

Factors Affecting Maintenance Organization and Nationalization of Maintenance Roles (Feedback): A Case of a Mining Share Company

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Abstract: Internally, an organization's maintenance objective establishes the deliverables for its execution strategy and a focal point for engaging its people. Externally, an organization's maintenance objective creates an insight into the organization's attitude to maintenance. Commencing with a clear objective is fundamental to a clear delivery strategy, otherwise, maintenance becomes too expensive. Thus, maintenance represents a significant proportion of the overall operating costs in the mining industry. As such, maintenance of Heavy Mining Equipment (HME) must be effectively and efficiently managed. However, before 2020, the reliability of the HME at AMSC was not satisfactory and this was attributed to poor management within the HME Department. During the initial stage of the Mine, maintenance did not appear critical as almost all or all the equipment was new and received less attention. Though the maintenance personnel at AMSC were "comfortable" with this approach in the past, as the Mine started to expand and production pressure increased, reliability of the core mining mobile equipment became critical and the existing personality / individual driven approach to maintenance was no longer sustainable nor desirable. Maintenance at the Mine lacked a clear objective and a clear strategy. Work execution was personality driven (driven by the individual) with loose coupling of roles and accountabilities allowing informal sub - systems to become acceptable responses in a capital - intensive business with various third - party obligations. The lack of systems of work led to duplication, rework and waste. This further, resulted into generating unproductive costs to the Mine, contributed to frustration within the HME Department staff and diverted resources away from activities that could increase machine health in the short term and shore up revenue generating capacity in the medium term. Therefore, the report gives feedback to AMSC Management on the outcome of the 2020 reliability improvement study recommendations. The most significant action to emerge from the study recommendations was the need to divide the HME Department into manageable Sections based on equipment type and activity. Each Section was assigned a Supervisor with specific responsibilities and accountabilities. The result of this intervention was improved equipment reliability, reduced maintenance cost as well as efficient utilization of manpower. The top management, the General Manager and the Employee Services Manager created an enabling environment where the HME maintenance staff was able to make reliability improvement decision without interference. The duo only provided guidance, transparency and ensured the Department operated within the confines of the organizational objectives and policies.

Keywords: Maintenance Organization, Reliability, Availability, Efficiency, Nationalization, Asset Life Cycle, Major Component

1. Introduction

A Mining Share Company (AMSC) Maintenance Organization comprises the Process Plant, Heavy Mining Equipment (HME), Major Projects and Construction. However, in this study, only HME is considered as it was the Department with the most equipment reliability issues.

The study took an ethnological approach in observing the activities of the Department for a period, January 2020 to July 2021 after the initiation of performance improvement strategies. The paper discusses initial challenges in the Maintenance Organization or the HME Department and dynamics which affected the Artisan Nationalization program. The Artisan Training program was in place for over five (5) years, but no trainee had been certified to full Artisan level.

This report is prepared in the context of engagement to highlight the outcome of the initiatives and strategies implemented to improve and leveraging maintenance management at AMSC. Consequently, the report does not discuss individuals, but merely, every aspect of the equipment reliability improvement measure undertaken by management at AMSC. As such, the reader should be careful to take this into account when forming any opinions

after going through the document. The researcher's intention is to discuss issues that affected the operations of the HME Department and to present a spectrum of activities that were carried out at the Mine to mitigate these issues. To ensure the personal aspect is avoided, the term 'Maintenance Organization' is used.

Maintenance Organization in this context is defined as people with a common goal working together for maintaining satisfactory equipment and machine reliability in order to achieve productive operations and high quality work output. However, there exists no universally admitted method to designing a maintenance system. It depends on the organizational structure with defined hierarchy of authority and defined maintenance procedures and policies. In the highly uncertain economic climate of the moment, a major priority for a mining company is to improve operational efficiency through an effective Maintenance Organization.

2. Objective

The reliability of the HME at AMSC did not satisfy the Mine Management expectations. The numbers of equipment breakdown as well as the maintenance cost were high. Mouli et al (2014: 255) indicates that, breakdown of equipment

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causes unpredictable losses; therefore, reliability of machinery is essential particularly in production processes such as Mining. To mitigate the equipment reliability problem at AMSC, the Mine Management carried out a study to identify the major cause of the poor equipment reliability. From the study results, a number of interventions were proposed and implemented. The most significant action was to divide the HME Department into Sections according to equipment type and activity. Each Section was assigned a Supervisor with specific responsibilities. The result of this intervention was improved equipment reliability, reduced maintenance cost as well as efficient utilization of manpower. As narrated by Barabady (2017: 647 - 653), maintenance cost is a significant part of production costs and logistics and spare part management should be considered early in the design. Therefore, this report has been prepared to give feedback to the AMSC Executive Management on the progress of the strategies implemented in 2020 to improve equipment reliability and to minimize maintenance costs.

3. Maintenance Organization

Though there is no such thing as a perfect Maintenance Organization or an ideal structure, whatever is developed for an organization such as a mining operation needs to have certain explicit tools and systems built into the responsibilities of specific roles within the organization. An organization that is unable to effectively plan and schedule its maintenance activities can never deliver a cost - effective maintenance function. Most importantly, a maintenance Team that does not put the asset owner at the heart of the maintenance strategy will never be aligned to the organization's strategy and will ultimately fail to meet the organizational requirements. Figure 1 (created by: Galatia, 2021), shows the requirements of an effective maintenance Organization for a Mining operation such as AMSC.

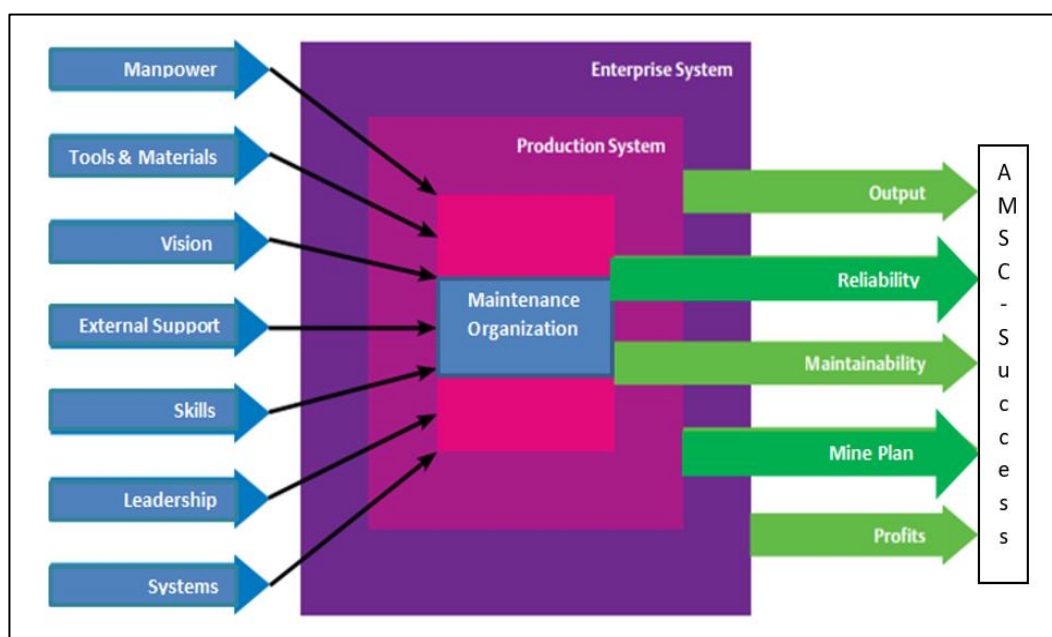


Figure 1: Maintenance Organization Based on AMSC

The concept in Figure 1 has been operationalized by defining each element in order to simplify the presentation.

3.1 Manpower

Manpower planning is an essential function of a Maintenance Organization and a prime requisite for organizational success. There must be a balance between the available manpower and workload. Excess manpower is a cost to the company and lower than normal number will affect maintenance planning and subsequently, resulting into incomplete maintenance activities. This can also result into stress of employees and loss of morale. Therefore, a continued supply of optimal, able and quality labor is essential for achieving the pre - determined goals of an organization. As such, a Maintenance Organization in pursuit of an effective HME labor force must review both organisational structure as well as the capability and quality of the workforce.

3.2 Tools and Materials

The quality of tools used by the maintenance Team is as important as the tools themselves when it comes to work and repair quality. Being a known fact that there is an extensive range of tools that are required for a wide variety of maintenance activities, it is important to ensure that the right types and quality of tools are chosen to meet maintenance needs. Otherwise, wrong tools result into poor quality of work as well as delayed completion of tasks and consequently a safety hazard to both personnel and equipment.

Another critical aspect of a maintenance process is the availability, type and quality of materials used. This is a wide scope and requires special attention. In an operation like mining, quality of maintenance parts and materials such as lubricants is essential. To ensure this is achieved, a Quality Management System (QMS) is required. This may

take a duo process, Quality Assurance (QA), this should be built into the maintenance activities and designed to ensure that, quality is observed by the maintenance personnel when carrying out any task. Secondly, Quality Control (QC) must be performed to ensure that, all work carried out within the maintenance system is inspected and any potential deviations from maintenance standards corrected. Therefore, it takes both types of activities to reach desirable quality goals. As such, a maintenance organization needs to review and find solutions to parts and materials management issues. The inspection of both work carried out by Artisans/Technicians as well as the quality of maintenance parts should be the focal point. The involvement of the maintenance personnel in the procurement of parts and materials should always be emphasized.

