

Enhance and Develop the Key Performance Indicators for Large Maintenance Sectors

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Abstract— Generally, maintenance is a one of the core departments in the large industrial organizations. Continuous evaluation of maintenance performance is mandatory to ensure having less down time and efficient equipment with optimum resources. Key performance indicators (KPIs) are the common tools to evaluate the gained outcomes against the set targets which should be in line with the overall organization's objectives. Maintenance manpower whom are working in large sectors will provide several technical reports for the performed activities considering used strategy, the performed activities, followed steps and the findings. Besides that, when using the modern maintenance like reliability centered maintenance and inspection plans, there will be a requirement to provide another type of reports which are the root cause failure analysis (RCFA) and failure mode effects and criticality assessment (FMECA) reports. At the end, every report should be closed and archived and kept once problem solved for reference and lesson learned when needed. But for long term ongoing troubleshooting and investigation, some reports may be ignored or forgotten. Thus, provision of reports and its submission in specific cut off time shall be considered and to be followed by assigned focal. For employees' individual evaluation, it is important to evaluate each employee alone as it will reflect the personal assessment for individual assessment like promotion, bonus, training, replacement, etc., most of organizations and companies do only the individual evaluation for the working manpower, but also it is needed for higher level of management to assess the average of the overall maintenance large section. This study is made after reviewing most of maintenance KPIs in several areas, two more KPIs are proposed due their importance and added value for proper evaluation. These two KPIs are for: -

- The reports submission at specific time frame
- Measure the overall maintenance department as average performance besides the employees' individual assessment

Keywords— Maintenance Engineering, Maintenance Management, Key Performance Indicators, Maintenance Strategies, Manpower Evaluation, Root Cause Failure Analysis (RCFA) and Failure mode effect and criticality assessment (FMECA).

I. INTRODUCTION

A Key Performance Indicator (KPI) is a measurable character that reflects how effectively the business objectives are achieved. Currently, most of the premises and organizations are using KPIs at several sectors in multiple levels to evaluate their positions compared to the set targets. Generally, the high-level KPIs may focus on the overall performance of the business, while low-level KPIs may focus on performed processes in the departments such as production, sales, marketing, human resources, supporting team and others. KPIs

provide a focus for strategic, operational improvement and create an analytical basis for decision making and further improvement.

Generally, there are two categories of measurements for KPIs which are: -

- Quantitative facts without feedback from personal opinions, prejudices, or interpretations presented with a specific value - objective- preferably numeric measured against a standard.
- Qualitative values based on or influenced by personal inputs, questionnaires or opinions and presented as any numeric or textual value.

In order to set a strategy for KPIs, employees can start with the basics and understand what the organizational objectives are, how to plan on achieving them and who can act on this information. Moreover, it needs understanding of which business processes need to be measured with a KPI dashboard with whom such information should be reported and what would be the outcomes and privileges from the KPI evaluation from the higher level for the working team like (bonus, development, penalties, etc.). One way to evaluate the relevance of a performance indicator by using "the SMART criteria". The letters are typically taken to stand for Specific, Measurable, Attainable, Relevant, and Time-bound.

Key performance indicators (KPIs) are the most important factor presenting performance during the time using regular tracking on specific periods. Obviously, tracking of the progress against the KPI is important by setting milestone or as agreed front-end period for assessment like weekly, monthly, quarterly or in annual basis.

In this study, the focus is on the employee' evaluation especially in the area of technical reports submission. Generally, the preventive and corrective maintenance, shutdown, budget utilization, reliability measurements are reported by the technical dedicated team. But still main reports have no specific cut off time for the submission which leads to keep several maintenance activities open. These major reports are the root cause failure analysis (RCFA) report and failure mode effects and criticality assessment (FMECA). These reports are normally prepared by assigned technical staff when there are unplanned findings, inspection observations or unscheduled break down. Moreover, the average evaluation assessment is needed for the overall maintenance department beside the staff performance evaluation.

