

TPM CONCEPT AND IMPLEMENTATION APPROACH

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Abstract

The present paper deals with the concept, introduction and implementation approach of Total Productive Maintenance (TPM) in detail. TPM is a maintenance program which involves a newly defined concept for maintaining plants and equipment. This paper will define TPM history, benefits, its (TPM) strengths as a maintenance philosophy, its implementation approach, difficulties in its implementation and cost of implementing TPM. The paper also deals with the organization structure required for TPM implementation and shows that how the organization structure affects the results of TPM. The paper also discusses about the right ingredients required for successful TPM implementation. TPM is to Maintenance very much as Total Quality is to Production. The goal of the TPM program is to markedly increase production while, at the same time, increasing employee morale and job satisfaction. The results of implementing TPM program in terms of increased plant efficiency and productivity are outstanding. The paper concludes that the implementation of TPM is definitely not an easy task, which is considerably burdened by organizational, behavioral and other barriers, and necessitates the difficult mission to change peoples' mindsets from a traditional maintenance approach.

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1. TPM Concept

TPM stands for “Total Productive Maintenance” and builds a close relationship between Maintenance and Productivity, showing how good care and up-keep of equipment will result in higher productivity. It is a philosophy of continuous improvement that creates a sense of ownership in the operator(s) of each machine as well as in their supervisor. It is a process of maintenance management that empowers the organization with a progressive, continuous philosophy of enabling all manpower resources to work together to accomplish the mutual goal of manufacturing efficiency.

Modern manufacturing requires that the organizations, that want to be successful and to achieve world-class manufacturing, must possess both effective and efficient maintenance. One approach to improve the performance of maintenance activities is to implement a Total Productive Maintenance (TPM) system (**Hermann, 2000**). Today, the competition has increased dramatically. Customers focus on product quality, delivery time and cost of product. Because of these, the company should introduce a quality system to improve and increase both quality and productivity continuously. Total productive maintenance (TPM) is a methodology that aims to increase the availability of existing equipment, hence reducing the need for further capital investment. Investment in human resources can further result in better hardware utilization, higher product quality and reduced labour costs (**Chan, et al., 2003**).

According to **Roberts (1997)**, the TPM program closely resembles the popular Total Quality Management (TQM) program. Many of the tools such as employee empowerment, benchmarking, documentation, etc. used in TQM, are used to implement and optimize TPM. **Williamson (2000)** suggest that Total Productive Maintenance is the equipment and process improvement strategy that links many of the elements of a good maintenance program to achieve higher levels of equipment effectiveness. The five key elements or pillars of TPM include:

1. Improving equipment effectiveness by targeting the major losses.
2. Involving operators in the daily, routine maintenance of the equipment.
3. Improving maintenance efficiency and effectiveness.
4. Training for everyone involved.
5. Life-cycle equipment management and maintenance prevention design.

According to **Environment protection Agency (2006)**, TPM engage all levels of an organization to maximize the overall effectiveness of the equipment. This method further tunes up existing processes and equipment by reducing mistakes and accidents. Whereas maintenance departments are the traditional center of preventive maintenance programs, TPM seeks to involve workers in all departments and levels, from the plant-floor to senior executives, to ensure effective equipment operation. Autonomous maintenance, a key aspect of TPM, trains and focuses workers to take care of the equipment and machines with which they work. TPM focuses on preventing breakdowns (preventive maintenance), "mistake-proofing" equipment to eliminate product defects and/or to make maintenance easier (corrective maintenance), designing and installing equipment that needs little or no maintenance (maintenance prevention), and quickly repairing equipment after breakdowns occur (breakdown maintenance). TPM is focused primarily on keeping machinery functioning optimally, minimizing equipment breakdowns and associated waste by making equipment more efficient, conducting preventative, corrective, and autonomous maintenance, mistake-proofing equipment, and effectively managing safety and environmental issues. The ultimate goals of TPM are zero equipment breakdowns and zero product defects. The other important goal is the total elimination of all **six major losses**, including breakdowns, equipment setup and adjustment losses, idling and minor stoppages, reduced speed, defects and rework, spills and process upset conditions, and startup and yield losses.