3.3 Vision

The aim of a maintenance Organization in a mining operation is to provide reliable equipment to operation Departments on time and within cost. As such, in order to achieve these goals effectively, the Maintenance Organization must have a clear vision which must fit into the core organization vision. Tsang (1999 691 - 715) indicates that a better maintenance process should be guided by the integration of critical success business factors, which should be derived from the overall organizational strategy. The vision should provide a long - term objective that the Maintenance Organization must actively work towards to achieve. Strategy is a plan for how the Maintenance Organization is to achieve this vision, while the policy is a statement of intent and a guideline to regulate decisions and achieve the desired objectives. In an HME set - up, performance indicators such as Meantime To Repair (MTTR), Meantime Between Failure (MTBF), Availability and Planned Maintenance Compliance should be emphasized. Other aspects such as labor utilization and budgeting should equally be considered.

3.4 External Support

The main sources of external support for a mining operation are Suppliers and Contractors. Therefore, supplier and contractor management should be a key element for an effective Maintenance Organization. Though Supplier Management is largely a Supply function, the Maintenance Department needs to be fully involved with supporting the Supply functions in an organization. To ensure this is adequately complied with, the HME Department should be fully engaged with Supply Chain in:

- 1) Supplier Selection – The Maintenance Department should assist the Supply Department in Supplier selection as they are more familiar with the equipment used on the Mine site. Their technical contribution assists in avoiding ordering wrong or poor quality parts and materials.
- 2) After Sales Facilities – When major equipment such as Mining machines is supplied to the Mine, the Supplier liaises with the Maintenance personnel on all technical matters. This is to ensure that the equipment purchased by the Mine is fit for purpose (meets the criteria).
- 3) Inspection of work – The Maintenance personnel inspect work such as rebuild carried out by Contractors and make recommendations. This also involves the

inspection of equipment and parts supplied to the Mine site.

- 4) Specifications – The Maintenance personnel assist the Supply Department in drafting site build specifications for equipment to be purchased to ensure correct equipment is procured.
- 5) Parts Forecasting – The Maintenance Department through the Planning Section provides spares projections as well as determining maximum and minimum stock levels of maintenance parts and materials. This assists the Supply Department in carrying an economical inventory as well as avoiding or minimizing parts runout.

This relationship between the Maintenance and Supply Department is crucial. If there is no effective coordination and communication, there is always a high probability of stock run out which results into equipment extended downtime. On the other hand, high inventory holding is possible which subsequently affects the organizations' bottom - line.

3.5 Skills

Skills are essential and require close monitoring and administrating to ensure effective equipment operation. Here, both managerial and technical skills are considered. Factors such as years of relevant work experience on a specific machine, personal disposition, work environment, motivational management, training and continuing education, are all relevant factors which tend to impact on the effectiveness of the performance of a maintenance system. Cabahug (2004: 119 - 122) commented that, factors such as, years of relevant work experience on a specific machine, personal disposition, operator reliability, work environment, motivational management, training and continuing education, are all relevant factors which tend to impact on the effectiveness of the performance of a maintenance system. These factors may affect the effectiveness of performance of a maintenance system. As such, if the Maintenance Organization is not administered and managed by talented and educated people, the unit cost of operation will be affected adversely. Well - trained, well - educated Managers fully equipped with contemporary management techniques and skills will have a positive influence on the costs of maintenance. In short, it may be said that, the quality of the people running the Maintenance Organization, is as important as the quality of the equipment they work on. Additionally, continuous training of maintenance personnel is important to keep up with the dynamics of technological advancement in the modern Mining equipment and machinery. In supporting the importance of technical skills, Mkemai, Gustaffsson and Schunnesson (2011: 43) indicate that, training of maintenance personnel is key to reducing equipment breakdowns through proper identification and resolution of equipment faults.

3.6 Leadership

To create an effective Maintenance Organization, a senior leadership (Engineers, Superintendents, and Supervisors etc.) is required to influence the whole functional activity. Maintenance performance can never rise above the quality

of its leadership and supervision. From good leadership stems the teamwork which is the essence of success in any enterprise. Superior leadership shapes nearly every facet of a Maintenance Organization. Additionally, leadership must go with a well formulated structure which must adequately cover all areas of the Maintenance Organization. The two aspects, leadership and management are defined in the context of this study and may not be generalized. Management is taken as managing processes, projects, and people, it is based on outcomes and focuses on optimizing maintenance activities. Additionally, management involves providing support to employees. On the other hand, leadership is viewed as understanding the people one works with. By being a good leader, a Manager can make sure his subordinates are satisfied with their jobs.

3.7 Systems

The Maintenance Organization should start with an organizational structure. The organizational structure should define how activities such as task allocation, coordination, and supervision are directed within the Maintenance Organization in order to provide efficient equipment within time and cost. Further, the organizational structure will influence the Maintenance Organization actions and provide the foundation on which standard operating procedures and routines are anchored. It should determine which individuals get to participate in which decision - making processes, and thus, to what extent their views shape the Maintenance Departments' actions.

Systems must include Computerized Maintenance Management System (CMMS), also known as computerized maintenance management information system (CMMIS), Operating philosophies, programs and strategies. All these must be aimed at making the Maintenance Organization effective and efficient. There should also be systems in reporting, managing equipment reliability and responding to employee's needs.

When all these variables are correctly managed, the Maintenance Organization is effective and operates at a proactive manner rather than reactive. Thus, the level of machine breakdown and rework is minimized. High equipment reliability comes as a result of good maintenance practices and this results into high productivity and achieving production budgets. On the other hand, reliable machines allows the enable systems within the Mining fraternity to be effective and to work within plan. Finally, when the productivity is achieved within cost, a mining operations makes a profit and is able to sustain operations going forward.

4. Workforce Nationalization

In general terms, Nationalization is the process of transforming privately - owned assets into public assets by bringing them under the public ownership of a national government or state. Therefore, Workforce Nationalization in the context of this study, is considered as the AMSC's initiative to recruit, employ and development the citizens of the country in order to take up certain jobs. Thus, reducing the country's dependency on an expatriate workforce. These

efforts are defined as a multi - level process through which reliance on the expatriate workforce is reduced and citizens are prepared to take up jobs performed by expatriates. Such preparations will enable National employees to perform their jobs equally as well, if not, better than expatriates in the shortest possible period if the focus is sustained.

Integration of a skilled workforce and reducing dependence on expatriate workers has been one of the top agendas for AMSC Management. As the country's economy continues to grow, continued economic growth and industrial diversification demand a qualified and competent local workforce. On the other hand, with the growing population of young Nationals graduating from various Universities and Colleges every year within the country, there is an urgent need to integrate them into the job market especially in the private sector to strike the right balance in representing local talent in the workforce. To meet such challenges, some Mining organizations in corroboration with the Government adopt human resources development strategies which target the employment of native - born workforce through various incentives, regulations, policies, educational reforms, and economic diversification plans.

However, workforce Nationalization goes with various challenges such as, "Balancing workforce Nationalization efforts while leveraging experienced expatriate talent; public pressure to reduce local unemployment especially in the backdrop; skills shortage and increased global competition. Additionally, another level of challenges stems from the fact that, there is little to no systematic approach or framework to dealing with challenges arising from the need for workforce Nationalization. Rare and few points of view on the topic of workforce nationalization come from specialized advisories and through leaders in this space such as Agile Dynamics 'Workforce Nationalization framework'. Further, a number of Governments do not get fully involved in workforce Nationalization, more especially in the private sector, usually for the fear of losing investment from foreign investors.

5. Discussion

The ability to get the most out of a maintenance Organization is largely dependent on the provision of plant, equipment, work areas and people that are not only safe, but also reliable in the consistent delivery of quality, time and cost outcomes that underpin the required production profiles over time. However, the HME Department at AMSC was not adequately structured to effectively provide the required resources and systems. Unlocking superior performance is about reducing the variation in the performance of people so that systems and processes become more stable and outcomes more predictable. Stability in work execution requires effective management of people, plant and equipment as well as work areas. Certainly, this was not the case with the HME Department at the Mine. The lack of effective Management of these resources led to 'variability in work execution' where the Department responded to individuals' and short - term agendas resulting in processes that were unstable with respect to the key organizational requirements of quality, time and cost. The Department did not develop the necessary competencies, discipline and

corporate memory mainly because no gap analysis was conducted to determine the needs of the Department. Firefighting was the order of the day.

Since the Mine was growing, with the open pit getting deeper, it was unrealistic to expect individual Managers to have the same level of control and be as effective with multiple challenges which come with growth. It may seem obvious, but people only know what they know, and it is the role of the organization to determine what they need to know in the context of the business they are engaged. Therefore, Management conducted a study to identify the major cause of the numerous breakdowns within the HME. Significant

findings arose from the study and mitigation measures implemented. The factors identified are organized into specific components and discussed in this document.