II. LITERATURE REVIEW

[1] They defined the key performance indicators as financial and non-financial indicators that organizations use in order to estimate and fortify how successful they are aiming previously established long lasting goals. Their research gave explanation of some KPIs that are used in cars dealerships. Graphical examples of KPIs measured in Toyota dealerships were also adopted. The concept of performance management is used by most of the organizations to ensure that either they are going on the right path or not. [2] Their paper explored the key performance indicators (KPIs) and the impacts on the overall organizational performance in manufacturing sector in Pakistan. The presented data were collected from the top level management of the eighty-four best manufacturing organizations by using a structured questionnaire and the impact of KPIs on the overall performance of the manufacturing organizations were evaluated. The results showed that the manufacturing organizations put more focus on the customer satisfaction and products in terms of performance measurement. Key Performance Indicators (KPIs) allow gathering knowledge and exploring the best way to achieve organization goals.

Many researchers have provided different ideas for determining KPI's either manually, semi-automatic or automatic applied in different fields. [3] They demonstrated different approaches for exploring key performance indicators in different directions including manual, selection, or prediction approaches. As there are diverse ideas, however, they noticed that the prediction approach is still a vital field for research as most of the research are based on a determined point. Even the international standard organization (ISO) had the references of basic elements of using KPI as of 9001, 2000 and developed it to implement a quality management system (QMS) 9001, 2015. This term is commonly used and has been for many years, so the QMS including ISO 9001, 2000 (Certified Service Organization) are elaborated more on the KPI 's requirement and the importance of KPI's processes of internal use, audit and management revisions [4]. [5] He made an important distinction that separates performance indicators from results indicators (like profits, market share percentages, or customer satisfaction numbers). Also, he developed a methodology as new chapters that focus on implementations issues and doing a brainstorming about the performance measures as progress reports. [6] He presented in his book several examples to illustrate the selection and use of the KPIs and provides tools such as KPI selection templates and Key Performance Questionnaires would help applying the most appropriate KPIs effectively in your business.

There are many factors that may contribute to the successful delivery of simulation projects. [7] Their study of simulation projects led to the question of what project success and failure mean. Computer simulation projects which categorized as a service type project have been carried out in many sectors in order to improve the performance of systems. Their results suggested the proposed framework and questionnaire that could be used with some confidence to measure and monitor the performance to benchmark simulation projects which could be done during the course of

the project or after its completion. This could facilitate the identification of issues in a simulation project at early time.

Also, KPIs can be applied in equipment and systems evaluations. [8] In this research, a multi-tube heat exchanger filled with phase change material (PCM) was investigated experimentally to evaluate its capability to serve as a heat storage unit in solar domestic water heating (SDWH) systems. Numerous operational conditions comprising the PCM initial temperature and the water discharge flow rates and the shell-and-tube latent-heat storage unit (STLHS) as a part of a SDWH system. The STLHS unit is assessed according to several quantitative, qualitative, and economic key performance indicators to fulfill the domestic needs according to the benchmark water temperature and fuel saving. [9] Their set KPIs were applied in a manufacturing process in a mechatronic system domain and also in food process operation in the production domain and came out with evaluation monitoring results. [10] Their study was to identify and examine the various (KPIs) of Green-Lean practices in manufacturing industries. Future research will focus on ranking these KPIs of green lean manufacturing using appropriate Multi-Criteria Decision Analysis (MCDA) technique.

