

AN INVESTIGATION INTO MAINTENANCE ERRORS COMMITTED BY ELECTRICAL / ELECTRONICS TECHNICIANS & THEIR EFFECTS ON PRODUCTION INDUSTRIES IN BENUE STATE NIGERIA

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Abstract

The study was carried out to investigate into maintenance errors committed by electrical /electronic technicians in production industries in Benue State. Two research questions and one hypothesis guided the study. A descriptive research design was used and stratified purposive sampling technique employed to obtain respondents from production industries. The population of the study was seventy respondents comprising of forty five (45) electrical/electronic technicians and twenty five (25) supervisors working in these industries. A 30 item structured questionnaire on a four point scale was used for data collection. The instrument was trial tested in Plateau State using 20 subjects to determine the reliability of the instrument. Split half reliability coefficient formula was used and a reliability coefficient of the instrument yielded 0.68. Data collected were analyzed using descriptive statistics of mean and standard deviation to answer research questions, while a t- test was employed to test the hypotheses at 0.05 level of significance. Findings revealed that: recognition failures, memory failures, skill-based slips, among others are the common types of errors committed by electrical/electronic service technicians which often lead to either accidents or equipment breakdown or both. It was recommended that Good quality feedback should be provided to allow users to judge how effective their actions have been and the state of equipment or individual as a result of such actions.

Introduction

The useful life of man-made things can be extended by maintenance. Maintenance can be defined as those activities required to keep a facility in "as-built" or a productive condition that allows such facility to deliver its original productive capacity (Reason, 2000). Maintenance therefore is any activity designed to keep machines, equipment or building in good working condition. Maintenance encompasses all those activities that relate to keeping facilities and equipment in good working order and making necessary repairs when breakdowns occur so that the system can perform as intended (Stephenson, 1999 in Nande (2013). Maintenance activities may include monitoring the conditions of operation of equipment, carrying out emergency repairs, servicing equipment, replacing worn out parts or performing building upkeep.

Maintenance activities in Benue State production industries as elsewhere are classified into repairs and servicing, and are performed under two basic types of maintenance, namely; preventive maintenance and breakdown maintenance. Dhillon (2002) described breakdown maintenance as unscheduled maintenance or repair to return items/equipment to a defined state. Breakdown maintenance is subdivided into Opportunity maintenance, Operate to failure and Condition based maintenance.

Opportunity maintenance is specifically concerned with items other than those originally the cause of the maintenance work or repair. Opportunity maintenance work may arise as a result of damage observed or identified as requiring automatic replacement each time that plant fails. In condition based maintenance, it is the actual corrective condition of the plant or equipment that determine the form or the frequency of maintenance. Similarly, corrective maintenance is repair or replacement of components when the machinery fails to operate.

Electrical and electronics technicians involved in preventive maintenance monitors the equipment's operating conditions which usually determine their actions for repairs or servicing. Preventive maintenance may be fixed time type, design out maintenance or planned preventive.

Fixed time maintenance can be described as individual or group replacement or repair prior to failure based on the prescribed date and is effective where failure is clearly time dependent. Design out maintenance on the other hand is a system of Plant condition monitoring and control which enable any faulty area to be identified before occurrence. Similarly, planned preventive maintenance is work carried out with forethought, controls and records to avoid possible further breakdown.

Maintenance and repairs are the actions involved in fixing to its original working condition any kind of mechanical or electrical device should it become out of order or broken (Defense Logistica Agency, 2011). Maintenance and repairs can also be described as restoration of a broken, damaged, or failed device, equipment, part, or property to an acceptable operating or usable condition or state (Mason, 2009). Repair is carried out after failure is detected and there is need to restore an asset to its factory condition in which it can perform its intended function. Blueprints and engineering specifications are usually followed during repairs to fix equipment components. Where replacement for broken or defective part is not readily available and machine must be quickly returned to production, the part is fabricated in the plant machine shop by experienced personnel.

Activities carried out during maintenance and repairs include: regular monitoring, inspection, clean up, lubrication, adjustment, alignment, calibration, replacement, or replenishment of the equipment. This helps to prolong an asset's useful life, prevent its breakdown and keep it in a capable condition to perform its intended function within its designed specifications (Online Business Dictionary, 2009). Maintenance servicing activities are carried out on routine basis.

