



Modelling of Safety Management System (SMS) Using Fire Systemic Safety Management System Model (FSSMS) for Bonga Offshore Oil and Gas Field, Nigeria

Idriss U. and Lawan M. Z.

Department of Chemical Engineering, Faculty of Engineering, University of Maiduguri,
PMB 1069, Maiduguri

ABSTRACT

The Bonga offshore Field encompassed many Oil and Gas blocks which were modelled in such a way that their safety system coherently working in order to enhance Safety, Health and Environmental (HSE) performance using Fire systemic Safety Management system (FSSMS). The operational units (Well heads, Gas compressor, Electrical Panel and Separators) and Oil Blocks of Bonga Offshore field have been used to illustrate some of the characteristic of the Fire systemic safety management model (i.e. recursive structure and organizational structure), the system were linked based on their relationship strength or weakness in order to maintain effective communication so as to retain the risk level within the acceptable limit. It is hoped that the approach will lead not only to more effective management of safety in the oil and gas industry, but also to more effective management of safety for any organization.

Keywords: Recursive structure, systemic view point, communication linkages, safety management system.

INTRODUCTION

The Bonga Field is an oil and Gas field in Nigeria. It was situated 75 mile southwest of the Niger Delta, License block OPL 212 on the Nigerian shore, which was later change to OML 118 in February 2000. The field covers nearly 60 km² with an average water depth of 3,300 ft, the field contain about 6,000 mm barrels of Oil. In 1996 the first field was discovered by Shell Petroleum Company Nigeria, where the Nigerian government gave the approval for its development in 2002. The production for both petroleum and natural gas started in November 2005 using FPSO vessel. The Oil and Gas produced are offloaded via Tankers and Pipeline to Nigerian Liquefied Natural Gas (LNG) plant. The Shell Nigerian possesses 55% of the license, Exxon 20%, Nigerian AGIP 12.5%, and Elf Petroleum Nigeria Limited 12.5% (Offshore Technology, 2020).

The occurrence of Piper Alpha disaster in 1987 in the North Sea UK, where hundred and sixty-seven employees were killed and injured few employees, come to be the wakeup call for transformation in offshore oil and gas industry safety management system (Cullen, 1990). Eventually, inquiry regarded this accident come up with recommendation for systematic safety management plan as well as provided safety case (Cullen, 1990). Accidents like the Piper Alpha disaster as well as other accidents which have occurred world-wide have highlighted the need to develop a proper safety management system for all oil and gas Field (HSE, 1997). In the first place its intensity was such that it could not be disregarded in the oil and gas organizations around the globe, and secondly, a certain number of measures have been achieved as a result of the

incident (Parte-Cornell 1993). Development of proper Safety management system (SMS) for Bonga Offshore Oil and Gas Field Nigeria it's become very essential at its beginning of the development of the field, the field is depicted in Figure 1.

The main causes of Piper Alpha are deficiencies in the communication channels of the Safety Management System (SMS) units, and challenges in controlling the exchange between safety as well as productivity within the Oil and Gas Platform in the field. The proper Safety Management system had been developed by adopting Fire safety management system, in order to maintain the risk within acceptable limit and sufficient communication channels.

Models of Safety Management Systems

The industries that deals with major hazard facilities must established and implement safety management system according to Australian work place safety regulation (Pearse *et al.*, 2001). Establishment and implementation of safety management system (SMS) is the primary means of assuring safe operation of major hazard facilities, "A safety management system (SMS) is a comprehensive and integrated system for managing health and safety risk at a major hazard facility" (NETWORKSAFE 2009). The academe, regulatory and industry have put a considerable amount of commitment to examine and develop procedures which will help in addressing safety and environment issues (Santos-Reyes and Santos-Reyes, 2002). Some institutions have developed their Safety management system (SMS) from environmental standard like the ISO 14001 (E&P Forum, 1994).