5.1 Summary of Components

A summary of the findings for the most critical areas is highlighted, showing the component as the area of concern. Purpose, indicates the need for the component; background, presents the major highlight of the issue; observation highlights what was seen from AMSC Maintenance Organization and finally the summary, giving an overview of the situation.

| 5.1.1 Structure | |
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| Purpose | The purpose of this component is to explain the importance of the organizational structure to a maintenance organization and to assess the model and effectiveness of the structure at the Mine. An organizational structure assists in defining authority, responsibility and relationships within an organization. It facilitates better understanding of the objectives and the policies of the organization and lays down both channels and the patterns of communication. It eliminates ambiguity in operations and fosters accountability. |
| Background | The HME Department structure did not clearly define authority, responsibility, relationships nor channels of communication. The Department was headed by the Engineering Manager and below him came, the Maintenance Engineer, Superintendents, Supervisors, General Foremen, Foremen and then other Operatives. However, despite having these roles, the leadership responsibilities were not defined. The allocation of work was not specific as the leaders were not assigned Sections. The poor organizational structure design resulted into among other issues, confusion within roles, a lack of coordination among departmental members, and failure to share ideas. |
| Observations | Responsibilities and expectations were not clear, hence, it was difficult to identify individual roles, responsibilities, interactions and dependencies. Operatives, more especially Technicians, were answerable to several Supervisors within the HME Department. The employees usually become confused by receiving a variety of messages and being given conflicting instructions. In certain instances, it was seen that some Technicians were loyal to Supervisors they liked and not to others, thus, playing one Supervisor against the other, which steered friction among Supervisors. On the other hand, this condition led to problem solving initiatives and new ideas to be none existence and innovation almost impossible. Even though some of the HME personnel had innovative ideas to improve various sections of the Department, poor communication led to such ideas not to reach the right source for development and implementation. As such, Technicians and other HME Operatives who come up with new ideas kept them to themselves. A bad organizational structure does little to foster the concept of teamwork. The poor structure also led to most employees to be unwilling or unable to cooperate with each other and this resulted into delays in completing tasks. A number of workers focused on their individual tasks and could not offer assistance to others unless directed to do so by a Supervisor, This equally delayed completion of certain tasks. Due to these challenges, manpower utilization was very poor and maintenance cost higher than expected. |
| Mitigation | In the third quarter of 2020, the Department was segmented into Sections according to fleet type and leadership was allocated accordingly. Some National Artisans who showed leadership qualities were given supervisory roles and understudied by the HME Engineer and Expatriate Supervisors. From the new structure, the number of personnel required in HME Department was determined and hiring of qualified and competent personnel commenced. Four months after implementing the new structure, the reliability of the equipment improved; CAT775 Dump Truck Availability improved from an average of 56% to 89%, CAT789 Dump Trucks from 38% to 75%, Excavators CAT6015 and 6018 from 54% to 85% and Auxiliary equipment from 40% to 88%. Due to the flexibility in the structure, the National Artisan training program was made possible as each trainee was allocated a Section and worked under the supervision of an appointed, qualified and competent mentor. |
| Summary | The new organizational structure addressed the qualifications, competencies, skills and experience required to deliver the organizations' objective. With this structure in place, each individual knew his/her role, where they fitted into the overall HME structure, their responsibilities and accountability and what was expected of them. |
| 5.1.2 Leadership | |
| Purpose | The reason for reviewing this component is to assess and understand the level of leadership in the HME Department. To be a successful leader/manager, one needs to demonstrate leadership ability. A leader must be self-motivated, organized, trustworthy, empathetic and optimistic. A true leader has a clear vision of where they want the maintenance Team to go and they set a positive example that encourages others to follow. The leader's motivation and confidence must rub off on the Team and create a healthy and productive work environment. Leadership is also about getting the job done properly through others. Delegating work to subordinates is an important function of management, otherwise nothing ever gets done. Delegation frees up precious time so that a Manager can focus on high-level, high-value activities. Great leaders get things done by inspiring and empowering others to do great work for them. They foster motivation by giving subordinates autonomy to do the job, by creating a supportive environment, and by giving recognition when the job is done well. With the undefined roles, this aspect was not practical from the HME leadership. |
| Background | The HME Department failed to provide competent leadership and this led to informal leadership prevailing over Management in controlling and regulating the behavior of employees. This situation also resulted into leaders |

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| | <p>failing to influence workers, to improve their performance and to provide adequate communication within the Department. Further, there was no effective two - way communication, man - to - man personal relationship, no participation and creation of opportunity for need satisfaction. This condition led to poor equipment reliability and high maintenance cost which became a major concern for Management and shareholders.</p> |
| Observations | <p>There was no firm leadership in the HME Department to direct the Team. There was a culture of silos where each leader had his own favorites. Leaders did not set standards for the Team nor did they set Key performance indicators (KPIs) for their subordinates. There was no feasible tool for measuring performance of individuals. The sense of responsibility from the leadership was not visible and this made the people on the ground not to understand their roles. Additionally, the leaders were not committed to knowing what their subordinates were tasked to do. In short, measuring of subordinate’s performance was non - existence. Due to lack of performance appraisal, some of the employees were misplaced and wrongly considered incompetent. High turnover of Managers and Supervisors was observed and this was mainly because of misunderstandings within the Department and working without a defined strategy. This condition steered up frustration among managers. The leadership seemed not to understand the concept of the HME Management and this resulted into making wrong decisions. Supervisors worked in silos and did not present real challenges the Department was facing. In certain instances, written strategies were copied from internet and presented to top Management. However, these strategies were not specific to BMSC and this created confusion as the intended objectives could not be met. Employees often suffered from emotional problems as the line of reporting was not specified. As such, they got frustrated because of their inability to do certain jobs, to secure promotions, to sharpen their skills, to get along with people, etc. The leadership within the HME Department did not render their subordinates any, wise counsel nor tried to remove barriers (real or imaginary) and could not instill confidence in these employees.</p> |
| Mitigation | <p>To enhance leadership, the Department was divided into Sections and specific Supervisors were assigned to each Section. Each Supervisor was given a set of responsibilities and accountability set in form of Key performance Indicators (KPIs). The Section leader presented the performance of the Section every day during the equipment performance review meeting chaired by the HME Engineer. Competent National Artisans were appointed in supervisory roles and coached by senior HME officials.</p> |
| Summary | <p>Maintenance lacked a clear objective and a clear strategy. Work execution was personality driven (driven by the individual) with loose coupling of roles and accountabilities allowing informal sub - systems to become acceptable responses within the Department. Relying on ‘personalities / individuals’ to deliver acceptable maintenance outcomes brought with it significant known and unknown risks. The rules, relationships and processes necessary to deliver effective maintenance outcomes were not visible and consequently people made their own rules to suit the circumstances, which could or may not align with AMSC’s expectations. This did not provide comfort / protection to those with legal / regulatory responsibilities. The lack of systems of work led to duplication, rework and waste. These added unproductive costs to the mine, contributed to frustration within the maintenance and production groups and diverted resources away from activities that could increase machine health in the short term and shore up revenue generating capacity in the medium term. The result being that, maintenance at AMSC was in a ‘variability’ paradigm with unpredictable quality, time and cost outcomes. This paradigm reflected an attitude to maintenance that was driven by behaviors promoted by the existing formal / informal routines applied to the maintenance function. However, the segmenting of the Department helped to improve leadership within the Department.</p> |

5.1.3 Assets and Life Cycle Management

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| Purpose | <p>The purpose of this section is to explain the requirements for developing a ‘whole of life’ approach to the management of assets through effective specification, justification, procurement, commissioning, maintenance, disposal and liability strategies which enables informed decisions based on effective investment proposals and practical management plans.</p> |
| Background | <p>The Mine did not have a firm approach to specifying the requirements for individual assets over the procurement to retirement. Additionally, the Department did not ensure that assets were fit for purpose, significant maintenance interventions identified in advance, disposal values maximized, and post disposal liabilities mitigated. Senior Management proposed a run to failure strategy for all components. This however, resulted into serious collateral failure of components, thus, presenting high maintenance costs.</p> |
| | <p>Equipment purchase decisions and specifications were made by user Departments with little or no involvement of the Engineering Department. There was neither a maintenance risk assessment nor operational risk assessment prior to placing orders for new equipment. This led to purchasing wrong equipment or equipment of poor quality such as experienced with the CAT789B Dump Trucks and Dozers where huge sums of money were spent in correcting rebuild errors. Galatia (2021) indicates that, a machine or component life starts right from needs analysis through to machine configuration and application. Therefore, both operation and technical staff involvement is critical in major equipment purchase decisions. New equipment mobilized to site fell in line with the general maintenance paradigm of consultants and not necessarily, what was required for the long - term health of the asset. This was noticed from the Consultant who was hired by the Mine to source equipment. All the equipment sourced by the consultant did not meet the Mine requirements in terms of quality. The Mine had to spend huge sums of money to correct errors and in certain circumstances; equipment was decommissioned at very low hours due to high maintenance and recovery cost. Dump Truck (DT37) is one example, the machine only operated for three months and it was decommissioned due to high maintenance and correction cost arising from a poor rebuild. The absence of a proper asset maintenance plan for individual equipment eliminated an important tool for increasing the level of accuracy in budgets / forecasts, establishing appropriate manning levels and providing lead indicators of future asset health. Equipment and component life cycle data was tracked and archived through the Planning Office. However, lack of formal processes for regular verification of asset health and component liability eliminated the ability to provide a reality check on the performance of equipment components. Further, the absence of standard machine specifications and lack of full involvement of the maintenance personnel in equipment purchase decisions, allowed outsiders, such as</p> |