1.1 Six Major Losses

The six major losses that can result from faulty equipment or operation, whose elimination is the major objective of the TPM, are as shown in **Table 1**. The elimination of all these six major losses that can result from faulty equipment or operation, as summarized in Table 1, can results in a dramatic improvement in the Overall Equipment Efficiency (OEE).

1.2. Overall Equipment Efficiency (OEE)

Overall Equipment Effectiveness (OEE) incorporates not only Availability but also Performance Rate and Quality Rate. In other words, OEE addresses all losses caused by the equipment: not being available when needed due to breakdowns or set-up and adjustment losses; not running at the optimum rate due to reduced speed or idling and minor stoppage losses; and not producing first pass quality output due to defects and rework or start-up losses. A key objective of TPM is to cost effectively maximize

Overall Equipment Effectiveness through the elimination or minimization of all these six losses. A simple model outlining these losses is shown in **Figure 1**.

□ **Overall Equipment Effectiveness (OEE) = A x PR x Q , Where**

- **A-** Availability of the machine. Availability is proportion of time machine is actually available out of time it should be available.

- **PR-** Performance Rate and $PR=RE \times SR$

Rate efficiency (RE): Actual average cycle time is slower than design cycle time because of jams, etc. Output is reduced because of jams

Speed Rate (SR): Actual cycle time is slower than design cycle time machine output is reduced because it is running at reduced speed.

- **Q-** Refers to quality rate. Which is percentage of good parts out of total produced sometimes called yield.

All these figures are usually expressed in percentage and higher OEE translates into higher equipment efficiency from the equipment. Surprisingly, the OEE of most equipment range from 40%-60% when first time measured, whereas the benchmark is 85%. As such, OEE has become the accepted indicator to assess, that how plants actually manage their most expensive asset, the equipment, to produce saleable goods, with minimum losses and wastes.

□ **World Class O.E.E. = 85%+**

1.3. TPM History

Venkatesh (2005) state that TPM is an innovative Japanese concept. The origin of TPM can be traced back to 1951 when preventive maintenance was introduced in Japan. Nippondenso was the first company to introduce plant wide preventive maintenance in 1960. With the automation of Nippondenso, maintenance became a problem as more maintenance personnel were required. So the management decided that the routine maintenance of equipment would be carried out by the operators. (This is Autonomous maintenance, one of the features of TPM). Thus, Nippondenso which already followed preventive maintenance also added Autonomous maintenance, done by production operators. The maintenance crew went in the equipment modification for improving reliability. The modifications were made or incorporated in new equipment. This lead to maintenance prevention. Thus preventive

maintenance along with Maintenance prevention and Maintainability Improvement gave birth to Productive maintenance. The aim of productive maintenance was to maximize plant and equipment effectiveness to achieve optimum life cycle cost of production equipment. By then Nippondenso had made quality circles, involving the employee's participation. Thus all employees took part in implementing Productive maintenance.

1.4. Benefits of TPM

The main benefits of TPM are as follows:

- Increased productivity and OEE (Overall Equipment Efficiency).
- Rectify customer complaints.
- Reduce the manufacturing cost by up to a great extent.
- Satisfy the customer's needs by almost 100 % (Delivering the right quantity at the right time, in the required quality).
- Reduce accidents.
- Follow pollution control measures.
- Higher confidence level among the employees.
- Keep the work place clean, neat and attractive.
- Favorable change in the attitude of the operators.
- Achieve goals by working as team.
- Horizontal deployment of a new concept in all areas of the organization.
- Share knowledge and experience.
- The workers get a feeling of owning the machine.

2. TPM Implementation

TPM focuses on optimizing planning and scheduling. Availability, performance and yield are other factors that affect productivity. Availability losses arise from breakdowns and change-over, i.e., the situation in which the line is not running when it should be. Performance losses arise from speed losses and small stops or idling or empty positions. In this case, the line may be running, but it is not producing

the quantity it should. Yield losses consist of losses due to rejects and poor start-up behavior in the line producing the products. These losses lead to low values of the overall equipment effectiveness (OEE), which provides an indication of how effective the production process is. TPM helps to raise the value of the OEE by supplying a structure to facilitate the assessment of these losses. Application of TPM leads to both short- and long-term improvements.