*Corresponding author. E-mail: idriss446@gmail.com

Author(s) agree that this article remain permanently open access under the terms of the Creative Commons Attribution License 4.0 International license

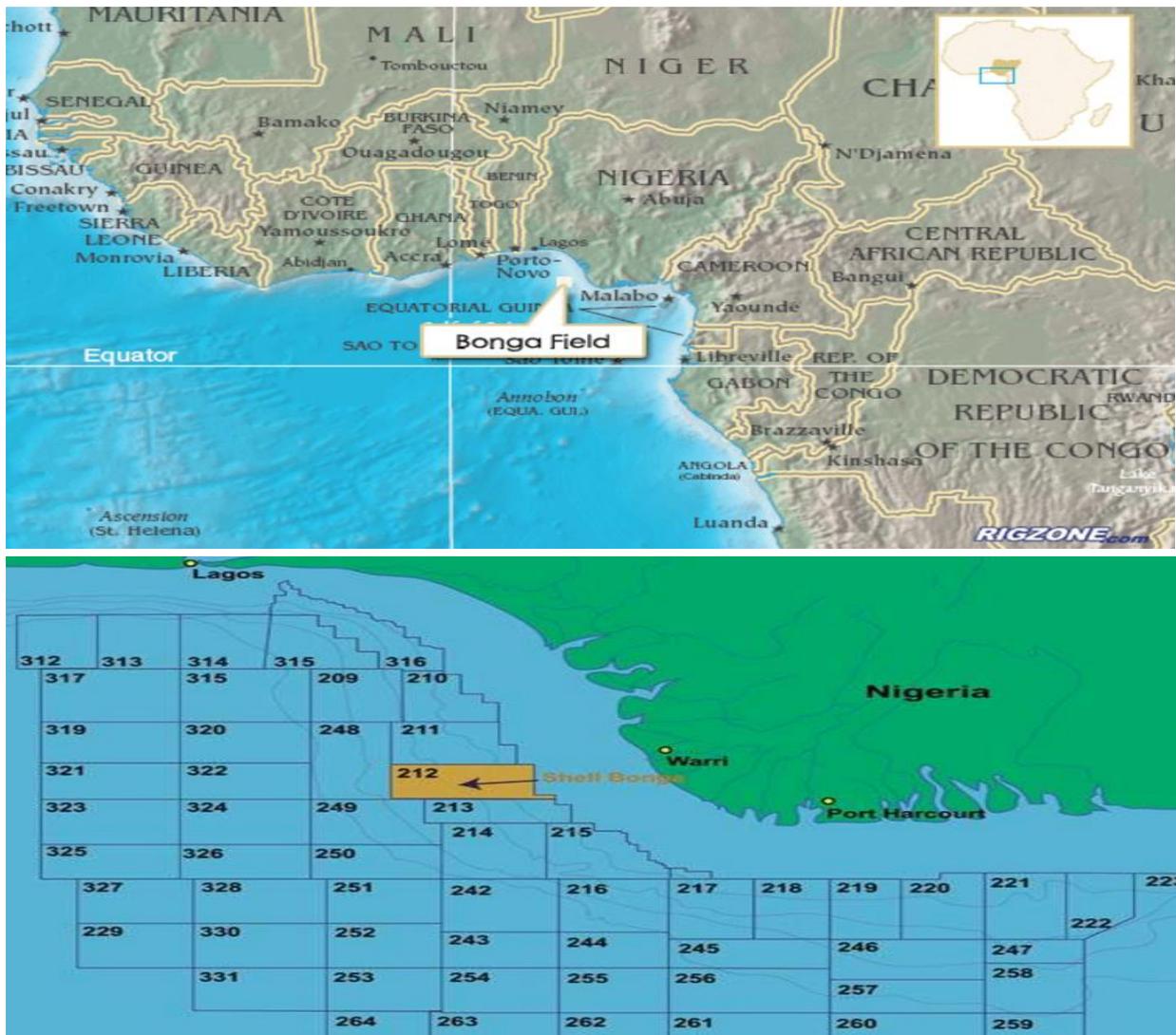


Figure 1: Bonga Offshore Oil and Gas Blocks (Rigzone nd).