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| Observations | consultants with less knowledge of AMSC needs, to dictate the purchase of new, secondhand and refurbished equipment. Though the Primary Component Replacement plan (PCR) existed, it was not followed as planned mainly due to lack of a proper condition monitoring system and decision making. Most of the maintenance decisions were made by senior Management officials and this left the qualified and competent maintenance personnel with no authority to analyse equipment performance and make technical decisions. The result of this was poor equipment reliability and multiple equipment downtime. |
| Mitigation | The Planning Section was restructured to ensure roles were clearly defined and responsibilities assigned appropriately. This included the introduction of the Planning Engineer. The role is meant to oversee all the planning activities of the HME Department. To assist the Planning Section in equipment reliability issues, the Reliability Section was introduced, headed by the Reliability Engineer. The main function of this Section is to track equipment life, assist in equipment purchase and rebuild decision, condition monitoring, assessing and refurbishing of failed and overdue equipment components. A system of tracking equipment and component life was enhanced and a position of the Maintenance Data Analyst was created. The Data Analyst task is to collect all equipment performance data such as Meantime To Repair, Meantime Between Failure, Availability, Planned Maintenance Compliance, maintenance cost and all other information related to equipment and manpower performance. This data was analyzed and provided to the HME Engineer and the Planning Engineer for further analysis and decision making. Site specific equipment specifications were introduced. These provide all the important details of equipment to be purchased on the Mine site. This is done in order to avoid procuring equipment not fit for purpose. Additionally, a technically sound, qualified and competent Engineering and Maintenance Consultant has been appointed and works with the maintenance Team almost on a daily basis. The Consultants worked for AMSC and has the full understanding of the Mine requirements. On the other hand, the new Management has given authority to the maintenance personnel to make independent maintenance decisions without interfering in the running of the Department. This step by Management has motivated the HME Team to work harder. |
| Summary | The enhancement of an effective asset lifecycle management strategy has assisted the Mine in breaking down the various stages in the life of Heavy Mining Equipment (HME). This has enabled the maintenance personnel to sufficiently analyse equipment performance, opportunities for cost or efficiency savings, and when and how to replace equipment when business needs arise. The strategy has brought about a number of advantages. Firstly, the Department is able to adequately define the Heavy Mining Equipment, along with the condition, usefulness, and cost - effectiveness of each machine in order to assist with future planning. Additionally, the clear and defined asset lifecycle management approach has helped the Mine to approach its register in a proactive, rather than reactive manner. Enhancing the component life cycle management has enabled the HME maintenance staff to predict likely future scenarios in relation to component life. This allows Management to take positive and well - planned steps relating to maintenance and eventual equipment replacement. The well formulated asset lifecycle management strategy has emerged as a great tool to ensuring regulatory compliance of the organization's asset register. The strategy has also assisted the maintenance personnel in understanding the new equipment before it arrived on site. Thus, the maintenance Team is able to know the kind of tools required and how these tools are to be used to leverage success. |

5.1.4 Parts and Materials Management

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| Purpose | Materials management system ensures the availability of right materials with minimum wastage so as to cut losses. It is a core Supply Chain function and includes Supply Chain planning and Supply Chain execution capabilities. Specifically, materials management is the capability an organization use to plan total materials requirements. Thus, user Departments are expected to be fully involved with the materials management process. As such, this section explains how the HME Department deals with its materials requirements at the Mine. |
| Background | The reliability of equipment was poor with a number of machines being down for longer periods awaiting replacement parts. The maintenance personnel, however, indicated that, the condition was caused by the extended lead - time of replacement parts as well as the non - availability of certain routine maintenance parts. |
| Observations | A number of major mining equipment was down awaiting replacement parts. On the other hand, a number of routine planned maintenance schedules were not followed due to lack of replacement parts on site. This situation resulted into more breakdowns such that even those machines which had sufficient maintenance parts were not maintained as the Technicians in charge of maintenance were always engaged with breakdown work. It was however, reviewed through a study conducted in 2020 that, the materials manage system within the HME Department was not effective and did not engage the Supply Chain in time. The impact of Parts and Materials management on productivity and quality of maintenance outcomes was not fully understood and this resulted into poor performance especially in terms of time, cost, quality, and productivity. The Planning Supervisor did all parts and materials requesting and follow - up alone. This was because, the rest of the planning staff worked merely as Clerks since they had no planning experience. The task was too large for a single Planner with two data clerks. Though component replacement scheduling existed, the plan or spares projections was not shared with the Supply Department and no prioritizing of requirements was made. All parts were request at the same level of criticality making it difficult for the Supply personnel to distinguish between the high and low priority items. Additionally, the Department did not have a Materials Coordinator to operate as a link between the HME and Supply Department. Expediting of parts was done by the Maintenance Supervisors who were usually tied up with maintenance and breakdown work. Further, the maintenance personnel did not proactively provide sufficient information such as materials focus to the Planning Department. In most cases, requests were made only when there was a breakdown or when a potential failure was observed. There were no scheduled meetings between the maintenance and Supply personnel to discuss the status of requested parts and materials. |
| Mitigation | A study was conducted in March 2020 and it was found out that, Supply only contributed 16% to the equipment downtime. The major drawback was lack of an effective materials management process within the HME Department to initiate the needs. To this effect, the Planning Section was reorganized and a position of Parts Coordinator was introduced to monitor martial movement. A weekly update meeting was also introduced between |

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| | HME Planning and Supply Chain to discuss the spares and materials status. |
| Summary | Parts and Materials management presents a significant opportunity to reduce rework / waste and improve maintenance outcomes whilst ensuring inventory remains fit for purpose. With the initiatives implemented, the forecasting of parts and materials became effective with reduced machine downtime. |
| 5.1.5 Work Identification | |
| Purpose | To successfully manage a well - defined 'maintenance planning and scheduling' work process, it is important to start with an effective and timely identification of equipment problems, followed by the capturing and communication of the information in clear and concise terms. The objective should be clear: The Maintenance Work Identification methods need to support early identification of equipment problems or potential problems, while capturing the issues in an effective manner. It creates timely awareness and maintenance / reliability involvement. This helps to address equipment issues during the early stages and keeping losses to a minimum. Additionally, addressing Work Identification deficiencies is a good starting point towards an improved Maintenance Planning and Scheduling model. Visibility to equipment problems is essential and dealing with existing problems starts with early Work Identification and Notification Entry. Therefore, this component highlights the work identification process carried out by the HME Department, challenges faced and mitigation strategies implemented to resolve maintenance work identification issues. |
| Background | Though the Planners prepared work schedules, the maintenance personnel did not follow the issued work plans. The maintenance personnel reacted to work in an informal manner with little or no planning. Within the HME Department, there was lack of discipline and structure, where people ignored identified work because responsibilities were not clearly defined. There was no identifying and prioritizing of work, the maintenance personnel concentrated more on breakdown work which was random. Warranty investigation was not adequately defined and work priorities were not well defined or documented as to who was accountable for what work. This elevated the risk of defects not being prioritized correctly and becoming 'not my job by default'. |
| Observations | <p>Though the asset register was available for all equipment on site, there was no clearly defined work identification methods in place, thus, there was little structure and responsibility in place to help identify equipment, safety and process issues. The focus was mostly on entering Work Requests for equipment problems that needed attention immediately or in the very near future. As such, a large percentage of existing problems was simply not identified. Though work or problems were identified by workshop and field maintenance personnel, the priority and possible consequences were considered as low or insignificant. Most of these jobs were not entered into the CMMS (NAVISION) system until a problem escalated to a high - risk and high - priority issue. Specific, clear and concise work requests outlining the problem and the equipment involved only existed in few cases, and were often restricted to one or two individuals within the HME Department. Additionally, due to communication challenges as the Department had personnel from different countries, work requests were usually written in very general and vague terms, making it very difficult to understand the problem or work suggested. It usually took days in follow - up, to gather the additional information needed to identify the real problem or action required. The other challenge identified was that, clerks who entered maintenance notifications into NAVISION did not receive training or any form of organized coaching. The clerks fought their way through the system's screens and functions and created their own entry approach. Then, once they had saved the notification records, they had no idea how to retrieve the information to track the request status or make any additions or changes. This led to delays in executing work and in some cases the recorded task was totally forgotten and not done. There was also lack of communication between the workshop personnel and the planning staff. On several occasions, the workshop and field personnel carried out work without the concert of the Planning Staff. There was yet another issue, that of delayed or none submission of works orders. Though the maintenance personnel collected works orders from the planning office, they did not return them to the planning office for data entry and analysis. This situation made it difficult for the planning personnel to compute such information as Planned Maintenance Compliance and labor utilization computations.</p> <p>On the other hand, requirements for Pre - Start Inspections were reasonably well understood – however, pre - start inspections were conducted by operators without maintenance personnel intervention. This approach hid or compromised the quality of the Pre - Starts and reduced the usefulness of Pre - Start Inspections as the first line of work identification. Sorting out the quality of Pre - Start inspections and process for handling Pre - Start inspection reports needs to be a priority with full involvement of maintenance personnel, however, this was not the case. Daily Inspections and Service Sheets provided prompts, but not a clear acceptance standard was defined. In some instances, a checklist may have been completed and 'ticked', but underlying defects were not recognized or highlighted. Defects notified to the planners were captured in spreadsheets, nevertheless, there was a significant level of defects recorded in other spreadsheets, written in note books or stored in files that were not formally recognized – meaning equipment backlog records were not be accurate. Due to the high number of breakdowns, there was no time to accurately identify backlog work. Damage to equipment appeared to be both an issue and a cause of frustration, however damage investigation and action to prevent damage did not appear to be a priority. Therefore, the true cost and production impact of damage was not known. Though claims were recorded, the system for identifying, reporting and following up warranty issues was not effective.</p> |
| Mitigation | The first thing was to conduct an investigation into the cause of poor work identification. A system has been put in place for the maintenance personnel to accompany operators when carrying out pre - start inspections and resolving all faults that require immediate attention. Identified faults that do not require immediate attention are deferred and reported to the Planning Section as backlog work. Additionally, the Mechanics from the lubrication station have also been given a task of inspecting vehicles during refueling and greasing and reporting any identified faults or potential faults to the planning Section. To further enhance the inspection of machines, the HME Department has been divided into Sections according to equipment type and allocated responsibility to specific individuals. This has improved communication between the work floor and the HME leadership. Further, the role of machine inspector |