Common KPIs were calculated and linearly aggregated in a global index able to convey the wastewater treatment plant energy performance. Such index allowed to carry out comparisons among energy consumptions supported by a dedicated built-up database collecting sectorial data, considered as a reference. [11] Their case study based on ten selected waste water treatment plants. Their methodology suggested to focus on such cases by carrying out specific on-site inspection. The proposed procedure could also be applied with the aim of prioritizing actions to pursue energy savings among a large set of wastewater treatment plants. [12] Their study were proposed for natural gas pressure regulation stations with energy recovery by using different KPIs values for custom prediction models based on system characteristics. Finally, the used simulation was conducted using UniSim Design Suite software. The two systems were configured and implemented and the results showed that the model successfully predicted the heat needs of pressure reduction stations and the proposed KPIs turned out to be a helpful tool to manage design development and system operations. Plenty of studies have proposed the use of a Life Cycle Assessment (LCA) methodology to determine the environmental impact of renewable installations. [13] Their research presented a base grounded approach to be followed for a holistic approach from environmental point of view of renewable based technologies. Through some proposed assessment criteria, the scalar quantification of the environmental impact of multiple energy systems were listed and implemented for energy system assessment. [14] Their paper presented a review of the major existing indicators used in the operation and maintenance of wind farms (WFs). They proposed a list of suitable KPIs allowed stakeholders to have a better knowledge of an operating asset and make informed decisions. It is concluded that more detailed studies of specific KPIs and the issues of their implementation are probably needed. Their research

brought out a proposed strategy map and respective key performance indicators (KPIs) in human resources (HR). The article provided an overview of how HR activities are supported in order to reach the partial goals of HR as defined in the strategic map. Overall the aim of the paper was to show the possibilities of using the modern Balanced Scorecard method in human capital. The aim of presented research is to find and set the KPIs on HR level according to defined HR strategy and targets. The research also presented the strategy map which is a necessary part of the HR scorecard and serves as a base for specifying the KPIs.

[15] Their research aimed to explore the importance of KPIs, its impact on Talent development and the advantages of using the performance management system especially in the large companies where there are difficulties in assessing employees' performance. Using of statistics and indicators in organization were considered as one of the top criteria for measuring and tracking performance and the rating of the desired goals achievements. [16] In their study, they highlighted the active talents need learning, development and frequent gaining of knowledge. They found that such care about the development, training and researches would affect directly their KPIs results and achieve clear improvements.

III. PROPOSED KPI'S

Organization's objectives, strategies, working staff, products, budget, safety, policies and procedures follow up etc. shall be assessed through using suitable KPIs in order to have well monitoring and control to achieve higher benefits and scores. Every line manager will perform the evaluation based on the assigned activities and position's duties. The key indicators shall be customized based on the set indicators, work nature and duties.

KPIs can be categorized into several different stages like inputs, process, outputs and project deliverables. Every organization needs strategic, operational and other measures like project progress, risk and employee measures. To have dependable KPIs, the below main four steps of process shall be followed: -

- 1) Continuous reviewing the business objectives
- 2) Analyze existing performance
- 3) Set KPIs targets
- 4) Review progress and update

Therefore, in order to obtain better performance regarding the employees' contribution and their inputs, there are four major performance metrics shall be considered for the employees' assessments against the following: -

- 1) Performance review against organization's objectives (from roles and responsibilities per position),
- 2) Performance standards (Know –how, attitude to work, follow up of the set procedures and policies, etc.).
- 3) Behavioral competencies like (planning, initiative, integrity, analytical thinking, etc.).
- 4) In addition to highlight the employee's development overview mainly for the area of strength and weakness of the related employee.

All maintenance working team should deliver more efforts to ensure obtaining higher score points and achieve targets.

Table [1] shows a comprehensive KPIs for maintenance section including two additional proposed KPIs. The sorted KPIs were related to several maintenance strategies and sorted based on the common best practices in oil and gas fields as well from some conducted previous researches [17], [18].

The two additional KPIs were proposed are in below: -

- 1) KPI for main technical reports submission mainly for (RCFA and FMECA) to ensure all reports are completed within agreed time frame with clear indication either as closed case or with described next step. Usually, in the reports' recommendation or the next steps, there will be a further action like modification, upgrades or more study.
- 2) KPI for evaluating the average of the overall related maintenance manpower annual performance. The working team has direct impact into the overall performance results, thus the average level is also need to be considered in order to know the working team competencies which will be subjected to management analysis and decisions like (set training, promotions, satisfaction, replacement, outsourcing, etc.).