TPM entails having a

- Linear organizational structure.
- Multi-skilled workforce.
- Rigorous reappraisal of the way, the thing is done and so improvements are introduced, resulting in simplification and/or standardization.

TPM seeks to encourage the setting of ambitious, but attainable, goals for raising the value of the OEE and to measure any deviations in, what is achieved, relative to the original objective. **(Eti, et al., 2000)**

Hermann (2000) states that the introduction of a TPM system is by no means an easy task, because there are several barriers that encumber the implementation process, the driving forces to success have to be identified and well understood, and a process of organizational change has to be managed successfully.

2.1. Organization Structure for TPM Implementation

The results of TPM implementation depends upon the organization structure. Improper organization structure can lead to the failure of TPM implementation. A typical organizational structure for TPM implementation is as shown in **Figure2**. For this purpose, a person should be made responsible for implementing TPM, i.e. a plant manager should be appointed as TPM coordinator. The coordinator will look over the whole TPM implementation process. According to **McBRIDE (2004)**, TPM requires effective leadership from the top. That is the part of the meaning of "total" in 'Total Productive Maintenance'. Without effective leadership that links TPM efforts to the business and holds the people accountable, for performing highly specified work, the equipment performance and reliability will continue to decline and TPM initiatives will be short-lived.

Many of today's business leaders have risen through the ranks when maintenance was only responsible for "fixing things" – not for preventing problems. Viewing maintenance as a non-value-adding

support function, many business leaders often subject the maintenance department to severe cost-cutting; this usually results in higher costs due to decreased equipment effectiveness. TPM is not like a standard project, which normally has a starting, and an end that seldom exceeds one year. Rather, TPM is a long range “living program” which can take more than few years to implement and enjoy the lasting benefits when the whole organization has become strategy focused, instead of evaluating one new program after another, before implementing TPM thoroughly.

2.2. Steps for Implementing TPM

The 12-step process is designed to implement TPM: Accomplish TPM acceptance; Create TPM support from management, unions and employees; Create enthusiasm and positive expectations for TPM; Develop a realistic custom installation plan; and Accomplish world-class results in a timely manner.

Step 1: Announcement of top management decision of implementing TPM: - Top management needs to create an environment that will support the introduction of TPM. Without the support of management, skepticism and resistance will kill the initiative. Detailed TPM articles including TPM objectives should be clearly stated in company’s newsletter, newspaper and magazine.

Step 2: TPM education Program and collection of information: - This program will inform and educate everyone in the organization about TPM activities, benefits and its objectives.

For managers: offer seminars/retreats according to level,

For general workers: provide slide presentation.

This step of implementing TPM also consists of collection of information about TPM and to understand how it works. TPM coordinator must understand what TPM is, how it works, its proper implementation sequence, the amount of effort that will be required, how it can be benefited for the plant, how long it will take to implement etc. Information resources include TPM conferences, TPM seminars, TPM books, magazines, the Internet, and conversations with consultants. **(McBRIDE, 2004)**

Step 3: Establish an organizational structure: - This group will promote and sustain TPM activities once they begin. Team-based activities are essential to a TPM effort. This group needs to include members from every level of the organization from management to the shop floor. This structure will promote communication and will guarantee that everyone is working toward the same goals.

Step 4: Formulate basic TPM policies and goals: - Analyze the existing conditions and set the goals that are Result oriented, Specific, Measurable, Attainable and Realistic. Then predict the results. The established TPM policies and goals should be very much clear to everyone involved in TPM implementation.