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| | has been introduced with the task of inspecting all equipment leaving the work. In terms of warranty claim, a tracking system has been formulated and managed by the Planning Section. |
| Summary | Fostering the quality of pre - start inspection, daily inspections and service sheet documentation has promoted the identification of issues requiring action. This has also brought about a more comprehensive understanding of machine back log and machine health. |
| 5.1.6 Work Planning | |
| Purpose | In a work place, though a plan cannot remove all obstacles that may arise during the execution of various tasks, it however, gives an opportunity to organize thoughts of management and operatives, helps to evaluate options and reduces potential difficulties within an organization or work processes. On the other hand, proper planning prevents poor work performance, enables effective allocation of resources and limits the amount of rework or waste which retards productivity and delays in work schedules. The purpose of reviewing work planning is to understand how work together with the required facilities, equipment, skills, labor, resources, parts and materials and work schedules are managed by HME maintenance staff at AMSC. |
| Background | Work performed within the Department was random and only focused on the day to day activities. Generally, equipment downtime was high mainly because spare parts were not readily available or manpower to work on broken down equipment was allocated to other tasks. The number of rework was equally high and such failures were not investigated to identify the root cause. Thus, there were numerous related breakdowns which were not investigated. This adversely affected productivity and became a major concern for Management. |
| Observations | The Department did not specify the goals to the Team members, thus, there was no clearly defined number of goals, objectives, nor programs to provide guidance. In short, the HME leadership did not identify, understand the needs or set meaningful priorities in order to pursue desired results. The Department depended only on informal daily scheduled work and attending to breakdowns, both of which were not forward look. The lack of knowledge made it difficult to stay committed to processes. The other inhibiting factor was having people in leadership positions who did not adequately understand the concept of planning, but carried out work on first come first save basis. The focus was to send the equipment into operation without taking into consideration the quality of work. Additionally, the Department staff did not differentiate between planning (how the work is to be completed) and scheduling (when the work is to be completed) – the focus was on scheduling. Planning was seen by the HME management Team to be relevant to PM Services and breakdown only. The absence of formal planning processes and routines had a significant impact on the quality of maintenance schedules and the productivity of the maintenance crews. The Department did not allocate planned maintenance, breakdowns and backlog work in a planned manner, emphasis was on breakdowns and this seriously affected Planned Maintenance Compliance. The average Planned Maintenance Compliance was below 70%. Additionally, due to the ineffective labor structure, there was no accountability in terms of completing PM work nor planning for tasks. On the other hand, issued job cards were not always returned to the Planning office and this equally made it difficult for the Planning personnel to have adequate feedback from which they could base their planning. Feedback assists the Planning personnel to identify backlog work and plan the execution of such tasks with minimum interruption to planned maintenance activities. The Planning Section was under staffed. The Senior Planner carried out almost all planning tasks from data collection, materials coordinating, equipment performance analysis, creating of job cards and chairing daily equipment performance review meeting to name a few. |
| Mitigation | <p>The start point was the development of an organization structure which divided the Department into fleet type and nature of work. The structure was formulated in order to define how activities such as task allocation, coordination, and supervision were to be directed in order to achieve set objectives. This structure specified threads of authority as well as responsibility and accountability by segmenting the Department into individual Sections. Therefore, to achieve this cause, extra labour was recruited to ensure all roles were adequately managed. The new structure created flexibility within the Department with roles sufficiently defined. This eliminated role conflict and random responsibilities. Further, allocating of work and monitoring of progress is made feasible as all reporting streams are defined and clarified. To ensure that work is easily identified, planned, scheduled and executed, the whole planning Section has been revised with new role introduced. This includes:</p> <ol style="list-style-type: none"> i. Planning Engineer: Who is the head of the Planning Section, looking at all work relating to planning. ii. The Planning Supervisor – Assisting the Planning Engineering with the day to day work, ensuring that data is collected and analysed appropriately. The role also ensures that work is planned, scheduled and executed accordingly. iii. Planners – This role is responsible for planning daily work, breakdowns and backlog work. The position also ensures that maintenance parts and materials are always available on site. iv. Scheduler –The main function of this role is to schedule work. This includes allocating work bays to equipment (queuing) for planned maintenance or breakdown repairs. v. Data Analyst – Collecting and analysing all equipment performance data as well the Department cost data. vi. Dispatchers – These are control room operators who collect equipment performance data on a 24 hours basis and submitting this information to the Planners and maintenance personnel. They are also a channel between the operations department and maintenance personnel in communicating equipment breakdowns and related issues. vii. Parts Coordinator – This role is a materials management role and is responsible for identifying, projecting, scheduling and ordering of maintenance parts and materials. The main function of this role is to avoid parts runout and overstocking of inventory. <p>To augment the Planning Section, the Reliability Section has been introduced. The primary function of the Reliability Section is to work in conjunction with the Planning Section in identifying and managing asset reliability risks that can adversely affect equipment reliability and/or business operations. This Section has three (3) major roles: Loss Elimination, Risk Management and Life Cycle Asset Management (LCAM).</p> <p>Loss Elimination This function involves the identification and management of factors affecting equipment reliability as well as</p> |

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| | <p>mitigating abnormally high maintenance cost assets. These losses are prioritized to focus efforts on the largest/most critical opportunities. The Reliability Section (in full partnership with the operations Departments) have developed various strategies to eliminate or reduce the losses through root cause analysis and innovation. This Section also critically looks at component management, which involves such activities as, component rebuild, salvaging of parts and the control of parts and materials usage.</p> <p>Risk Management Another role of the Reliability Section is to manage risk to the achievement of the Department’s strategic objectives in the areas of asset capability, quality and waste. Some tools used to identify and reduce risk included:</p> <ul style="list-style-type: none"> i. PHA - Preliminary Hazards Analysis ii. MI - Maintainability Information iii. FMEA - Failure Modes and Effects Analysis iv. SFMEA - Simplified Failure Modes and Effects Analysis v. FTA - Fault Tree Analysis vi. ETA - Event Tree Analysis vii. CA - Criticality Analysis viii. SOS – Scheduled Oil Sampling ix. NDT – None Destructive Test <p>To effectively manage risk, the Reliability Section also carries out in - depth research in areas where problems persist or are unique.</p> <p>Life Cycle Asset Management The Reliability Section also takes part in equipment purchase decisions, component management through condition assessment, component repair and modification of existing assets. These activities assist the Planning Section in tracking equipment performance and making proactive plans.</p> |
| Summary | <p>The changes to the organisational structure and the introduction of new roles and Sections has presented a significant opportunity in improving the quality of work output and the reduction in the duration of maintenance interventions. This is as a result of the adjustments made to the Planning Department. It has also been made clear that, though planning is the responsibility of the Planners, it is the duty of the Artisans and Supervisors to provide comprehensive and accurate information to assist with the planning process.</p> |
| 5.1.7 Work Scheduling | |
| Purpose | <p>Maintenance scheduling is the process of selecting, prioritizing, coordinating, and communicating when work takes place and who is assigned to do it. On the other hand, it is a process of matching work priorities and resource availability. The maintenance scheduling process is designed to ensure that the correct work is performed at the correct time with the correct available resources. Therefore, this section is considered in order to define the requirements for scheduling or ‘when the work is to be completed’ to ensure the efficient use of available resources and minimise machine downtime which adversely affects production schedules.</p> |
| Background | <p>There was a number of planned work not done each week and usually there was queuing at the workshop with some machines being in the queue the whole day. This was counterproductive as production vehicles were kept idle and in certain instances, machines would be parked at the workshop the whole shift and only to be released without being serviced or repaired.</p> |
| Observations | <p>To start with, the Senior Planner carried out both the role of Planner and that of Scheduler. Due to the large number of equipment, the Planner concentrated on planning and left out the task of scheduling to individual maintenance staff. Thus, emphasis was placed on planning and scheduling was not considered as an important task. This led to delays in carrying out certain critical tasks. In most cases, planned maintenance was missed resulting into some machine components such as filters to work beyond their life, this resulted in further equipment breakdown. In certain instances, Artisans were only issued with check sheets to carry out tasks, though the scheduled equipment did not turn up for maintenance. Allocation of bays was a challenge due to the high number of broken down equipment requiring space. The Artisans had to look for a bay where to service a machine and if the bay was not available, maintenance was postponed with little or no follow - up. Due to lack of effective scheduling, maintenance parts were not made available ahead of planned maintenance. This prolonged maintenance and sometimes machines went out without replacing certain parts which were due for replacement. Additionally, due to lack of formal scheduling, machines were taken to the workshop without being washed, this compromised the quality of maintenance. Further, the bays were not demarcated to indicate the kind of work to be carried out in a specific bay.</p> |
| Mitigation | <p>The most important thing was to develop a new structure for the Planning Section where the position of the Scheduler was introduced and clearly defined with responsibilities assigned to the role. Further, all work bays were labeled according to the type of work to be carried out. This initiative also introduced the Reliability Section which is also tasked with the responsibility of rebuilding components on site. This development frees some bays by removing the repair of components from work bays into the newly refurbished component rebuild workshop. An old storeroom has been renovated by the HME personnel into a Component repair shop.</p> |
| Summary | <p>After the implementation of the new structure and clear definition of roles, scheduling of maintenance work within the constraints of work has been made possible and enables the utilisation of available resources to be optimised and conflict within roles resolved. The queuing system for machines under planned maintenance or breakdown has improved and the downtime of equipment in the workshop has reduced by over 47%. This is also seen from the remarkable improvement in Planned Maintenance Compliance from an average of 60% to 98% per month. This implies almost all planned maintenance work for each month is completed as scheduled. With the improved communication, each time planned maintenance is deferred, the reason for the missed maintenance is appropriately communicated and documented. With the new developments in the Planning Section, maintenance activities of the HME have moved from a reactive to a proactive mode. Maintenance efficiency has improved remarkably as seen from the improvement in Planned Maintenance Compliance and decreased maintenance cost.</p> |