Regrettably maintenance and repairs or servicing activities performed are not without human errors. Human error is an imbalance between what the situation requires, what the person intends, and what he/she does (Occupational Health and Safety Agency for Healthcare (OHSAH), 2004). Dhillon and Liu (2006) defined human error as the failure to perform a specified task or perform a forbidden action that could lead to disruption of scheduled operations or result in damage to property and equipment. The researchers added that a significantly large proportion of total human errors occur during the maintenance phase of equipment. Therefore, errors committed during maintenance work which produce unintended results such as unwanted time delay, difficulty, problem, incident, malfunction or failure during or shortly after equipment start-up or in use may be known as maintenance errors. According to Dunn (2007), more than half of errors in maintenance are recognized as recurring errors – often many times.

Dunn (2007) and Reason (2000) classified the maintenance errors to include: recognition failures, memory failures, rule based mistakes, and knowledge based errors. Others are skill-based slips and violation errors. Recognition failures are acts of improper identification and detection of objects while memory failures are incorrect acts which indicate that bits of needed materials were forgotten (Dunn, 2007). Rule base mistakes are errors committed when work procedure is forgotten or the individual fails to carry out the necessary procedures required for the work. When an individual never fully understood an operational sequence for instance; and a wrong decision made during a work procedure with some novelty, knowledge based error is said to be committed. On the other hand, skill- based slips are human errors committed due to distractions or lost of concentration in the course of work (Mason, 2009). A violation is an intentional deviation from procedures or practices. For example, non-compliant actions that have become normal, actions performed in order to necessarily get a job done is referred to as violation errors (Schreiber, 2007).

Managers of manufacturing industries consider their maintenance operations to be of high standard; however, quality performance, equipment failures and safety incidents frequently reveal causes for concern (Dhillon, 2002). Maintenance errors pose significant financial burdens on production industries in terms of breakdowns. The impact of human error on maintenance

quality, costs, safety and equipment reliability is huge (Dunn, 2007); and therefore, demands real obligation to prevent them in production industries.

Investigation into maintenance errors committed by electrical and electronics technicians in production industries in Benue State is an examination of maintenance errors committed by electrical and electronics technicians in industries. Investigation of maintenance errors committed by electrical and electronics technicians focused on identifying the types of error, causes and effects and to provide preventive strategies to be applied while carrying out maintenance actions on electrical and electronic devices and instruments in production industries.

Production industry refers to any facility devoted to the conversion of raw materials into marketable products. The production system of many modern day industries is automated. This automation has not only increased productivity level of the industries but also reduced the number of some human operations including monitoring which leads to fatigue, its resulting errors with their adverse effects including accidents and equipment failure (Reason, 1990). Okonkwo (1997) stated that in a complete electrical/electronic system, failure of one among thousands of components may be catastrophic. The electrical and electronics equipment in production industries therefore require high reliability and effective maintenance by skilled maintenance personnel which may include qualified electrical and electronics technicians.

Qualified electrical and electronics technicians employed with other maintenance personnel in production industries carry out maintenance tasks in their respective disciplines on production equipment. Many a times during maintenance process, accident occurs or after maintenance activities have been performed, equipment fails during or shortly after start-up (Kirn, Noland & Hauber, 2007) as a result of errors committed during the process (Mather, 2007). Da Vinci (2009) noted that almost on a daily basis, various degrees of industrial accidents are recorded from minor to major injuries to employees in Nigeria. The devastating effects of maintenance errors and economic losses sustained during industry breakdown cannot be ignored. It is therefore, necessary that maintenance errors committed by electrical and electronics technicians on electrical and electronics equipment which play key and dominant roles in providing complete automation of production industries in Benue State be studied, and analyzed. This will help in identifying possible causes and elimination or reduction of these errors.

Statement of the Problem

Almost on a daily basis various degrees of industrial accidents are recorded from minor to major injuries to employees and equipment due to maintenance errors committed by service technicians. Many research studies have shown that over fifty percent of all equipment fails prematurely after maintenance work has been performed on them. Dunn (2007) noted that in the most embarrassing cases, such maintenance works performed were intended to prevent the very failures that occurred. Mason (2009) explained that errors committed by service technicians can increase the amount of breakdowns which in turn results in increase risk associated with equipment failure and personal accidents.