The two proposed KPIs are demonstrated in table [1] as described in Appendix I.

IV. DISCUSSION

There are several definitions for the KPI and most likely it can be defined as a process used to evaluate the success of an organization, employee, etc. and to evaluate the performance versus the objectives and its progress towards achieving the goals.

KPIs are the tools for internal and external evaluation in any performance management system and should be chosen on professional criteria with support of specialist and line managers or direct supervisors. KPIs will help to reflect if the business results are on target or veering. Using the right indicators will support to obtain the right results. However, lack of performance indicators leads to incomprehension and underestimation of the facts. Any change in company vision, strategies and business process shall require change in the KPIs.

So, KPIs need frequent updates and dynamic revision. Average evaluation for maintenance staff is a unique assessment to consider the department's staff average KPIs as per of the whole evaluation and it needs the head of maintenance department to ensure the implementation and proper assessment.

The advantages and novelty of these two added KPIs are: -

- 1) Maintenance technical reporting submission at particular time frame will improve the reporting quality, knowledge sharing and problems' solving skills.
- 2) Commitment to complete all open maintenance tasks and to keep following up the next step and report's recommendation till the end rather than ignore it or archive as open case.
- 3) KPI as average performance score for the whole maintenance working team will encourage all the maintenance members to provide more efforts, contribution and higher performance to gain good results.
- 4) Average score is suitable for top management to evaluate

quickly the large department and highlights the areas of strength and weaknesses.

- 5) Working team will keep seeking the organization’s management satisfactions and build team work spirit.
- 6) Similarly, can do the same average evaluation to the other departments based on their business processes and targets.

Possible to link the personnel’s evaluation with the departmental average score to assess the evaluation and determine the gaps through a software for process control.

V. CONCLUSION

KPI has several definitions, but at the end it comes to measurable figure of text description use to evaluate the organization resources and achievements versus set targets. Manpower are always considered as major factor for any obtained results. Maintenance staff are one of the core team to ensure having healthy systems, less down time and maximum overall efficiency. Thus, in this study, their KPI evaluation and contribution were considered on the technical reporting

submission (mainly for RCFA and FMECA) with specific time frame. Even if the report investigation need more time, so at least a preliminary version must be provided on particular time and to be followed till close out the report.

As well considered, the overall maintenance team as one group shall be assessed as an average scale beside the detailed individual assessment for everyone. This is to brief the higher management about all section assessment which lead to further decision like to increase the number of personals, trainings, outsourcing, replacement, etc. Once employees know about on time reporting submission and frequent assessment of their overall performance, logically they will increase their contribution, enhance their work quality and taking works execution properly and seriously.

APPENDIX

Appendix I: These two proposed highlighted KPIs are added in below table [1] with suitable scale and targets.

Category	Key Indicator	Scale	Target	Result
Maintenance and Inspection Execution	Compliance Safety: As per company HSE regulations (No of Major Incident due to lack of Maintenance)	No of Incidents	≤ 0	
	PM Completion %	%	≥ 97	
	CM Completion %	%	≥ 95	
	Unscheduled shut down due to maintenance/per plant	No of Shutdown	≤ 1	
	Inspection Plan completion%	%	≥ 95	
Reports Submission	Completion of Reports (daily , weekly, monthly, annually)	days’ timeline	≤ 5 days	
	RCFAs and FMECA	days’ timeline	≤10 days	
Costs	Budget utilization (Budgeted costs versus actual costs)	Utilization %	≥ 95	
Critical cases and outstanding	Number of critical outstanding jobs have direct impact to HSE/Production targets. (exclude delay due to delivery/visa/ security, etc)	No of critical cases	≤ 2	
Reliability, Availability and OEE%	Reliability	%	≥ 95	
	Availability	%	≥ 94	
	OEE %	%	≥85	
Maintenance section Performance review (Average)	Review section performance as average against objectives contribution, performance standards (Know How) and personals’ behavior.	Outstanding or Excellent or Good or Poor	Good as minimum average level for all team members	

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