| 5.1.8 Shift Management | |
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| Purpose | This element highlights the requirements for shift management in terms of shift deployment, shift supervision and shift completion. The aim of shift management is to ensure that the expectations for work are communicated effectively between shifts. This allows for work to be executed efficiently in accordance with applicable standards, plans and schedules. |
| Background | The Department runs two shifts, day from 06: 00 hours to 18: 00 hours and nightshift from 18: 00 hours to 06: 00 hours. The communication between the two shifts was not effective and this led to certain jobs not being handed over to the other shift. Sometimes, pending job could only be noticed when the operations Department made a follow up on the status of the machine. Additionally, expectations for tasks taken over by the incoming shift were unknown and parts or materials required for the jobs were not readily available due to poor communication. |
| Observations | Minimal consideration was given to shift management with limited appreciation of the separate processes of shift deployment, shift supervision and shift completion. Shift planning was more about allocation of the first job and not based on priority and resource availability. The absence of formalized shift planning clearly indicates that, there was need to establish mechanisms that could drive accountability within the Department. Due to the various levels of management and overlapping work areas, it was difficult to determine who was accountable for the quality and quantity of work completed or to be completed on the various shifts. There was no handover between shifts as each shift rushed for the bus. This made it difficult for the incoming shift to know and understand the status of equipment. On several occasions, the state of equipment was only known through the Mining control room in form of a breakdown report. The other problem is that, the shifts were not balanced in terms of skills, the nightshift had less manpower as well as skills. This condition led to most jobs, more especially those of a breakdown nature to be deferred to dayshift. Additionally, no Planned maintenance was carried out during nightshift and this overloaded the dayshift with work as they had to deal with all planned maintenance work and attend to breakdowns. |
| Mitigation | Shift handover has been introduced, where Supervisors from day and nightshift meet at the end of each shift to discuss equipment status and other related matters. This has been made possible through the appointment of extra Supervisors. Through the new organisational structure, all shifts are provided with adequate supervision and operatives. Additionally, skills and manpower have been revised to ensure both shifts are adequately covered. Carrying out of planned maintenance work has also been introduced in night shift and this has helped to reduce the crowding of work in dayshift. To avoid rushing for buses at the end of the shift, a bus has been provided by management as means of transport for the HME maintenance personnel. |
| Summary | The improved handover system and the balancing of skills in both shifts has minimized delaying of tasks and overloading the dayshift with work. Additionally, the strategy has significantly improved the quality of work, more especially in nightshift. |
| 5.1.9 Equipment Reliability Management | |
| Purpose | As a known dictum in the mining industry, the performance of mining machines depends on the reliability of the equipment, the operating environment, the maintenance efficiency, operation process and the technical expertise of operators. Therefore, there is need for the maintenance staff to understand these factors and implement strategies to ensure reliability of the equipment is sustained. Therefore, this element is considered in order to identify and assess the requirements for identifying, monitoring and analysing those items and competencies that are critical to the reliability of assets, work locations and work processes. |
| Background | The reliability of the HME was poor with a number of rework and premature failure of components. The poor reliability was across all machine types. Maintenance and Repair contractors were hire in certain periods to assist, but the improvement in reliability was not significant. The use of Contractors just increased the maintenance cost with no feasible improvement in equipment reliability. This was a major concern for Management. |
| Observations | The equipment performance indices such as MTTR, MTBF and Availability were recorded through the Planning Section, however, this data was not conclusively analysed to determine the equipment reliability or effectiveness. Further, there was no suitable method for analysing data to identify major bottlenecks in the system in order to find areas affecting equipment reliability. The Department did not have a Reliability Section to carry out reliability assessment such condition monitoring. Fluid samples were cut and sent out of the country for analysis. Sample results were only issued after three to four weeks, in certain cases, a month. This rendered the results ineffective as the waiting period was too long for the maintenance personnel to take quick and proactive actions in an event of an emergency. Additionally, the results were not interpreted on site once received, the reports were merely filed in the Planning office. Lack of skills also contributed to the poor reliability of the equipment. Firstly, the labour compliment was not enough and secondly, the program to improve the skills of the National Artisans was not effective. On the other hand, there was little understanding and knowledge of probable failure modes and reliability drivers or the ability to predict potential failure before the onset of functional failure. This was mainly due to lack of skills and competence of the maintenance personnel. Further, the lack of focus on reliability management especially in the less - tracked components such as rims, steering componentry, buckets and chassis represented a 'run to failure paradigm' with the risk of catastrophic failure and a missed opportunity to identify the drivers of availability and reliability specific to individual machines. Component tracking was available through the Planning Section, however, this data was not used to improve the reliability of equipment, but merely collected and filed. |
| | Addressing the quality of condition monitoring of assets is critically important and offers significant reliability / costs benefits to maintenance. In order to improve and sustain equipment reliability, the Department through the new labour structure introduced the Reliability Section. The main function of the Reliability Section include: <ol style="list-style-type: none"> i. Condition Monitoring (e. g. tribology) ii. Component rebuild |

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| Mitigation | <ul style="list-style-type: none"> iii. Failure modes and effects analysis (FMEA) iv. Equipment reliability improvement initiatives v. Loss elimination (e. g. oil losses) vi. Salvage reclamation activities <p>In order to collect, record and track performance data of each machine, the Planning Section has introduced the position of the Data Analyst and increased the number of Data Capture personnel. Additionally, to ensure that meaningful information is drawn from this data, the Reliability Section has been introduced to interpret the data and give observations and recommendations to the Planning and Maintenance personnel for action. The Reliability Section ensures that, equipment reliability is maintained through continuous equipment component inspection (condition checks) and monitoring. Additionally, the Section reports all potential equipment failure causes to the Planning and Maintenance Sections before the actual failure occurs. The Reliability Section is also tasked with the duty of repairing components on site and making use of salvaged materials. The Section is equally responsible for <u>investigating and finding solutions to equipment recurring and unique failures (failure analysis)</u>.</p> |
| Summary | <p>The introduction of Root Cause Failure Analysis within the Department has motivated the Team members to always wanting to know the root cause of failure of any major or unique equipment breakdown. Due to this development, smaller group meetings are held each time there is a major equipment failure. This approach has created better communication within the Department with fewer mistakes, better equipment performance, and improved efficiency and effectiveness in responding to problems and opportunities (the effect). Equipment performance is discussed each morning and any failures or conditions which need extra attention are reviewed and mitigation measures proposed or implemented. This proactive approach has enabled equipment performance to be managed on a 'leading' rather than 'lagging' basis.</p> |

5.1.10 Failure Analysis

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| Purpose | <p>Failure analysis is an objective, structured approach employed to identify the most likely underlying causes of a problem or undesired events. Thus, a root cause is the most reasonably identified basic causal factor or factors, which, when corrected or removed, will prevent (or significantly reduce) the recurrence of a situation. Therefore, the reason for analysing this area is to define how the requirements for determining the immediate cause (s), root causes and contributing factors to failure in equipment are managed.</p> |
| Background | <p>Despite the numerous HME breakdowns, the Department did not have any formalized structure designed to investigate the root cause of equipment failure. When any form of failure occurred, only the repair process was outlined and no cause of failure was investigated and his resulted into recurrence of failure.</p> |
| Observations | <p>Though safety related incidents were thoroughly investigated, equipment failure events were not adequately recognized by the HME Team at the Mine as events guaranteeing formal investigation. Hence, the potential learnings from a failure and the understanding of residual risks associated with a failure were missed altogether. Maintenance personnel were too deeply involved with daily reactionary tasks to recognize failure events and then investigate those failures to find opportunities to reduce the risk of repeat or similar failure. The other problem was that of leadership, the Department did not assign clear responsibility to the leadership of the Department, therefore, no one took responsibility to investigate failure causes in detail.</p> |
| Mitigation | <p>The first step in resolving this issue was to segment the Department into smaller and manageable Sections with specific leadership. This has been done to ensure that each Section or fleet is managed by a defined Team with specific accountabilities and responsibilities. The Reliability Section has been introduced to lead failure investigations with the help of maintenance personnel. A procedure has been initiated to investigate failure of major components or any unusual equipment failure. To enforce this standard, the HME Engineer has been made the leader of all failure investigations. The results of the investigations are shared among the maintenance personnel and a record filed by the Maintenance Planner for action and future reference. For any failure where the investigation is not conclusive, the Original Equipment Manufacturer (OEM) is engaged. To avoid firefighting, the principle of Failure modes and effects analysis (FMEA) has been introduced within the Department to identify potential failure causes and their impact on both the equipment and productivity. FMEA has been taken as a systematic tool used to evaluate reliability of the equipment and to identify where or how this equipment may breakdown, and to assess the relative impact of the potential failure.</p> |
| Summary | <p>With the introduction of failure analysis concept, the Department has seen a reduced number of rework with improved equipment reliability. Identifying the root cause of individual failures has enabled Management to implement appropriate corrective actions to limit the occurrence of repeat failure and to identify targets for reliability improvement. Additionally, failure investigation has been applied as a first step towards continuous improvement and presents a significant opportunity for the HME Department and the Mine as a whole to learn about the major and frequent equipment failure causes. From this thought process, the Department has been able to develop its corporate memory in terms of equipment failure causes and mitigation.</p> |

