.5%

Additional benefits cited by respondents included:

- Upgrade in knowledge
- Equipment Performance
- Reduced fire fighting calls and breakdowns
- Standardization between different maintenance departments
- Enhanced computer literacy, measurement
- Enhanced transparency and accountability
- Trending
- Time sheets of engineers

- Improved control of material tracking & delivery
- Be able to implement Asset maintenance program (RCM/RBI method) in the organization
- Inventory control
- Changes in maintenance processes
- Vendor details recorded,
- Improved KPI's control
- Cost projection

5 CONCLUSION:

World-class maintenance system has its foundation in best maintenance practices. Those practices include the following twelve areas[21]:

1. Leadership and policy deployment
2. Organizational structure
3. Inventory control
4. Computerized maintenance management systems
5. Preventive maintenance
6. Predictive maintenance
7. Planning & scheduling
8. Work flow
9. Financial control
10. Operational involvement
11. Staffing and development
12. Continuous improvement

A definition of best practices adapted to the maintenance process would read: The maintenance practices that enable a company to achieve a completive advantage over its competitors in the maintenance process”. The best practices in maintenance management are[22]:

1. Preventive maintenance
2. Inventory and procurement

3. Work flow and controls
4. Enterprise asset management system usage
5. Operational involvement
6. Predictive maintenance
7. Reliability centred maintenance
8. Total productive maintenance
9. Financial optimisation
10. Continuous improvement

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