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**A TERM PAPER**

**ON**

**OPERATION, MAINTENANCE AND MANAGEMENT OF ENGINEERING EQUIPMENTS FOR SUSTAINABLE DEVELOPMENT IN NIGERIA**

**SUBMITTED TO**

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**CHAPTER ONE**

**INTRODUCTION**

Since Nigeria’s Independence in 1960, successive governments of the federation have devoted a lot of effort to the creation of physical facilities, such as roads, power supply, water supply, educational buildings, housing, hospital, communication etc., which are basic requirements for the social and economic well-being of the nation. And it is obvious that the nation has been faced with a lot of engineering challenges since independence and it is evident that the management of operations and maintenance and management of engineering equipments are critical to service delivery and sustainable development. But, a developing country like Nigeria are faced with enormous challenges of financing, implementing and maintaining infrastructure, equipments or even facilities to deliver and sustain basic services to their citizenry and foster economic growth. Nigeria is currently facing many challenges to improve key infrastructures for economic development. The trend in Nigeria indicates that the country lacks both a critical mass of engineering personnel; maintenance engineers; maintenance technicians; and craftsmen, as well as a strategic planning framework of the maintenance system from the inception of equipments, infrastructure, facilities, through operations to decommissioning. This situation, some authors claim was partly due to the absence of a clear-cut assets maintenance policy in the country. Therefore, to ensure an increase of access to services to Nigerians, it is essential to cultivate and practice an effective maintenance management system. It is argued that the maintenance function remains an integral part of growth and therefore must be factored-in to the procurement or acquisition of an asset. We analyse the situation of poor maintenance management function in Nigeria through the lenses of the procurement systems and the culture of maintenance. Furthermore, we propose a well-structured plan for the education and training of maintenance engineering personnel and we advocate for the institutionalisation of the maintenance management function in the public sector by the formulation of a sustainable infrastructure maintenance management policy framework in conjunction with the public procurement policies for efficient public service delivery in Nigeria.

**THE HISTORY OF ENGINEERING IN NIGERIA**

Government establishments and private entrepreneurs in Nigeria have been addressing themselves to the problem of developing technology that is definitely a solution to improving the quality of life of the people, maximization of the use of available resources and creation of more job opportunities. The history of engineering in Nigeria traces its root to the establishment of the Public Works Department (P.W.D) of southern Government in Lagos in 1896, the P.W.D comprised mainly of three sections (Civil, Mechanical and Electrical). It was responsible for the management of engineering problems in the southern Government of Nigeria. As the country entered into independence in 1960, the three regions (North, East and West) had their separate P.W.D, [2,4].

In 1966, the Nigerian council for scientific and industrial Research (NCSIR) was established. The NSCIR gave rise to the establishment of International Institute of Tropical Agriculture, Ibadan (IITA) in 1967, Kaduna polytechnic in 1968, Yaba College of Technology in 1969, and a new council called Nigerian Council for Science and Technology (NCST). The creation of the NCST engendered the promulgation of Nigerian Steel Development authority (NSDA) Decree of 1971.In the same year, the Agricultural Research Council of Nigeria (ARCN) was established. Also, in 1971 on the recommendation of NCST, the industrial Training Fund (ITF) was established. In 1973, the Petroleum Technology Development Fund was created to train Nigerians in the field of Engineering, Geology, Science and Management in the petroleum Industry. This leads to the establishment of the Petroleum Training Institute, Warri. The National Science and Technology Development Agency (NSTDA) was established in 1977 and in 1980, a separate Ministry of science and Technology was born. In compliance with Vienna (1979), directives and recommendations, apart from the existing specialized Federal Polytechnics, more Federal Universities of Technology were also established in 1980 to cater for the training of engineering manpower. In 1987, the National Science and Technology Fund (NSTF) was put in place to provide fund for activities in science and technology. In 1988, the Raw Materials Research and Development Council (RMRDC)was born for the development of industrial raw materials, creating self-sufficiency and maximization of inputs to local industries.

Evidence of Engineering and Technology in Nigeria is seen in development and adaptation of appropriate machines and equipment for easing out tedium and drudgery in certain operations in agriculture and Industries developed by these government agencies. These indigenously developed adapted machines and equipment are now becoming regular exhibits at trade fairs, shows and exhibition that are regularly organized by government agencies, associations and private industrialists.

**THE ENGINEERING PROFESSION**

Engineering has been defined as that Art of Science that harnesses the resources of nature to produce and maintain an artefact for the benefit and convenience of mankind. It is the practice of designing machines, bridges, railways, electrification of cities, communication equipment, petrochemical industries etc. In short, it is the application of science to solve societal problems [1, 2]. Therefore, it bridges the gap between Society and Scientific Knowledge

The Oxford Advanced Learner’s Dictionary defines profession as “a type of job that needs special training or skill, especially one that needs a high level of education”. There are a number of characteristics which distinguished a profession from other less formally constituted trades and occupations [3].