Step 5: Master plan for TPM deployment and its presentation: - After establishing TPM policies and goals, a detailed proposed master plan for implementation of TPM is prepared and proposal is presented to management. This activity can be carried out by a consultant, plant personnel, or both. Consultant involvement typically begins with a plant visit to observe production operations, learn about the equipment (type, function, condition, problems and losses etc.), study maintenance operations (structure, size and tasks etc.), gauge orderliness and cleanliness in the plant, and talk to employees to determine their motivation and attitude. The consultant then can develop and conduct the TPM presentation to management, including questions and answers, and covers the following: **(Hartmann, 2000)**

- TPM overview (What is TPM?).
- What TPM can do for the plant, its Expected costs and benefits?
- Sequence of its implementation.
- Customized implementation strategy.
- How management and the union must support TPM.
- How to get organized for implementing TPM.

The presentation also can be made by plant personnel covering the same points with examples and impressions from seminars, conferences, and plant visits. The presentation should end with a recommendation to install TPM. Normally, management will make a positive decision at this point. This decision must include a commitment to strongly support TPM, carry out the necessary training and the feasibility study, appoint a TPM coordinator, and create the TPM steering committee. This plan will identify what resources will be needed and when for training, equipment restoration and improvements, maintenance management systems and new technologies.

Step 6: Feasibility study & its presentation: - According to **Hartmann (2000)**, every successful TPM installation has been preceded by a good feasibility study. The results of the feasibility study, will establish a base line, against which TPM results and progress can be measured and also helps in setting

the realistic goals, based on the data obtained. A feasibility study typically includes two to six teams (five to nine members each). It will include overall equipment effectiveness (OEE) observations and calculations for 40 to 100 percent of important equipment. The study will evaluate the condition of these equipments and the required current & future maintenance activities. Skills of plant personnel, cleanliness or orderliness of the plant, and plant culture (attitude, motivation, and management style) will be studied also. Then Feasibility study results are presented. Both management and the union should be present in the presentation. The presentation should propose an installation strategy and identify a pilot installation. It should conclude with a recommendation that TPM is to be installed. At this point, management will make a second and final commitment to install TPM. Now, at this stage, almost everybody has had some exposure or heard about TPM during the execution of the feasibility study. The OEE results are typically much lower than management thought, creating a strong motivation to get going and improve the productivity of equipment and the quality of product. The feasibility study presentation meeting can be regarded as the TPM kickoff.

Step 7: Pilot installation: A TPM pilot installation should cover between 10 and 25 percent of plant equipment, not just a few selected machines. There should be a minimum of six TPM teams to insure survivability of the installation. Areas appropriate for pilot installations are: where major improvement is needed (too many breakdowns, delays, or idle time, or low capacity or productivity) and where quick success is likely. A good feasibility study is required for all pilot areas. All employees in the pilot areas must receive TPM training. Clear goals and deadlines must be established and team meetings must be held on schedule.

Step 8: Plant-wide installation: TPM coordinators of most companies wait too long before expanding the TPM installation over the whole plant. There is no need to wait for final results of the pilot installation. A good and well thought out staggered expansion plan is important, as is a detailed installation plan for each additional area. Expansion initiatives should begin every 3 months (6 months maximum) using the same priorities and decision criteria as for pilots.

Step 9: Introduction audit: According to **Hartmann (2000)**, to insure good progress and a proper and successful installation, audits have proven to be very valuable. There are two types of audits: the first audit is fairly simple and checks if the TPM fundamentals are done correctly (teamwork, organization,

tasks, PM development, etc.) and whether the program is on schedule. They are typically carried out 6-12 month after launch by internal or external specialists.

Step 10: Progress audit: It is usually the last step before the certification. This audit will point out existing deficiencies (and opportunities) to bring TPM to a successful conclusion. The theoretical part of the audit will be done in the office with the team going over a lot of data followed by a practical part out in the plant around the equipment. The progress audit comes 18-30 month after launch to determine if and how:

- Preventive maintenance is carried out by the TPM teams.
- Equipment improvement activities have been executed according to schedules.
- Increase in OEE has been reached.
- The improved equipment condition has been accomplished and documented.
- The planned levels of skill have been accomplished.