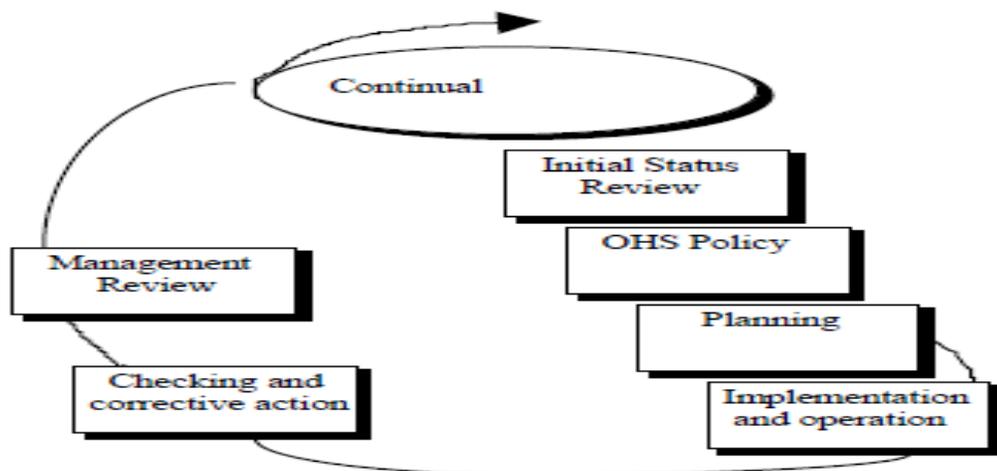


Figure 2: Environmental management system model (Santos-Reyes and Santos-Reyes 2002)

Environmental Management System Model

Environmental management system (EMS) is designated procedure for setting and meeting environmental objectives, it is comprised of policy, planning, evaluation, measurement, implementation, operation, management review and continual improvement as shown in Fig. 2 (EPA, 2013). The Hazard management analysis (HMA) is comprised of identification, assessment control and recovery, HMA assists in analysing crucial activities and operations term ‘safety critical’, for every safety critical activity, a collection of documents referred to as the SMS catalogue is developed (OSHA n.d).

Fire Systemic Safety Management System Model (FSSMSM);

Systemic can be described as the holistic assessment of a system as well as the evaluation of the possible failures in every event related to the system “as product of a working of a system”, and within that all likelihood of accident may be observed. “A systemic approach has been adopted to construct a systemic safety management system” (Santos-Reyes and Beard, 2008). “Systemic safety management system (SSMS) has been constructed by employing the concepts of systems, a number of systemic failures have come to light” (Santos-Reyes and Beard, 2009). Description of this model is based on the following: Environment of SSMS, Structural organization of the SSMS and Structural recursion and autonomy of SSMS.

Table 1: Environmental External factors of FSSMSM

| ENVIRONMENTAL FACTOR FOR SSMS | | |
|--|---|----------------------------------|
| Socio-Political Factor | Economic Factor | Physical Factor |
| Legislation Safety, Health and Environment Standard Regulatory Enforcement Major Accident or Disaster Professional Bodies Public Opinion Technology Suppliers of Goods and Services Trade Unions Product and Labour Markets National and Local Cultures | Insurers Trading Condition Economics Interest | Geography Location Climate |

Source: (Santos-Reyes and Beard, 2008)

Safety development, system 4: safety confidential reporting System 5: Safety Policy) arranged and constructed in such a way that it is necessary to achieved their functional association within them (Santos-Reyes and Beard, 2002).

METHODS

Research type adopted in this research is exploratory research where the research tries to clarify the relationship of safety management system and how it would be model in a systemic view point in order to improve safety in Bonga offshore Oil and Gas Field.

Deductive approach was adopted to achieve the modelling of safety management system (SMS) in the Bonga Offshore oil and gas organization. The research would be based on extensive study on concept of safety as well as hypothesized on universal management system.

In addition, the purposes for using an inductive approach are to reduce the complex safety management system of Bonga field data into a brief summary format, to make a connection between research objectives and the outcomes resulting from the data, as well as develop a SMS model.