Maintenance errors have caused losses in the past and will continue in the nearest future if not identified and corrected (Kirn, Hauber & Noland, 2007). The losses in production industries raises questions on the type of maintenance error committed and whether these errors committed by electrical /electronic technicians in production industries leads to accidents / equipment breakdown in Benue State. Identifying the types of maintenance errors committed by electrical and electronics technicians will boost the economic stability of production industries and reduce health hazards associated with such errors. Therefore, this study sought to investigate into maintenance errors committed by electrical and electronics technicians in production industries in Benue State.

Purpose of the Study

The purpose of the study is to investigate into maintenance errors committed by electrical and electronics technicians in production industries in Benue State. Specifically, the study seeks to:

- (i) Identify the types of maintenance errors committed by electrical/ electronic technicians in production industries in Benue State
- (ii) Find out whether these errors committed by electrical/electronic technicians in production industries lead to accidents / equipment breakdown in Benue State

Research Questions

The following research questions guided the study:

- (i) What are the types of maintenance errors committed by electrical / electronic technicians in production industries in Benue State?
- (ii) Do these errors committed by electrical /electronic technicians in production industries lead to accidents / equipment breakdown in Benue State?

Hypothesis

A null hypothesis was formulated and tested at 0.05 alpha levels.

H_{01} : There is no significant difference in the mean responses of supervisors and electrical/electronic technicians on errors committed in production industries that lead to accidents/equipment breakdown in Benue State

Methodology

A descriptive survey design was employed for the study. The researchers used stratified purposive sampling technique to obtain respondents from production industries in Benue State. The population was 70 respondents comprising of forty five (45) electrical/electronic technicians and twenty five (25) supervisors working in production industries in Benue State. The researcher developed a 30 item structured questionnaires based on purpose, statement and the reviewed literature using a four point scale. The instrument was trial tested in Plateau state using 20 subjects to determine the reliability of the instrument. Split half reliability coefficient formula was used and a reliability coefficient of 0.68 was obtained. Data collected were analyzed using descriptive statistics of mean and standard deviation to answer research questions, while a t-test was employed to test the hypotheses at 0.05 level of significance. An item was considered needed if the mean response rating was 2.5 and above.

Results

Research Questions

- (i) What are the types of maintenance errors committed by electrical /electronic technicians in production industries in Benue State?
- (ii) Do these errors committed by electrical/electronic technicians in production industries lead to accidents/equipment breakdown in Benue State?

To answer research question one and two, mean rating responses and standard deviation of responses of electrical/electronic technicians and their supervisors working in production industries in Benue state for each item were computed. The summary of the responses are presented in table 1

Table 1: Mean and standard deviation responses on maintenance errors which result to various levels of accidents and equipment breakdown