Step 11: Certification: The certification process is gaining more and more importance, because certificate is used to show to the customer that equipment and product quality have been improved and standard procedures are in practice to maintain the equipment to the highest levels. The International TPM Institute certification process is based on a strict set of certification requirements.

Step 12: TPM Award: The final and most rewarding step of a TPM installation is achieving the TPM Award. The award testifies that your plant is world-class: highly productive, produces only top quality product, maintains its equipment in top shape, and has a culture based on teamwork.

According to (McBRIDE, 2004) maintenance and reliability as a core business strategy, is key to a successful TPM implementation. Without the support of top management, TPM implementation will be failed. It is certain that Implementing TPM using the above 12 steps will leads to “zero breakdowns” and “zero defects.” Ming-Hong (2004) suggests that to be successful, not only support is required from top management, but also from the head of each department. The other key factor is that each employee must feel that they also have been benefited from this activity. This will improve their performance. This improved performance will reflect in their monthly bonus. This will motivate the employee, which in turn will lead to better progress. The design of the activity should be kept as simple as possible.

2.3. Why TPM is Difficult to Implement?

According to **Hartmann (2000)**, at least every second attempt of installation of Total Productive Maintenance (TPM), results in failure. The reasons are many: lack of proper understanding of the total effort required, lack of management support, lack of sufficient TPM staff, union resistance, not enough training carried out, change of priorities, lack of persistence, failure to develop a good installation strategy, and simply choosing the wrong approach. **ChoyDS(2003)**, concluded that implementing TPM is a dramatic organizational change that can affect organization structure, work-floor management system, employee responsibilities, performance measurement, incentive systems, skill development and the use of information technology. No wonder the success rate of such large-scale change is less than 30% for most organizations and that's why, the TPM is difficult to implement

2.4. Difficulties Faced in TPM Implementation

Implementing TPM is not an easy task as it seems to be. A great infrastructure and commitment of all personnel from top level management to bottom level is required. A lot of problems have to be faced, while implementing it. Some of them are as follows:

- Sufficient resources like people, money, time, etc. and assistance are not provided.
- TPM is not a “quick fix” approach, it involve cultural change to the ways to do the things.
- Incomplete understanding of the methodology and philosophy by middle management.
- Many people treat it just another “program of the month” without paying any focus and also doubt about its effectiveness.
- Workers show strong resistance to any change.
- .Many people considered TPM activities as additional work or threat.

2.5 The Cost of Implementing TPM

One of the most frequent concerns among the manufacturing plant owners is: What is the cost of implementing TPM? (**Mora, 2002**).

The answer is: Cost of implementing TPM, is a formula where the components are already in plant:

- Maintenance programs in place.
- Age of the equipment.
- Pace to be taken.

- Some plants have excellent programs in place and have kept the equipment in very good shape, so the cost for implementing TPM in these plants will be lower than for those who have a bad program or none in place.
- Old equipment sometimes will face the high cost of parts if attainable.
- If a fast paced implementation is required, the cost per year will be higher.
- **Facing reality:** The cost of implementing TPM is not important. Compare it to a necessary surgery.

3. The Right Ingredients for a Successful TPM Implementation

All implementers want the implementation projects to be a success. So, following are the factors that keep TPM from succeeding (Mora, 2002).

|| Positive Factors

- **Top management cooperation:** It is the concrete factor that makes the efforts of TPM implementation a great success.
- **Training programs:** TPM discipline, while technical, is more cultural. Everyone in the organization must receive sufficient information on TPM. Therefore training programs/seminars should be arranged weekly/monthly for all levels of organization.
- **Statements for boost up:** Vision and Mission Statements should include the concepts like: 'Workers are the single most valuable asset in the company', 'all employees are company associates', or 'all employees are responsible for success' etc. Management must be ready to complete the move all the way from the old image of "power from authority" to "respect and admiration from true leadership".
- **A Preventive Maintenance program existence:** It is necessary to have a good Preventive Maintenance program in place, to have clear identification of each piece of equipment and have some history.
- **Complete information about equipment performance:** To begin a project, research for all possible information about the actual, expected and designed performance of project is done. It is

strongly recommended to establish a very good communication with the "owners", i.e. the operator of the machine, the area supervisor(s) and/or manager(s).

