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Hazards and Risk Assessment in an Oil and Gas Company

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Abstract— **This study identified hazards and assessed risks in an oil and gas company (petrochemical plant), Nigeria. The aim is to proffer control measures in a bid to reduce associated risk to as low as reasonably practicable. Using a purposive sampling, 2 operators in each unit, and a total of 22 activities in 6 units of the plant. Hazards and risks in each unit with sub activities were assessed and analyzed, using; Job hazard analysis, Checklist and assessment form with other tools. The risk assessment tools employed were Probability and Severity ratings. Analytical tools such as t-test and ANOVA were used to find out whether risk levels were significant. The results obtained showed that highest risk associated with the plant was 12 as rated in the risk matrix before control measure. The highest risk rating before control measures were related to welding, grinding, and cutting job on process equipment, continuous monitoring of process operations on DCS, cleaning of circulation water reservoir, cleaning and operations of vent devices and cleaning of spent alumina dropping truck with fire hydrant water.Majority of the risks associated with the plant, had a risk score of 4 (negligible). The result has shown that the highest risk rating before control measure had a mean of 9.5 and became 5.9 after control measure which is considered minor, indicative of treatment. ANOVA has shown that p-value is 6.09E-10 and a p-value less than 0.05 (typically ≤ 0.05) is statistically significant. The overall rating showed that hazards and risks were properly managed in the plant.**

Index Terms— **Assessment, analysis, Hazard, Checklist, and Hazard Identification.**

I. Introduction

Health and Safety Executive (2005) estimated that over 200 people have died from accident at work yearly and a number approaching over a million injured. Sicknesses have resulted from workplace and about two million of such cases have been recorded which has led to accidents. These statistics have shown a large gap to working safely, hence this study will contribute to narrowing the gap.

Avoiding accidents at workplace should be top concern for everyone including the team of management, contractor, employees and these can be done with a positive safety culture like hazard and risk assessment, better management systems, imbibing good practices such as- periodic safety drills, daily toolbox meetings, safety inductions on recruitment and supervision by a qualified safety supervisor when work is on-going.

The importance of hazards and risk assessment is now well known in most petrochemical plants (Azadeh et al., 2013), although hazards are yet to be reasonably minimized in the petrochemical industries and such has occasioned this research.

Petrochemical plants convert natural resources like crude oil and natural gas liquids into products for a wide range of applications, these plants produce many important building blocks for industrial processes, comprising ethylene, propylene, butadiene, and aromatics. Hassim & Hurme (2010) put forward an inherent Occupational Health Index which has been well-known for evaluating the health risks of process path during process study and development phase. The system takes into consideration both the hazard from the chemicals present and the potential for the exposure of workers to the chemicals (Hassim & Hurme, 2010).

The Petrochemical complex consists of a mixed feed ethylene cracker plant, polyethylene plant producing high density polyethylene (HDPE) and linear low-density polyethylene (LLDPE), a polypropylene plant producing different grades of polypropylene (PP). The main feedstock is Natural Gas Liquids (NGL) which may be supplied by pipeline from a gas separation plant and could be supplemented by Propylene Rich Feed (PRF) from a nearby refinery. A Petrochemical complex produces over 300,000 tons of polyethylene and propylene resins annually, majority of which are sold in the domestic market (Manish, 2020).

Polyethylene Plant uses Catalyst (Zieglar Natta) to convert Ethylene FE, butene, FB-1 / FC-1 to polyethylene. It is a combination of main catalyst and co-catalyst. The main catalyst is a mixture of Titanium Tetrachloride and vanadium oxy-chloride.

The polyethylene production process involves purification, absorption and reactor feed pumping, reaction, solution heating and solution absorber, polymer separation, catalyst & deactivator preparation, extrusion & palletizing, additive batch preparation, product stripper, drying and blending, recovery of solvent, monomer & co-monomer (Manish, 2020). The above processes come with enormous hazards and risks associated with them such as chemical exposure, inhalation of chemical, chemical bath, skin and body contact and irritation, Hydrocarbon exposure, cut injury, stress and strain, waist and back ache, fire, explosion, etc hence the need for this research. The following steps will help to minimized the gaps with respect to hazards associated with petrochemical plant; breaking the job down into the steps or tasks performed while doing the job, identifying and listing the hazards associated with each task (one after the another), writing a hazard description (also called a hazard scenario) and determining preventive measures to overcome these hazards.

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II. RESEARCH METHODOLOGY

A. Research Design

The descriptive research method was adopted for this study. The purpose of a descriptive study is to provide picture of a situation, person or event or show how things are related to each other and as it naturally occurs (Blumberg, Cooper and Schindler, 2014). The reason for chosing descriptive study is also to find out the inherent risks without changing the natural environment or situations of hazards and risks in the plant, to stand out as a correlational study.