5.1.11 Cost Management

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| Purpose | <p>Cost management is the control of actual or forecasted costs incurred, it makes possible the use of available resources in the form of men, materials and machines more effective. Thus, it helps in preparation of plans for development, expansion and their successful executions. The purpose of this section is to describe how the HME Department identifies, quantifies, analyzes and reports operating expenditure as well as capital. It highlights how informed evidence - based decision making processes are established.</p> |
| Background | <p>The Department costs were captured through a computerized system called NAVISON and the monthly over or under spent highlighted. However, the spending was not monitored on a daily or weekly basis to proactively mitigate unusual cost trends before the month end. The costs were only discussed with the Finance personnel at the end of the month. This was too late to take any control measures.</p> |
| | <p>The reporting of monthly costs was available, however, there was no proactive system within the Department to</p> |

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| Observations | <p>monitor cost/spending on a daily or weekly basis. Thus, maintenance costs and other associated operating costs were consistently high and no firm cost control mechanism was available. On the other hand, there was a loss in capital expenditure and other operating cost as most of the purchase decisions were made by senior Management who were not conversant with HME operations. In short, no cost benefit analysis nor a risk assessment was conducted prior to any major equipment purchase. High value equipment of poor quality was bought due to such kind of management style. In most cases, if not all, no warranty was claimed for the premature failure of equipment or components. Additionally, hiring of personnel with no strong HME management/maintenance background resulted into wrong and costly decisions. One example is the purchase of about 150 CAT789 Truck tyres which could not perform to expectation due to the wrong specifications (TKPH) provided by the Mine to the Supplier. As a way of concealing the failure, the HME Department assigned the premature failure of the tyres to the harsh environmental conditions and poor operator practices. However, when a detailed analysis was conducted, it was discovered that the Tyre Kilometre per Hour was incorrect. Galatia (2020) states that, it is always important to determine the site TKPH before purchasing heavy mining equipment tyres.</p> |
| Mitigation | <p>The Department has introduced a weekly meeting to review costs and plan expenditure for the following week. This initiative eliminates the idea of ‘surprise costs’ which only appear at the end of the month. Costs are continually monitored and any likely deviations corrected in time. Further, a system of segregating costs associated with rework and waste has been proposed in order for the Team to understand the impact of poor quality work. The sectionalisation of the Department has greatly assisted in the management of costs as each Section Head is responsible and accountable for own Section spending. This development brings within the Department a sense of innovation and a drive to minimize waste. A cost benefit as well as machine reliability and capability analysis is emphasised before purchasing any major equipment. This is a collective endeavour of the maintenance, operation and finance Department.</p> |
| Summary | <p>The sectionalisation of the Department has enabled the maintenance Team to be responsible for costs within their Sections. This move has made cost management to become part of the daily routine within the HME Department. In turn, this focus has promoted increased objectivity and commercial rigour in decision making. The major benefit is reduced maintenance and capital cost for the Department. The introduction of component rebuild on site has equally assisted in reducing component cost as most of the components are refurbished on site at a lower cost.</p> |
| 5.1.12 Employee Performance Evaluation | |
| Purpose | <p>Performance Evaluation is a formal and productive process to measure an employee’s work and results are based on their job responsibilities. It is an approach which helps to ensure that employees are recognized for their work and are being provided the right training opportunities to acquire further skills. This is beneficial to both the employee and the business. Therefore, the aim of this section is to explain how performance evaluation is managed within the Department and how the shortfalls are mitigated.</p> |
| Background | <p>Performance evaluation was conducted in the Department, however, when an appraisal was conducted, it was noted that, the employees were not aware of any form of goals or Key Performance Indicators (KPI) they were meant to achieve. This deficiency in performance evaluation caused individuals to be driven by their own goals. Additionally, collaboration within the Department was not visible, each group aimed at achieving its own goals without realising that achieving goals in one section of the Department does not warranty achieving the main departmental goal. The main goal is to provide reliable equipment to the operation Departments. Within the Department, everyone was pulling against one another rather than pulling together. This conduct resulted into poor departmental performance (poor equipment reliability), high maintenance cost, low motivation among employees, and lack of focus on priorities.</p> |
| Observations | <p>The Mine had a performance management system in place and employees were appraised every six months. New employees were assessed within the three months of probation. If the performance was not satisfactory, the employee was given a further three months and if the employee did not satisfy the conditions of probation after this extension, the contract was terminated. Likewise, the HME Department used to conduct performance appraisals for all employees, however, the major drawback observed was that, any senior official within the HME Department could appraise any subordinate even if the employee did not fall under their supervision. Additionally, no Key Performance Indicators were set for employees and the results of the appraisal were not discussed with the employee. Typically, Supervisors did not look at the employee’s skills and accomplishments during the specified period in order to track whether the employee performed up to expectations, exceeded them or failed to meet desired results. The assessed employee was only asked to sign the score sheet and thereafter, the document was forwarded to the Human Resources Department for filing. As such, there was a lot of dissatisfaction expressed by employees as some of them did not even know who appraised them nor countersigned the document. Due to this informal approach, a number of employees were not recognized for their work and were not provided with the right training opportunities to acquire further skills which could be beneficial to both the employee and the organisation. This was also one of the factors which largely contributed to the delayed Nationalization of Technical roles. The National Trainee knowledge gap was not adequately identified in order to provide the necessary on the job training. HME Management did not take full ownership of the training program, the task was left with the Training and Development Department. The notable factors which contributed to poor performance management are summarized:</p> <ol style="list-style-type: none"> i. Unrealistic Scoring – In performance appraisals, scores were informal and either too high or too low without any explanation to either condition. Lack of realistic targets and incentives created a neutral state of not caring whether one had an outstanding result or not as there was neither a reward nor some form or consequence. Thus, individuals’ strengths and weaknesses were not revealed. The whole exercise was done for convenience sake. ii. The process – The focus of senior officials was on process rather than the conversation. Most senior officials were not courageous in dealing with performance management, they opted to seek harmony and wanted to be liked by the subordinates. Thus, they only followed the policy of the company and saw it simply as a checking mechanism which had little relevance to anyone outside of the Human Resource Department. |

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| | <p>iii. Job Security – Subordinates felt insecure in their positions. A number of personnel were in the same role for extended periods with no form of promotion or pay rise. As a result of this, the employees were uncertain of their future. The main observation was that, the senior officials lacked the skills and confidence to inspire the subordinates.</p> <p>iv. Role conflict – Roles within the Department were not clearly defined and most of the time in a desire to manage the system, senior personnel carried out tasks of their subordinates forgetting subordinates had their own responsibilities and accountability. However, senior personnel had a role to play in tasks allocated to subordinates, but ultimately an individual had to be accountable for his or her performance and future career.</p> <p>v. Fragile goals – Each individual or group wanted to satisfy its informal goals. To a greater extent, employees did not have any idea how their everyday work contributed to the main organisational goal, which for some reason they didn't even know. Worse, individuals didn't see how their goals connected to their personal success. This created a sense of reluctance within subordinates.</p> <p>In short, goals are important to keep employees motivated and perform better, but the main problem with the HME Department was that, everybody was managing the wrong thing. They were focusing on individual performance when they should have been focusing on team performance.</p> |
| Mitigation | <p>The starting point was splitting the Department into smaller and manageable Section with own Supervision. All Section Heads were given specific responsibilities and accountabilities which included appraising of subordinates. In terms of employee appraisals, it has been decreed that each employee will only be appraised by his/her immediate Supervisor and that all assessments will be based on predetermined Key Performance Indicators (KPIs) set by the Section Head and approved by the HME Maintenance Engineer. Further, the organisational objective has been explained to all members of the Department. This includes how the HME goals link to the main company objective. For transparency and objectivity, all appraisal score sheets are countersigned by the HME Maintenance Engineer before being forwarded to the Human Resources Department. Additionally, all Section Leaders are advised to go through the appraisal sheet with each appraise and any areas requiring further improvement or training highlighted during this session. The Execution of subordinate appraisals has been made part of the KPIs for the Section Head.</p> |
| Summary | <p>With the improvement in the employee performance appraisal approach, a base to track each employee's performance has been created. Through accurate assessment of performance and skills, it is possible to identify where the employee's strength and weaknesses apply. Finally, bias in awarding of points during appraisals has reduced or eliminated due to transparency in the system. This has motivated the employees to work even harder.</p> |