- **Good communication skills of the TPM coordinator:** TPM coordinator is the key person in the success of the TPM implementation. The mission of TPM coordinator is not only to train the implementer teams, but also to educate everyone else in the plant. Coordinator has to become an expert in TPM culture and explain it to anyone in organization.
- **Full time worker(s) assigned to TPM tasks:** The TPM philosophy require continual dedication and training. One/two full time persons are required to attend a minimum of one seminar each year on TPM.
- || **Follow up:** Once a project is delivered back to the "owners", it is understood that TPM has just begun for that particular machine or system. The other 99% of the success will depend on the permanent communication that the coordinator establishes with the operators. This follow up builds up the confidence that the customers feel towards the project.

|| **Negative Factors**

Middle management: It is found that middle managers, supervisors, even some people at top, feel threatened in their positions by these changes. These people must be shown the advantages of sharing the knowledge and responsibility with the production operators.

- **Maintenance Technicians:** For years, maintenance has been considered as a repairing force. Now the focus must be on maintaining the equipment in normal operating conditions, thus preventing the failure. Many of the technicians feel that keeping some technical secrets, make them more valuable or their jobs more secure. This is not true. Under the new way of conducting business, the more the operators get involved in the maintenance tasks, the better the technicians can apply their expertise to higher level operations.
- **Concerned Production / Manufacturing / Engineering:** It must be made clear that TPM or other of these disciplines aren't an extra burden on production, manufacturing or engineering, but are instead, are the ways to ease the accomplishment of the goals.

4. CONCLUSION

Mora (2002), states that implementing Total Productive Maintenance is not a difficult task. However, it requires some customized training in order to succeed. The results of implementing an effective program in terms of increased plant efficiency and productivity are outstanding. **According to Kennedy (2005)**, it should be acknowledged that a TPM implementation is not a short-term fix program. It is a continuous journey based on changing the work-area, then the equipment so as to achieve a clean, neat, safe workplace through a "PULL" as opposed to a "PUSH" culture. Significant improvement can be evident within six months, however full implementation can take many years to allow for the full benefits of the new culture created by TPM

At this crucial point of global competition, the implementation of TPM not a matter of liking it or following the fashion. While TPM was in the 60's, just an innovative thing, today it has turned into a survival strategy. TPM is capable of bringing a machine back to original condition and even better. The cost of postponing a decision of implementing TPM, that have to make sooner or later, can be excessive. It is convincing that the losses for each day of delay are out of imagination. **(Mora, 2002)**. Apparently, successful TPM implementation can achieve better and lasting result as compared to other isolated program because there is an ultimate change in people (knowledge, skills, and behavior) during the progress.

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Table 1: Six Major Losses

Six major losses that can result from faulty equipment or operation		
S.No.	Loss Category	Costs to Organization
1	Unexpected breakdown losses	Results in equipment downtime for repairs. Costs can include downtime (and lost production opportunity or yields), labor, and spare parts.
2	Set-up and adjustment losses	Results in lost production opportunity (yields) that occurs during product changeovers, shift change or other changes in operating conditions.
3	Idling and Stoppage losses	Results in frequent production downtime and that difficult to record manually. As a result, these losses are usually hidden from efficiency reports and are built into machine capabilities but can cause substantial equipment downtime and lost production opportunity.
4	Speed losses	Results in productivity losses when equipment must be slowed down to prevent quality defects or minor stoppages. In most cases, this loss is not recorded because the equipment continues to operate.
5	Quality defect & Rework losses	Results in low standard production and defects due to equipment malfunction or poor performance, leading to output which must be reworked or scrapped as waste.
6	Equipment and capital investment losses	Results in wear and tear on equipment that reduces its durability and productive life span, leading to more frequent capital investment in replacement equipment.