1. The professional discipline has a command of a specialized body of knowledge necessary for planning, design, construction and operation of physical structures or engines/machines.
2. The body of knowledge is transmitted through recognized training and regularly updated on behalf of the professional body to ensure certified standards of proficiency.
3. A code of Ethics and standards govern the practice of the profession and ensure the satisfaction and safety of the client in particular and the society in general.
4. A monopoly is usually granted to a professional body by society through laws to ensure that only registered members can engage in the professional practice.
5. The members are committed to constant educational renewal through a lifelong learning of latest technology and professional development.
6. The professional body is legally to regulate itself, discipline its members and control the practice of the profession. The engineering profession exists in every aspect of human endeavour cutting across religious, socio-cultural, economic and political barriers, hence engineering is a way of life. Professionalism is about commitment to standards of excellence in the performance of tasks which require specialized skills and expertise. And a professionalism thus someone whose basic satisfaction is in performing well, task for which he has been trained and always strives to achieve the best standard possible in any circumstance. Thus, to be a professional is to flaunt the highest levels of the skills one professes to command [2,3].

**OPERATION, MAINTENANCE, MANAGEMENT AND SUSTAINABLE DEVELOPMENT**

Engineering has always been an important from inception. With the knowledge of well-trained personnel in different fields, work has been made easier and expertise experienced. Nigeria has not been backward in the training of Engineers, although many disputes cannot acclaim when we have collapsed buildings, faulty equipments, collapsed bridges etc. in the country. Nigeria is a developing country in West Africa and as such should develop methods, processes to have a sustainable development. This way, so many equipments, infrastructure, constructions, economy can be preserved and used continuously while upgrades can be done to them. In order to institutionalise the maintenance management function in Nigeria’s public sector, we propose a two-pronged approach. The first is the formulation of a public infrastructure maintenance management policy and second is the education and training of the maintenance engineering and management personnel.

When equipments are in good working condition, operated in the right manner, and all measures taken to maintain these equipments; ranging from cleaning to repairs it allows their life span to be increased. When it comes to [**engineering equipments**](https://planningengineer.net/courses/data-management-and-planning-reporting-skills/)**,** they often vary in size. While some pieces of equipment are light and portable, most of **heavy equipments** are massive and not even close to being easily maintained. These equipments are designed to complete the most difficult construction operations, and it is easy to understand that a team of specialists needs to make sure each of these machines will be capable of performing its task without any issues. **Heavy equipment management** refers to a type of a business which includes selection, optimization, proper usage and overall maintenance of the machinery involved in the project. The main goal of **managing equipments** is to ensure that the right equipment is selected for any job that needs to be done, as well as to keep it functional at all times. This process begins by identifying and choosing the appropriate equipment for the project.

Maintenance is the application of [engineering](https://en.wikipedia.org/wiki/Engineering) concepts for the optimization of equipment, procedures, and departmental budgets to achieve better [maintainability](https://en.wikipedia.org/wiki/Maintainability), [reliability](https://en.wikipedia.org/wiki/Reliability_engineering), and availability of equipment.

Maintenance is increasing in importance due to rising amounts of equipment, systems, machineries and infrastructure. Since the [Industrial Revolution](https://en.wikipedia.org/wiki/Industrial_Revolution), devices, equipment, machinery and structures have grown increasingly complex, requiring a host of personnel, vocations and related systems needed to maintain them.  Prior to 2006, the United States spent approximately US$300 billion annually on plant maintenance and operations alone. Maintenance is to ensure a unit is fit for purpose, with maximum availability at minimum costs.

Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs.

**EQUIPMENT FAILS**

Equipment fails because its physical substance and structure cannot support the last duty required of it.  In other words, a final incident destroys it because it is not physically able to withstand that incident.  In some cases, the end of an equipment’s life is instantaneous and without warning.  Many times, there is a gradual worsening of performance that can be detected.

 There are usually hundreds of combinations of causes that can make a piece of equipment fail and they can be categorized into:

**Over-stressed Components**

Physical matter can only survive within a limited range of imposed stresses and environments.  Once matter is stressed beyond its endurance it will suddenly fail.

Some common examples are overloading, becoming too hot and placing an item under fluctuating forces leading to fatigue situations.

**Physical Attack**

This is the case where the environment around the equipment actually damages the equipment.  When environmental attack gets too severe the equipment is compromised and fails, as it no longer has the strength or capacity to handle its duty.

Common examples are rusting, chemical corrosion, wear, erosion and cavitation.

**Error or Mistake**

Equipment can fail due to the wrong thing being done to it, or a wrong choice being made in ignorance.  Failure by error can start on the drawing board at the design stage.  It can be due to an operator or maintainer making a mistake.  It can be due to incompetent management decision.

Some examples include starting equipment when not fully rebuilt, forgetting to put oil in a gearbox, introducing incompatible chemicals and doing the wrong instruction sequence.

**Poor Design Choices and-or Poor Manufacturing / Assembly Quality**

As the heading implies there are times when a part is made incorrectly, built incorrectly or its design was unable to withstand the imposed service duty.