The study is to identify hazards, assess risks and evaluate risks in the selected plant unit and proffer suitable control measures. To achieve this, primary data was collected.

B. Study Area

The study area covered just a unit of a petrochemical plant in Nigeria. The topography is moderately flat in some area and within the rainforest zone of Nigeria which covers the total landmass of about 11,077 km (Udensi, 2017)

C. Data Collection

This research involved collection and analyzing of qualitative data, through a semi-structured interview and observation.

Semi-structured interview offers a balance between a formal interview's focus and the flexibility of an unstructured interview. Observation was used to study the behavior of the workers in the plant and also for hazards and unsafe acts and conditions that can create risks and harm. They were observed to figure out how they behave in certain conditions.A personal in-depth interview and covert observation precisely was used for data collection.

Data Collection Materials

Different job activities involved in the unit were first identified and itemized. Observation was conducted covering materials, equipment, environment, workers and standard operating procedures of various identified activities and sub-activities using the following tools;

1. A job hazard analysis report (JHA), see Table 3.1
2. Checklist
3. Hazards and risk assessment form

Table 1.0: A Job hazard analysis report (Safetyculture, 2018)

S/No.	Task Steps	Hazards	Hazards Consequences	Controls	Responsible Party	Comments

Source of Data Collection

The source of data collection in this study was primary, using the JHA and Checklist adapted from safetyculture, 2018.

The JHA and Checklists were distributed to 12 operators (purposive sampling) in six units of the plant, namely; Feed purification , Feed absorption , catalyst preparation and metering, polymerization (reactor unit), Pelletization (extrusion unit) and blending unit.

Step 1: They began the JHA for a specific job by breaking the job down into the steps or tasks performed while doing the job.

Step 2: the operators identified and listed the hazards associated with each task

Step 3: Wrote a hazard description (also called a hazard scenario) and the consequences of the hazards with their observations and information extracted with hazard identification checklist containing the necessary questions as indicated in the checklist, covering mechanical, electrical, radiation, flammable, health and environment, housekeeping and organizational areas**.**

Step4: Determined preventive measures to overcome these hazards and whose responsibilities.

D. Data Analysis

Different risk tools assessment were used in order to effectively analyze hazards and inherent risks which have given rise to hazards and risk concerns in the plant, these risk assessment tools include:

1. Probability rating (from 1 to 5)
2. Severity rating (from 1 to 5)

3. Risk rating/Risk score
4. Risk Matrix

Risk Rating / Risk Score:

The risk rating was determined by multiplying the likelihood of an occurrence of a hazardous event or exposure(s) and the severity of injury or ill health that can be caused by the event or exposure(s).

Risk Rating (RR) = Probability X Severity

Each Risk rating was assigned a specific colour as;

Negligible (light green); Minor (yellow); moderate (orange); significant (red) and Severe (dark red). See table 1: Risk score

Table 1.1: Risk score

Impact Rating	Color Code	Description
1 – 4		Negligible
5 – 9		Minor
10 – 12		Moderate
15 – 16		Significant
20 – 25		Severe

Based on the risk score, the risk was classified as Negligible, Minor, Moderate, Significant or Severe.

III. RESULTS

A total of 22 areas and other numerous sub activities were assessed in the petrochemical plant, as shown in tables 2.0 and 2.1. A statistical analysis done with t-test before implementation of control measures as seen in t-test table (table 2.4) indicated a mean of 9.5 which is approximately 10, falling within moderate region of risk classification in the risk rating provided in table 1.1. The risk rating reduced to 5.9 which fell within the "minor" region of our risk rating after a measure of control was implemented. A minor rating needs treatment to reduce it to as low as reasonably practicable (ALARP) until it is deemed acceptable according to a functional definition of risk management (Wilson & McCutcheon, 2021)

ANOVA: single factor and descriptive statistics have shown significant means that deserves to be further controlled, 5.9 and 5.9 respectively (see table 2.2)

ANOVA: single factor has shown that p-value is 6.09E-10 and a p-value less than 0.05 (typically ≤ 0.05) is statistically significant.

Table 2.0: Assessment Summary

Activity No	Highest Risk level before control	Highest Risk level after control	Remarks
1.	12	8	Minor
2.	9	6	Minor
3.	12	9	Minor
4.	9	4	Negligible
5.	9	6	Minor
6.	9	6	Minor
7.	9	6	Minor
8.	9	6	Minor
9.	8	6	Minor
10.	12	6	Minor
11.	6	6	Minor
12.	9	6	Minor
13.	12	6	Minor
14.	9	6	Minor
15.	9	6	Minor
16.	9	6	Minor
17.	12	6	Minor
18.	9	4	Negligible
19.	9	6	Minor
20.	12	6	Minor

21.	9	4	Negligible
22.	6	4	Negligible

Table 2.1 ANOVA:

Single Factor

Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Column 1	22	209	9.5	3.214286
Column 2	22	129	5.863636	1.361472

ANOVA

Source of Variation	*SS*	*Df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	145.4545	1	145.4545	63.57616	6.09E-10	4.072654
Within Groups	96.09091	42	2.287879			
Total	241.5455	43				

Note that a p-value less than 0.05 (typically ≤ 0.05) is statistically significant.