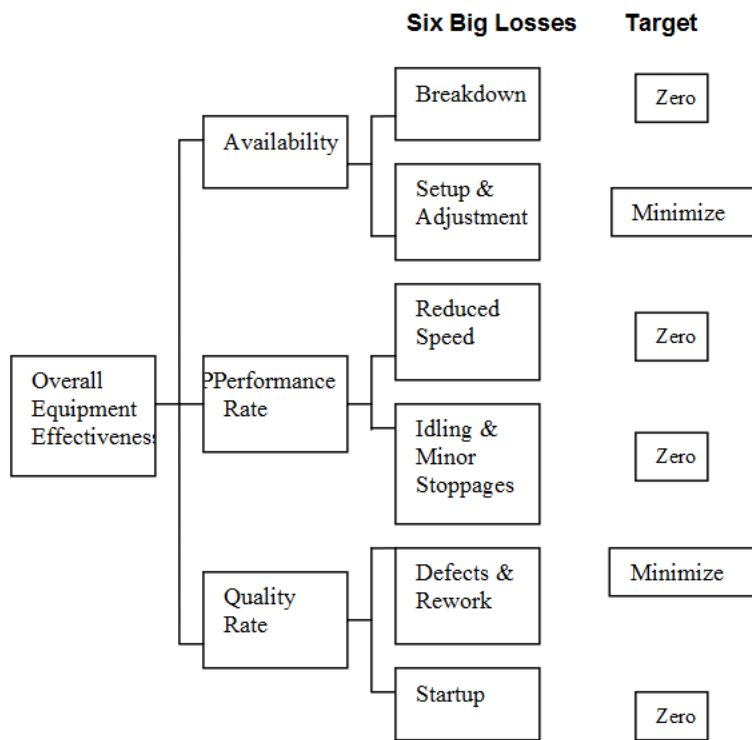


Figure 1: Overall Equipment Effectiveness Model

T.P.M. PLANT WIDE STRUCTURE

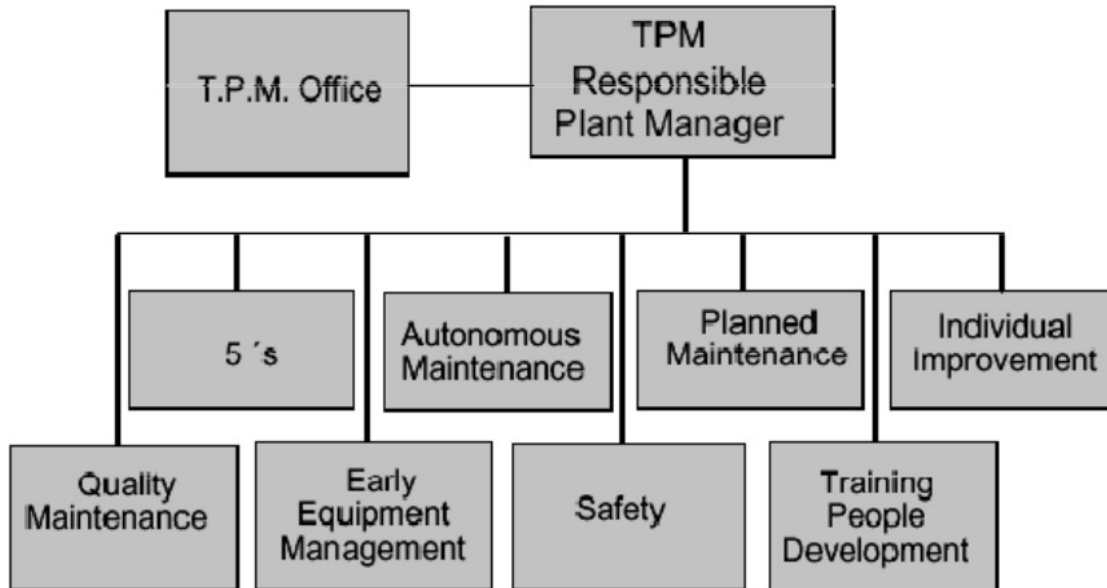


Figure 2: Organization Structure for TPM Implementation