Study Area

The Bonga Offshore Oil and Gas field is made up of about Six Oil and Gas Blocks each block contain operational platform producing Oil. Therefore, the Bonga field would be connected together with numerous Oil and Gas Platform as shown in Figure 1. The total operation (TO) and the Total safety management unit (TSMU) in the Bonga field are the needed data for this research as shown in Table 2, where safety management system of the field would be model using Fire systemic safety management system.

Table 2: Operations and their safety management unit of Bonga Field

| Bonga Field Operations | Bonga Field Safety Management Unit (SMU) |
|-------------------------------|---|
| Block 209 (B209O) | Block 209 (B209SMU) |
| Block 210 (B210O) | Block 210 (B210SMU) |
| Block 211 (B211O) | Block 211 (B211SMU) |
| Block 212 (B212O) | Block 212 (B212SMU) |
| Block 213 (B213O) | Block 213 (B213SMU) |
| Block 214 (B214O) | Block 214 (B214SMU) |
| Block 215 (B215O) | Block 215 (B215SMU) |
| Block 216 (B216O) | Block 216 (B216SMU) |
| Block 217 (B217O) | Block 217 (B217SMU) |
| Block 218 (B218O) | Block 218 (B218SMU) |
| Block 219 (B219O) | Block 219 (B219SMU) |
| Block 220 (B220O) | Block 220 (B220SMU) |
| Block 221 (B221O) | Block 221 (B221SMU) |
| Block 222 (B222O) | Block 222 (B222SMU) |

The production deck of the platform was situated at 25.6m higher than sea as well as contained four (4) modules A-D modules as normally found on offshore platform at every oil block. The modules consisted of Christmas tree or well head and were arranged in 12 in each row of 3 making 36. The module for production consists of two major

production separators, separator for separation of gas and water from the oil. The modules are as follows: Module A consists of wellhead, Module B consists of separators, Module C consists of gas compression equipment and Module D consists of electrical equipment.

Table 3: Operations and their safety management unit of Offshore Platform

| Platform Operation | Platform Safety Management Units |
|---------------------------|---|
| Module A Operation (OAM) | Module A Safety Management Unit (SMUAM) |
| Module B Operation (OBM) | Module B Safety Management Unit (SMUBM) |
| Module C Operation (OCM) | Module C Safety Management Unit (SMUCM) |
| Module D Operation (ODM) | Module D Safety Management Unit (SMUDM) |

Source (Parte-Cornell 1993)

Bonga Field Safety Management System Modelling Using Fire Systemic Safety management System

Recursive Structure of Bonga Field Using FSSMS

In applying the SSMS model in modelling the safety management system of a Bonga Field, firstly, all the systems involved and their boundaries were identified (i.e. subsystem/operations) as discussed in the literature (i.e. system I to VI). System I is the core unit for all business process that takes place in an organization, which signifies that all the risks that occurred in oil and gas operation take place in system I.

SSMS modelling begins by connecting the subsystem in the system I both vertically and horizontally. Oil and gas organization was divided into three levels (Recursion 1-2) as required by this research (i.e. Focus on Bonga Field and all Platforms Involve). Level I of system I comprises of the two most important areas in oil and gas industry i.e. Operation of Oil and Gas Production (OOGP) and Safety Management Unit of Oil and Gas Production (SMUOGP). The OOGP is an interaction in all the process that is conducted for production and service while SMUOGP concern all safety management activities involved in managing oil and gas production operation.

To maximize the outcome of system I, the Bonga Field OOGP has to be decomposed into all Oil and Gas Block 209-223 that is recursion I to II. Each of these operations will further decomposed into the next recursion (i.e. recursion II to III), Operations of Platforms) into A-operational module (OAM), B-operational module (OBM), C-operational module (OCM) and D-operational module (ODM) as illustrated in recursion III as summarized in Table 3. Decomposition of the operations into different recursion above identifies the steps of importance or interest in safety management system that would be focused on (i.e. recursion I, and II, III).