Design errors include selecting undersized equipment, wrongly specified components and introducing safety risks.  Manufacturing errors like poor welding, poor casting, incorrectly positioned holes and out of tolerance machining are real possibilities.  Similarly, assembly errors, such as under-torque on bolts, poorly fitted electrical connections and short-cut assembly quality practices will eventually lead to equipment failure.

**Lack of Maintenance and Care**

When equipment is designed the designer makes the assumption that it will be treated with reasonable care and it will undergo a minimum amount of required maintenance.  When care and maintenance is withheld from equipment for an extended period of time, accumulated problems develop which eventually cause failure.

This can include not changing lubricating oil, leaving electrical equipment open to dust and dirt ingress, starting machines under full load, not checking remaining service life and not cleaning equipment down.

**Unimagined Incidents and Knock-on Effects**

Occasionally an unexpected disastrous event occurs that destroys equipment.  These include sabotage, acts of God, such as lightning and terrorism.

Included in this category are unforeseen preventable events that are a consequence of planned events.  An example is where a bolt falls into a machine during a repair and is not noticed.  On start-up the bolt is jammed into the working parts and causes a breakdown.  Another example is negligent behaviour, such as backing forklifts into operating plant or out-of-control vehicles running into machinery.

**MAINTENANCE STRATEGIES**

These equipment fails can be avoided or curbed by maintenance strategies. Some of these strategies are:

**Improved Technologies**

New inventions and innovative designs usually occur in response to existing problems.  It is a wise and valid maintenance strategy to be constantly looking for new technologies that reduce equipment operating problems. When a potentially useful technology is found test it in a controlled and monitored experiment to prove its worth in your situation.

It is my strong belief, after decades of involvement in maintenance management, that the only long-term solution to the need for maintenance it to invent equipment that does not need it.  This means discovering new technologies that do not fail, or that vastly increase the mean time between failures.

Actively look for such technologies because they will make your operation wealthy. Make it an engineer’s task to spend time each month seeking improved technology that stop the need to do maintenance or that boosts reliability.

When you change to a new technology that solves a maintenance problem you immediately gain the benefit of improved production output. This benefit continues throughout the equipment’s life.

**Predictive Maintenance**

Predictive Maintenance (PDM) is a very powerful maintenance strategy.  It involves monitoring for evidence of changed conditions within the equipment.  The amount of change and the rate of change are tracked and used to predict the time of failure.

PDM is based on the recognition that many failures take time to happen.  Typically, there is a start point, a gradual worsening, and eventually a point where the item cannot perform its duty.  Finally, there is a point in time when it breaks and totally fails. If it is possible to detect early onset of the failure then there is often time to manage the equipment carefully and continue operation until a replacement is actually needed. PDM techniques include thermography, oil debris analysis, vibration monitoring and ultrasonic thickness testing.  They are all methods that detect a change, and allow measurement of the rate of change, so that predictions can be made on the equipment’s continuing performance. When a predictive maintenance management strategy is used, problems will be spotted immediately and can be acted on before a failure occurs that shuts the operation down. With these strategies, equipment fail can be at limited rate as such these engineering equipments operation can continue as they will carry out the purpose they are being made for, management will be easier as the maintenance rate will be effective as such production and other aspects can be accounted for.

**CHAPTER 2**

**The Task Ahead for A Sustainable Development In Nigeria**

1. Different engineering personnel in various fields should be employed in all engineering Departments in both government and private establishments, so that specific jobs can be given to an engineer in his/her chosen area of specialization. That is, there should be division of labour.
2. The pay package of engineers in Nigeria should be commensurate with their counterparts in Europe and America, so that they will not be tempted to eat the capital of any project.
3. Existing engineering facilities and infrastructures should be upgraded with the present-day state of the art facilities in order to meet up with the present-day demand.
4. Engineering conferences organized in Nigeria should always adhere to workshop sections after technical paper presentation, this will go a long way to develop our local technology and sustain the economy.
5. Routine maintenance work should be carried out, on a regular basis after a project have been commissioned, this will increase the life span of such infrastructures and facilities.
6. Strategies should be put in place for maintenance and management of engineering equipments.
7. The operation must be done by qualified engineers to avoid accidents, spoilage or other hazards.

**CONCLUSION**

Engineering is a double-edged sword. It is both the cause of many environmental, social, economic and political problems faced by man and also a key to solving them. It is now recognized that engineers need considerable support in their attempts in various walk of life to promote sustainable development. There is no doubt that a lot has been achieved by the Nigerian engineers in this respect, but our unsatisfactory performance so far is a principal challenge for us to preserve the conditions for life and welfare of mankind, today and in the future. Even though our submissions here may not be all inclusive, it is our candid opinion that if the opinion given above are adhered to, and the engineer upholds the values of truth, honesty and trust-worthiness, human life will be safeguarded. In Nigeria, these measures put in place for operation, maintenance and management of engineering equipments for a sustainable development will be effective in Nigeria. This way economy, wealth and engineering can be boosted in the nation.

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