| S/N | Maintenance Errors Nt=45, Ns=25 | \bar{x}_T | \bar{x}_S | SD _T | SD _S | Remarks |
|--|--|-------------|-------------|-----------------|-----------------|-------------|
| Recognition failures: | | | | | | |
| 1 | Inability to identify correct object(s) | 3.65 | 3.76 | 0.48 | 0.44 | Sa/b |
| 2 | Inability to identify correct signal(s) | 3.63 | 3.71 | 0.49 | 0.47 | Sa/b |
| 3 | Inability to identify correct message(s) | 3.43 | 3.47 | 0.50 | 0.62 | Sa/b |
| 4 | Inability to detect problem state(s) at the right time cause | 3.39 | 3.20 | 0.49 | 0.56 | Sa/b |
| Memory failures: | | | | | | |
| 5 | It was forgotten to put up warning sign | 3.79 | 3.76 | 0.41 | 0.47 | Sa/b |
| 6 | Following interruptions in sequence of operations, actions were forgotten and omitted or skipped | 3.80 | 3.18 | 0.41 | 0.73 | Sa/b |
| 7 | It was forgotten to replace worn out and frayed belts on equipment | 3.67 | 3.65 | 0.47 | 0.49 | Sa/b |
| 8 | It was forgotten to lock-out unsafe equipment | 3.47 | 3.47 | 0.50 | 0.51 | Sa/b |
| 9 | It was forgotten to put tag on unsafe equipment | 3.39 | 3.41 | 0.53 | 0.51 | Sa/b |
| Rule based mistakes: | | | | | | |
| 10 | A spanner that loosely held a bolt was used to tighten the bolt | 3.75 | 3.75 | 0.48 | 0.45 | Sa/b |
| 11 | Person(s) involved in team work not communicated when team work was completed and equipment energized | 3.69 | 3.71 | 0.51 | 0.47 | Sa/b |
| 12 | Inability to inspect completed tasks physically | 3.67 | 3.71 | 0.52 | 0.47 | Sa/b |
| Knowledge based errors: | | | | | | |
| 13 | Required servicing was not performed | 3.51 | 3.47 | 0.51 | 0.51 | Sa/b |
| 14 | Wrong equipment was installed | 3.45 | 3.41 | 0.50 | 0.51 | Sa/b |
| 15 | Wrong part was installed | 3.39 | 3.53 | 0.49 | 0.52 | Sa/b |
| 16 | An unacceptable condition of equipment was accepted | 3.53 | 3.67 | 0.54 | 0.49 | Sa/b |
| 17 | Wrong grease was applied at appropriate points of the equipment | 3.50 | 3.60 | 0.71 | 0.51 | Sa/b |
| 18 | The good practice was not followed when the problem for the first time was solved | 3.71 | 3.56 | 0.46 | 0.51 | Sa/b |
| Skill-based slips: | | | | | | |
| 19 | Parts of equipment incorrectly replaced | 3.67 | 3.56 | 0.52 | 0.51 | Sa/b |
| 20 | Screws or bolts were left at 'finger-tight' rather than properly secured | 3.62 | 3.75 | 0.49 | 0.45 | Sa/b |
| 21 | Foreign objects which cause short circuit were not cleared when the job was completed and equipment energized | 3.78 | 3.75 | 0.42 | 0.45 | Sa/b |
| 22 | A screw was excessively driven and it caused wear or damage | 3.70 | 3.63 | 0.46 | 0.50 | Sa/b |
| 23 | Cable insulations were wounded | 3.64 | 3.50 | 0.49 | 0.52 | Sa/b |
| 24 | Motor bearings were over-oiled, resulting in oil being thrown onto insulation (fire hazard) and onto the floor (fall hazard) | 3.53 | 3.44 | 0.50 | 0.51 | Sa/b |
| 25 | Inaccurate measurement was taken | 3.57 | 3.50 | 0.54 | 0.52 | Sa/b |
| Violation errors: | | | | | | |
| 26 | The procedure was ignored | 3.64 | 3.71 | 0.53 | 0.59 | Sa/b |
| 27 | A pair of pliers was used to tighten a nut onto a bolt | 3.74 | 3.00 | 0.49 | 0.50 | Sa/b |
| 28 | A knife was used to drive a screw | 3.66 | 3.71 | 0.52 | 0.69 | Sa/b |
| 29 | It was impossible to get job done if procedures were followed strictly | 3.60 | 3.06 | 0.50 | 0.56 | Sa/b |
| 30 | Rules were not adhered to in order to get job done faster and have thrill | 3.53 | 3.71 | 0.50 | 0.59 | Sa/b |
| Grand (Mean and Standard deviation) | | 3.60 | 3.53 | 0.5 | 0.5 | Sa/b |
| | | | | 0 | 2 | |

NB: Nt = no. technicians, Ns = supervisors, \bar{X}_t = mean response of technicians, \bar{X}_s = mean response of supervisors, Sdt = standard deviation of response of technicians, Sds = standard deviation of response of supervisors Sa/b = serious accidents / serious breakdown respectively.

Table 1 indicates that the following types of errors were errors committed by electrical/electronic technicians during maintenance servicing. They include: Recognition failures, Memory failures, Rule based mistakes, and Knowledge based errors. Others were Skill-based slips and Violation errors. All the respondents in the study agreed that the identified errors in the study were types of errors committed by various electrical/electronic technicians in industries in Benue state during maintenance services and that these errors usually lead to accidents/ equipment breakdown in the state.