Structural Organizational of Bonga Field

Organizational structure describes the modelling of safety management system of Bonga Field (i.e. OOGP and SMUOGP) base on the recursion I, II and recursion II, III, which the recursion structure model have focused on for safety management system. The Block 209 (B209O) to Block 223 (B223O) are the operations which are already identified by recursion 2 as outline in Table 2, all these subsystem are being modelled together by using zigzag line and non-stop line.

RESULT AND DISCUSSION

Result of Recursion of the Bonga Field

The Operations in Oil and Gas Block must have certain degree of dependence on each other, the modelling network

represents the interdependence in the system I of B209O to B212O which may be weak or strong, depending on physical interdependence as explained in Table 4,

Table 4: Operational Interdependence (Strong or weak dependence) of Oil and Gas Blocks in Bonga Field

| Zigzag line & straight line | Physical Interdependence | Description |
|-----------------------------|--------------------------|--|
| | Strong Weak | |
| 1 | X | The distance between Oil and Gas pipe line connected from B209 to B212 is very far and it has direct connection. |
| 2 | X | The distance between Oil and Gas pipe line connected from B209 to B211 is far and it has direct connection. |
| 3 | X | The distance between Oil and Gas pipe line connected from B210 to B212, is very far distance |
| 4 | X | The Oil and Gas pipe line connected from B209 to B210, with a very close distance |
| 5 | X | The Oil and Gas pipe line connected from B210 to B211, with a very close distance |
| 6 | X | The Oil and Gas pipe line connected from B211 to B212, with a very close distance |

The operations in Bonga field covers all the facilities as well as workforce for the production of oil and gas in all Oil Blocks platforms, the operations and their safety

management system linkages (Communication channels) are shown in Table 5.

Table 5: Communication Channels between Safety Management Unit and their Operations in Bonga Field

| SMUs | B209O | B210O | B211O | B212O | B213O |
|-------|----------------|----------------|----------------|----------------|----------------|
| B209S | A ₁ | | | | |
| B210S | | B ₁ | | | |
| B211S | | | C ₁ | | |
| B212S | | | | D ₁ | |
| B213S | | | | | E ₁ |

Managerial interdependence between the safety management units in Bonga field, all the safety management systems are interdependent, if any changes occurs from the set up criteria in the operations of any

platform will immediately communicate to all safety management units within the Bonga field simultaneously through the given channels as shown in Tables 6 and 7.

Table 6: Managerial Interdependence Communication channels between SMUs in the Bonga Field

| SMUs | B209S | B210S | B211S | B212S | B213S |
|-------|----------------|----------------|----------------|----------------|----------------|
| B209S | | A ₄ | A ₅ | A ₆ | A ₇ |
| B210S | B ₂ | | B ₅ | B ₆ | B ₇ |
| B211S | C ₂ | C ₃ | | C ₆ | C ₇ |
| B212S | D ₂ | D ₃ | D ₄ | | |
| B213S | E ₂ | E ₃ | E ₄ | E ₅ | E ₇ |

Table 7: Managerial Interdependence Communication channels between Systems of the Bonga Field

| SMUs | SYSTEM II | SYSTEM III |
|-------|----------------|----------------|
| B209S | A ₃ | A ₂ |
| B210S | B ₄ | B ₃ |
| B211S | C ₅ | C ₄ |
| B212S | D ₆ | D ₅ |
| B213S | E ₇ | E ₆ |

DISCUSSION

Safety management system (SMS) of Bonga Field and Bonga Oil and Gas Blocks platform was modelled by adopting systemic methods with the aim of maintaining the risk between the acceptable limit. Systemic Safety Management System model was applied to the oil and gas organization in case of Bonga field as well as Bonga Oil and Gas Blocks platform with respect to this research, safety management system of Bonga Oil and Gas Block platform and Bonga Field were modelled base on the structural recursion and structural organization of SSMS model. Safety management system using systemic method covers five functional coordinated systems (System I: Safety policy Implementation, System II: Safety co-ordination, System III: Safety function, system III: safety audit, System IV: Safety development, system IV: safety confidential reporting and System V: Safety Policy) that are necessary to be interrelated (Santos-Reyes and Beard, 2009).