Table 2.3 Descriptive statistics

ONE WAY

Highest Risk level before control		***Highest Risk level after control***	
Mean	**9.5**	**Mean**	**5.863636**
Standard Error	0.382235394	Standard Error	0.248767
Median	9	Median	6
Mode	9	Mode	6
Standard Deviation	1.792842914	Standard Deviation	1.166821
Sample Variance	3.214285714	Sample Variance	1.361472
Kurtosis	-0.165125406	Kurtosis	2.19182
Skewness	0.027268919	Skewness	0.486422
Range	6	Range	5
Minimum	6	Minimum	4
Maximum	12	Maximum	9
Sum	209	Sum	129
Count	22	Count	22
Confidence Level(95.0%)	**0.79490201**	**Confidence Level(95.0%)**	**0.5173**

	4		**4**

Table 2.4. T-Test: Paired Two Sample for Means

	Highest Risk level before control(VARIABLE1)	***Highest Risk level after control(VARIABLE2)***
Mean	**9.5**	**5.863636364**
Variance	3.214286	1.361471861
Observations	22	22
Pearson Correlation	0.512173	
Hypothesized Mean Difference	0	
Df	21	
t Stat	10.93494	
P(T<=t) one-tail	1.98E-10	
t Critical one-tail	1.720743	
P(T<=t) two-tail	**3.96E-10**	
t Critical two-tail	2.079614	

IV. Discussion

The results obtained from the research showed that in table 2.0, the highest risk rating after control measure was 6 which is minor, while the highest risk rating before control measure was 12, indicative of moderate risks and were necessary to be controlled. This is in corroboration with the view that any risk that scores above minor is suspected to degenerate and must be given attention (Pradeep & Mishra, 2019).

Hitting of pipe line/structures which could cause accident during cleaning of spent alumina by dropping truck is one of the activities to have had a risk score of 12. Another one of the same risk rating is body and hand connection with hot surface which could lead to burns, hot stress and strain and head injury due to closed pipes during cleaning and operations of vent devices.

From table 2.0, the highest risk rating after control measure was 6 which is minor and needs treatment to prevent degeneration. The lowest in all, after control measure was 4 which show negligible risk and this is consitent with the view that risk must be reduced to as low as reasonably practicable (ALARP) (Wilson & McCutcheon, 2003). Considering the cost of constructing a petrochemical complex, a little risk that could degenerate to cause the company any loss, should be given adequate attention in the form of putting in place the necessary layers of protection.

Given the nature of day to day activities which include volatile activities, some scholars in the literature have attempted to conceptualize the inevitability of accidents in the sector (Ilodiuba, 2021). This is the reason why it is necessary to identify and assess risk in a petrochemical company.

V. Conclusion

22 areas and other numerous sub activities were assessed in a petrochemical plant in Nigeria, as shown in table 2.0. A statistical analysis done with t-test before implementation of control measures as seen in table 2.4 indicated a mean of 9.5 which was approximately 10, falling within moderate region of risk classification in the risk rating. The risk rating reduced to 5.9 which fell within the “minor” region of risk rating after the measure of control was implemented. A Minor rating needs treatment to reduce it to as low as reasonably practicable (ALARP) until it is deemed acceptable according to a functional definition of risk management (Wilson & McCutcheon, 2021).

ANOVA single factor and descriptive statistics have shown significant means that deserves to be further controlled, 5.9 and 5.9 respectively.

Anova single factor has equally shown that p-value is 6.09E-10 and a p-value less than 0.05 (typically ≤ 0.05) is statistically significant.

The overall rating has shown that, hazards and risks were properly managed in the assesssed unit of petrochemical plant.

However, for continuous improvement, the following recommendations will help;

1. Do risk assessment every 3 years using Checklist method as it has proven to be effective in a Petrochemical plant from the results.
2. Do retraining every 3 years to enhance workers performance.
3. Weekly walk through survey is proffered in areas considered to have a risk classification above negligible.
   a) It’s therefore worthy of note, that it’s possible to have a work area with risks as low as negligible (as low as reasonably practicable) (Wilson & McCutcheon, 2021). This will generally, enhance teaching or training on risk assessments for any new unit built in a

petrochemical complex or to train new intakes

b) Review of measures of control should be done when new equipments are installed, any change in the operating procedures and as well as policies.

c) Finally, I recommend integration of findings into general risk management of petrochemical plants..

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