5.1.13 National Employees Technical Training - Nationalization

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| Purpose | <p>The aim of workforce nationalization is to boost employment among local citizens and reduce the number of expatriates. This creates a sense of ownership and pride among the National employees because citizens tend to benefit from their input and they are assured that, their efforts are recognized by the Government. At the time of the study, the Mine was the major employer in the country. Therefore, Nationalisation being one of the major subjects of the Government, it is imperative to discuss it in this document.</p> |
| Background | <p>Roles, specifically those in the Engineering field were held by the Expatriates from different countries. However, this was a major concern for both the Mine Management and the Government who wanted the National Employees to attain the required skills to take over some of the role occupied by Expatriates. To this effect, an Artisan Training program was established at the Mine. The Training and Development Department conducted training on site. To enhance the training process, a small workshop to serve as a training centre was established and an Expatriate instructor hired.</p> |
| Observations | <p>Though the training program existed, the Mine had not produced any Artisan by the time of the study despite having the program running for more than five (5) years. Various inhibiting factors were responsible for the drawback (workforce Nationalization) and these include:</p> <p>i. The high turnover of expatriate employees - This created inconsistencies in training of the National workforce, as each set of expatriates came with its own approach to the Nationalization program.</p> <p>ii. Lack of Technical Training skills among the expatriate workforce - Most of the expatriates were only good at their practical work, but with very little or no coaching skills. This condition made it difficult for the expatriates to identify the skills gap and formulate strategies to narrow the knowledge gap within the National Artisans Trainees.</p> <p>iii. Lack of information among the Expatriates - There was a gap between Management and the Expatriate Technicians (not until 2020) in terms of training requirements. The Expatriate Technicians did not understand what was required of them in terms of providing training to the National Artisans.</p> <p>iv. Lack of performance measurement tools - Training was emphasized by the Mine Management, but there were no tools available to measure the performance of both the National Artisan and the Trainer. Most of this workload was heaped on the Training and Development Department with very little or no involvement of the operating Departments such as the HME Department.</p> <p>v. Expatriate job security (Fear of takeover) - Some of the Expatriates felt a quick knowledge transfer to the National Workforce could accelerate their exit from the Mine. Therefore, certain Expatriates created an expression which portrayed the National employees to be slow learners. A number of skills such as fault diagnosis were not availed to the National Artisans. Expatriates deemed such jobs as special skills which could not be carried out by the National Artisans.</p> <p>vi. Benefits not clearly stipulated by Management - A benefit tied to any task stimulates ones morale. Previously, Management did not put up any form of incentive for the Trainee or Trainer.</p> |
| | <p>To improve the training process, a number of measures were implemented:</p> <p>i. The first step was to identify the knowledge gap, this has been done with the help of the Training and Development Department. Trainees were assessed and those with good education background and showed a positive</p> |

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| Mitigation | <p>trend in the assessment have been put under a fast tracking program. This involves undergoing both practical and theoretical training on site within the shortest possible time.</p> <p>ii. After completing the Fast Tracking program with Training and Development Department, the trainees have been attached to the HME Department where they carried out actual work under supervision of appointed mentors.</p> <p>iii. To ensure that the trainees are adequately coached, trainees have been paired with the Expatriates appointed by HME Management as mentors. This pairing system is of great significance as the trainee is coached and monitored on a daily basis with progress recorded and reported to HME and Training and Development Management.</p> <p>iv. Progress of each trainee is monitored and corrections made proactively where necessary. Each trainee has his own logbook where he records all work carried out.</p> <p>v. To improve the training process, both the trainee and the trainer (mentor) are assessed on a weekly basis. Additionally, the HME and Training and Development Management hold a meeting each week to review the progress of trainees. On a daily basis, the same management reviews the previous days' pairing outcomes. This is to ensure each trainee is paired and receives the necessary coaching.</p> <p>vi. To ensure that both the trainee and the trainer are motivated, Management has assigned an incentive to the training program.</p> <p>vii. To augment the Nationalization strategy, a succession plan has been developed and progress reviewed regularly.</p> <p>The full involvement of the HME staff and senior company Management officials such as the General Manager and the Employee Services Manager has greatly assisted in making the training program a success.</p> |
| Summary | <p>The new training initiative put in place by Management has given confidence to National Artisan trainees. By 2021, quarter four (4), the first stream of Artisans is set to graduate to full Artisan level.</p> |

The elements highlighted are derived from the outcome of the study conducted in 2020 which aimed at identifying the major cause of the low equipment reliability and the high equipment maintenance cost from the HME Department.

6. Conclusion

The HME Department lacked a clear maintenance objective and strategy. Work execution was personality driven (driven by the individual) with loose coupling of roles and accountabilities. This allowed informal sub - systems to become acceptable responses in a capital - intensive business with various third - party obligations. Relying on 'personalities / individuals' to deliver acceptable maintenance outcomes brought with it significant known and unknown risks.

The rules, relationships and processes necessary to deliver effective maintenance outcomes were not understood by the maintenance personnel and consequently people made their own rules to suit the circumstances which did not align with AMSC's expectations and did not provide comfort / protection to those with legal / regulatory responsibilities. The lack of systems of work led to duplication, rework and waste. These added unproductive costs to the Mine and contributed to frustration within the maintenance personnel.

The maintenance Department attempted to deliver real change by simply applying additional resources without a 'recipe' for delivering effective maintenance outcomes. This approach resulted into limited performance outcome and ultimately created more confusion. Therefore, to be sustainable, a change in maintenance paradigm has been initiated to coordinate the various systems and considers 'what is required', 'how to achieve it' and 'who is accountable'. The systems have driven behavior and behavior driven attitude. This has been made possible by dividing the HME Department into Sections according to the fleet type and activity. Section leaders have been assigned to these Sections and responsibilities and accountabilities outlined.

The shift to the new organization structure has created greater engagement, reduced risk and resulted into higher productivity as the delay / disruption effect of rework and waste have been minimized. Importantly, the HME personnel have been motivated as they can perform their work in a transparent environment.

With the clear definition of responsibilities through the new structure, an improvement in equipment reliability has been noticed. Additionally, the workshops and the surrounds are always kept clean. Further, a summary of the procedural duties assigned to each role or Team has enabled individuals within the HME to understand accountabilities as changes are made. A performance review meeting has been introduced which is held every morning to review the performance of the equipment.

Further, the dividing of the Department into Sections has created some form of completion. This competition has created a 'voluntary' aspect of 'deliver what we say we will deliver' attitude where the elimination of rework and waste has become part of the daily routine.

To ensure that the Sections are adequately manned, a number of technical personnel both at Management and operative levels have been hired. The hired personnel have come with various skills which are supporting the new HME culture.

The whole revolution from the poor performing to superior performance of the HME Department has been initiated and sustained by the General Manager and the Employee Services Manager who always engage with the departmental staff to ensure the improvement strategy is sustained. This move has motivated the HME staff and has led to improved performance of individuals as they feel the spirit of care. This motivational approach by AMSC Mine Management is supported by the comments from Gagné (2005: 331 - 336) who stated that, motivation in a work environment provided

satisfaction of basic needs, if the employee is not motivated, good performance is not be guaranteed.

7. Recommendation

The HME Department has significantly improved and this good work must be sustained. To ensure continued sustainability, the following is required:

- 1) Communicate clear goals and expectations to the employees – the Department must continue communicating the performance of the Department on a daily basis. This has been made possible through the daily equipment review meeting introduced. The improvements in the HME Department have created a ‘Departmental pride’ with every Team member wanting to be identified with this success.
- 2) Performance Appraisal – The majority of employees always want to be a part of a compelling future, want to know what is most important at work and what excellence looks like. Therefore, to keep the HME personnel motivated in this line, KPIs should be realistic and meaningful in order not to discourage the employees.
- 3) Trust – Subordinates feel secured when they can trust their leaders. The HME Department has created a culture of trust and transparency. Therefore this trend must be sustained. Employees need to trust their Superiors as well as each other. Employees are constantly watching leadership to see how their decisions affect the strategic direction of the organization and if their behaviours reflect what they say. If the actions of the Superiors do not match what they say, subordinates tend to be demoralised.
- 4) Training – The HME Department must continue engaging with the Training and Development Department to ensure the Artisan training program is sustained. This can only be sustained with continuous checks and assessment.
- 5) Cost Saving – In as much as the performance of the HME Department has greatly improved, emphasis must be on reducing maintenance cost through innovation such as component rebuild. The reclamation of usable components from the salvage yard must be encouraged. Additionally, ‘smart’ buying is encouraged where waste is eliminated.
- 6) Condition Monitoring – The onsite fluid analysis must be prompted to ensure the analysis of oil and other fluids is carried out on site. This will enable prompt and effective monitoring of machine component life.
- 7) Maintenance Strategy – A maintenance strategy must be formulated to ensure that new employees buy into the foundation of the system and that the Department should be tied to specific goals and processes.
- 8) Machine Replacement Strategy – The machine life cycle must be closely monitored and aging machine replaced accordingly. This will reduce the cost of components.
- 9) Hiring – The Department must be strict at hiring employees. Personnel must be hired on merit and must be a right fit for the Department.

Finally, all members of the Department must be involved with Departmental decision making and problem solving to

some extent. When employees get the idea that their superiors are the ones who solve or make all decisions, the employees are demotivated and this takes away their sense of empowerment, and ultimately it is likely to decrease engagement over time. Team members must be encouraged to take responsibility, and work through problems or issues on their own, or collaboratively. It is not the Manager’s job to fix everyone else’s problems, but to guide and show confidence in subordinates.

The Artisan Training program has taken a positive direction with at least fourteen trainees bound to be certified to full Artisan role by the end of 2021. In support of this statement, Ljungberg (1998: 495 - 507) states that, human factor represented by maintenance technicians and other related staff is the backbone of the maintenance system in any organization. As such, the effectiveness of the different facets of the performance system is very much dependent on the competency, training, and motivation of the overall human factor in charge of the maintenance system.

Management and the HME staff should continue monitoring and supporting the training program through planned inspections and performance evaluations. Additionally, more trainees are required to commence basis training to ensure continuity.

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