System I (i.e. implementation of safety policy) made up of several operations that work interdependently upon each other. Safety policy implementation (system I) is achieved through the assistance of the other systems from system II to system V. System II (i.e. safety co-ordination) is to assure that all those operations of system I are managed and operated base on the agreement (policy) in Bonga field, system III (i.e. safety function) assures that all the safety policy in Bonga field and Bonga platform function very well within the subsystems and system III* is the subordinate of system III in carrying out the function of audit sporadically, then system IV (safety development) takes care of identifying weakness, strength, treat as well as developing strategic standard in line with systemic changes in the Bonga field's safety policies. Eventually, system V (safety policy of Piper field) is liable for instituting safety policies in line with the challenges (weakness, strength and threat) from system IV for the entire Bonga field (Santos-Reyes and Beard, 2008). The three (3) line Communication channels (i.e. safety management units and their Operational unit, Managerial interdependence and safety management units, and Managerial interdependence and safety management units) as shown in Table 5,6 and 7 are responsible for identified the risk as well as controlling it to acceptable limits. These five (5) systems in this model of the Bonga field and Bonga platform, demonstrate and explain the role of each management system personnel (i.e. system role means the role of employee's managing the system). Again, the five systems in SSMS model have

something in common with key management element found in the existing safety management approach such as environmental management system (EMS), although the approach does not include structural organization from a systemic view point (BS 8800 2004; Druker 1974; OHSAS-18002, 2000).

The SMS modelling of oil and gas is designed based on SMS in focus of recursion; this work focuses on recursion I and II, and II and III. Generally, the purpose of systemic safety management system is to be capable of retaining the risk level between the acceptable ranges in every level of recursion based on operational dependence relation (i.e. weak or strong) on each other as outline in Table 4, this would control the risk level within the acceptable level in organizations means that health, safety, and environmental performance is at the acceptable level (Weldon and Wallace, 2006).

Systemic safety management system (SSMS) incorporates relative autonomy (i.e. every operation in system I is responsible for its own activity accompanied by minimal interference from the other system II – V) by permitting decision making at local level there after communicating to the entire organization (Santos-Reyes and Santos-Reyes, 2002). These decisions were made locally according to their understanding to the safety policy and task specification, the subsystem and operations responsible for the decision making in system I operation based on the communication channels as summarized in Table 5, 6, and 7. Consequently, every system I operation (B209O, B210O, B211O, B212O), should be enriched with making its decision relatively autonomous in order to achieve organizational safety policy effectively in systemic view point.

CONCLUSION

A SSMS model can be described as a systemic sequence of interconnected systems which are planned in the organisational structure. The five systems of the SSMS model are planned to retain risk within a bearable limit in the life cycle of the operations. The SSMS organization of oil and gas industry is proposed to manage safety in an intelligible manner by treating an organization interdependently both vertically and horizontally. The horizontal and vertical interdependent are managed through the interrelations (i.e. communication channels) around the different operations. These channels outlined fittingly so as to react to the necessities as displayed in the organisational operations.

Autonomy of SSMS model should be further developed to execute process operations simultaneously in the energy sector. External environmental factors should be further investigated to consider making every decision locally in subsystems in SSMS model. Development of application software for design, development and implementation of an SSMS model should be considered for offshore oil and gas industry.