Values of mean and standard deviation of responses for electrical/electronic technicians on individual items range from $\bar{X}_t = 3.43$ and Sdt = 0.41 to $\bar{X}_t = 3.80$ and Sdt = 0.71 respectively; while mean values and standard deviation of responses for supervisors stood between $\bar{X}_s = 3.00$ and Sds = 0.44 to $\bar{X}_s = 3.76$ and Sds = 0.73 indicating that the various types of maintenance errors were committed by electrical/electronic technicians in production industries in Benue state during maintenance services and they usually lead to accidents or eventual breakdown of equipment. The respective high grand mean response values of technicians and supervisors ($G\bar{X}_t = 3.60$ and $G\bar{X}_s = 3.53$) on these errors further agreed with the individual item assessment of the errors by the two groups of respondents. The corresponding grand standard deviation of responses of technicians and supervisors on the various types of maintenance errors and their effects which stood between Gsdt = 0.50 to Gsds = 0.52 further affirmed how closely these two groups of respondents agreed among themselves on the identified types of maintenance errors and their consequences to individuals and equipment. This may be interpreted to mean that maintenance errors committed by electrical/electronic technicians indicative of items lead to serious accidents/equipment breakdown in production industries in Benue State.

Hypothesis

There is no significant difference in the mean responses of supervisors and electrical/electronic technicians on errors committed in production industries that lead to accidents/equipment breakdown in Benue State.

Table 2: t-test of mean responses on errors committed

| Group | \bar{X} | SD | df | SE | t-Cal. | t-Crit. | Decision |
|-------------|-----------|------|----|------|--------|---------|----------|
| Supervisors | 3.53 | 0.52 | | 0.05 | | | |
| | | | 64 | | 0.24 | 1.67 | Accept |
| Technicians | 3.60 | 0.50 | | 0.05 | | | |

Note: \bar{X} = Group grand mean, SD = Group standard deviation, SE = Standard error, t-cal. = calculated and t-critical = 1.67

Table 2 shows that the value of t- calculated (0.24) was less than the table value (t-critical) of 1.67 at 0.05 level of significance. This revealed that there is no significant difference between the mean responses of supervisors and electrical/electronic technicians on errors committed in production industries that lead to accidents/equipment breakdown in Benue State. Therefore, the null hypothesis was accepted indicating that the difference in means was not statistically significant.

Discussion

Finding on types of maintenance errors committed by technicians indicates that they include; recognition failures; memory failures; skill-based slips; rule-based mistakes; knowledge-based

errors; and violations. This finding is consistent with Mason (2009) who noted that maintenance errors range from becoming distracted and forgetting important checks to knowingly deviating from a permit to work procedure in order to save time or to get the job done in unexpected circumstances. Similarly, Dunn (2007) classified human errors which occur in maintenance activities according to their contributing factors as recognition failures; memory failures; skill-based slips; rule-based mistakes; knowledge-based errors; and violations. Electrical and electronics maintenance technicians who are also human beings commit such errors during maintenance activities in Benue State production industries. This is attested by the two groups of respondents who confirmed that they were types of errors encountered during maintenance services. Dunn (2007) explained that more than half of maintenance errors are recognized as having happened before-often many times.

On whether maintenance errors committed by electrical and electronics technicians in manufacturing industries can lead to accidents/ equipment breakdown in Benue State, respondents unanimously agreed that skill based errors, rule based and knowledge based errors among others usually lead to accidents and equipment breakdown in Benue state process industries. This finding agree with Abiose & Otache, (2000) as cited in Nande (2013) who observed that violation of safety rules was found to have resulted into six ocular accidents in Nigerian factories. Health and safety executive of the United Kingdom in Mather (2007) also found that more than 60% of all maintenance failures had human error as the root cause, with only 21% representing true engineering failures. This finding also agree with Kirn, Noland and Hauber (2007) who identify errors which cause equipment failures and accidents to include: Crew turnover, Skill based error, Rule based error and Knowledge based error.

Conclusion

The study clearly identified recognition failures, memory failures; skill-based slips, rule-based mistakes, knowledge-based errors, and violations errors as key errors committed by electrical/electronic technicians in Benue state production industries. It also pointed out that such errors are responsible for the various levels of accidents and equipment breakdown in the state and must be checked.

Recommendations

The following recommendations are based on the findings of this study:

- (i) The effects of maintenance errors should be investigated and pooled into database to enable maintenance personnel understand the risk involved in improper maintenance electrical/electronic gadgets.
- (ii) Good quality feedback should be provided to allow users to judge how effective their actions have been and the state of equipment or individual as a result of such actions
- (iii) Maintenance error is a form of human error therefore it is inevitable but it should be avoided and managed when it occur.

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