REFERENCES

- BS 8800 (2004) *Occupation Health and Safety Management Systems – Guide* [online] available from <<http://www.safety.ncl.ac.uk/uploads/BS%208800%202004%20Occupational%20Health%20&%20Safety%20management%20Systems%20-%20Guide%202004.pdf>> [26/07/2013]
- Cullen, W. (1990) *The public inquiry into the piper Alpha disaster. Part 1 and 2* London: HMSO
- Druker, P. (1974) *Management tasks, Responsibilities, Practices* [online] available from <<http://www.slideshare.net/siddharthgyagi/management-tasks-responsibilities-practices-by-peter-druker>> [20/07/2013]
- EPA (2013) *Environmental Management System (EMS)* [online] available from <<http://www.epa.gov/EMS/>> [20/06/2013]
- E&P Forum (1994) *Guidelines for the Development and Application of Health, Safety and Environmental Management System* [online] available from <http://www.workcover.nsw.gov.au/formspublications/publications/Documents/ohs_management_systems_4231.pdf> [20/06/2013]
- HSE (1997) *Successful Health and Safety Management* [online] available from <<http://www.hse.gov.uk/pubns/priced/hsg65.pdf>> [16/06/2013]
- Nigerian offshore (n.d) “Energy in deep water” [online] available from <https://web.archive.org/web/20120119153301/http://wwwstatic.shell.com/static/nga/downloads/pdfs/briefing_notes/bonga.pdf> [16/09/2020]
- NETWORKSAFE (2009) ‘*Safety Management Systems: Guide for Major Hazard Facilities*’ [online] available from <www.safeworkaustralia.gov.au> [04/07/2013]
- Offshore Technology(OT) (2020) “Bonga Deep-Water Project, Niger Delta, Nigeria” [online] available from <<https://www.offshore-technology.com/projects/bonga/>> [08/09/2020]
- OSHA (n.d) *Safety & Health Management System e Tool* [online] available from <<https://www.osha.gov/SLTC/etools/safetyhealth/comp2.html>> [20/06/2013]
- OHSAS 18002 (2000) *Occupational Health and Safety Management Systems Guidelines for the Implementation of OHSAS 18001* [online] available from <http://www.bre.polyu.edu.hk/research/ConstrSafetyAtHeight/archive/Fall_from_Height_Sol_Int/IntOrgGuideline/OHSAS18002.pdf> [27/07/2013]
- Pate-Cornell, E. M. (1993) *Learning from the Piper Accident: A Post-mortem Analysis of Technical and Organizational Factors* [online] available from <<http://engineeringfailures.org/files/Learning%20from%20the%20Piper%20Alpha%20Accident.pdf>> [14/08/2012]
- Pearse, W., Gallagher, C., and Bluff, L. (2001) *Occupational Health & Safety Management System Proceeding of the First National Conference* [online] available from <http://www.workcover.nsw.gov.au/formspublications/publications/Documents/ohs_management_systems_4231.pdf> [20/07/2013]
- Santos-Reyes, J., and Beard, A. (2001). ‘A Systemic Approach to Fire safety Management’ *Fire Safety Journal* [online] 36 (4), 359-390. Available from <<http://www.sciencedirect.com/science/article/pii/S037971120000059X>> [01/07/2013]
- Santos-Reyes, J., and Santos-Reyes, D. (2002) ‘Assessment of safety Management Systems in Oil and Gas Industry’. *Offshore Technology Conference* [online] OTC 14164. Available from <<http://www.onepetro.org/mslib/app/Preview.do?paperNumber=OTC-14164-MS&societyCode=OTC>> [28/07/2013]
- Santos-Reyes, J., and Beard, A. (2008) ‘A systemic approach to managing safety’. *Journal of loss Prevention in the process industries* [online] 21(1), 15-28. Available from <<http://www.sciencedirect.com/science/article/pii/S0950423007001167>> [05/07/2013]
- Santos-Reyes, J., and Beard, A. (2009) ‘A Systemic Analysis of the Edge Hill Railway Accident’. *Journal of loss prevention in the process industries* [online] 41(6), 1133-1144. Available from <<http://www.sciencedirect.com/science/article/pii/S0001457508000869>> [09/07/2013] <<http://www.sciencedirect.com/science/article/pii/S0001457508000869>> [07/07/2013]
- Weldon, D., and Wallace, J. (2006) ‘The what and How for HSE Management Systems’. *Society Petroleum Engineers International* [online] SPE 98472. available from <<http://www.onepetro.org/mslib/app/Preview.do?paperNumber=SPE-98472-MS&societyCode=SPE>> [08/07/2013]