Impact of Configuration Management on Safety: A Study in A Steel Manufacturing Industry

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Abstract

The paper reports on a study conducted to examine the impact of configuration management on safety in a steel manufacturing company. Findings from literature were used to determine the relationship between configuration management and safety. In addition to a review of literature, empirical data was collected from a steel manufacturing plant. This study adopted a qualitative research design approach in the form of case studies. These studies on specific events and interviews with professionals within the steel manufacturing organizations were carried out in order to achieve the objectives of the study. The initial stage involved identifying the problem, while the next stage entailed conducting a review of extant literature about the concept of CM, leading to a formulation of theories about its practice. Findings were that configuration management had a negative impact on safety in the steel manufacturing plant.

Keywords
Configuration management, Safety, steel manufacturing industry

1. Introduction

With rapid globalisation, a challenge to constantly adapt to change while providing consistent quality products to customers and managing competition is ever present (Yuchun et al., 2013; Phelan et al., 2014). Further challenges for organisations and manufacturing plants are the fact that their success is measured according to their ability to produce quality and consistent products in a safe effective way while satisfying customer needs. In the current environment, remaining competitive requires that organisations should focus more on the effectiveness of their operations (Guess, 2006). The effectiveness of business operations in delivery good quality products can however be hampered by safety incidents, reworks and lack of information. One way of improving effectiveness in business is through configuration management (CM) (Hastings, 2009). Configuration management is one of the systems used to manage project changes and track quality. Inadequate configuration management processes constitute a barrier in availing available good quality products that are safe and meet the specifications (Quigley et al., 2015). Lack of CM can also lead to loss of life or even of a facility as well as disappearance of information and failure to update drawings for every modification of the manufacturing plant or project, which could lead to loss of products, markets, customers, and sometimes, in loss of human life (Sorrentino, 2009; Parametric Technology Corporation, 2003; Quigley et al., 2015). Organisations are enabled to manage change and maintain quality and safety by implementing configuration management from the start (Wais, 2004). In the manufacturing industry, CM identifies controls, and maintains the consistency of manufacturing plant and the quality of manufactured products through the entire lifecycle of the product (Hodges, 2011). By so doing, it ensures the existence and the life of a product and thus configuration management is also used to enhance safety (Heruc et al., 2015). Therefore, research on the issue of configuration management is important.

1.1 Motivation of the study

The study was motivated by observations made by the researcher in a steel manufacturing plant. The observations were that unnecessary and preventable accidents could have been avoided had documentation of certain changes to equipment simply been recorded. The resulting loss of life was a compelling motivation to embark on the study. Equally, it was noted that implementation, or lack, of configuration management was attributed to a myriad of complex reasons. Therefore, given the consequences of what was perceived to be associated with configuration management and the complexity associated with its implementation, the current study was embarked upon. Therefore, from observations made by the researcher, it appears that there is little effort paid to configuration management in steel manufacturing plants in South Africa; this may result in a serious compromise of safety in the manufacturing plants during operation. The objective of the study was therefore to establish the extent to which configuration management impacts on occupational health and safety.

2. Literature Review

2.1 Brief history of the configuration management concept

The existence of CM dates back to the 1950s and the concept has been in use ever since (Otero et al., 2007; Admiari et al., 2010; Lindkvist et al., 2013). According to Lindkvist et al. (2013) and Steyn (2015), the United States (US) of America Department of Defense (DOD) (2001) adopted and documented the principles of CM when concerns were raised regarding aircraft design and maintenance. The US DOD's document (973 MLT-STD-973) became the 'encyclopaedia' of CM and to date continues to be the pillar for all the standards of configuration, as well as the EIA-649 standards.

Kidd et al. (2014) explained that CM was formally introduced by the US DOD in the 1950/60s where it was developed to address the lack of data uniformity and alter issues of control in the race for a successful missile launch in the 1950s. The history and origins of CM are further supported by Smith et al., (2015) indicating that CM has been practised since the 1970s by United States of America Department of Energy (DOE). Hass (2002) also expounds this, explaining that CM gained momentum in the late 1960s; by the late 1970s, military standards had been developed and published in this field. According to Otero et al. (2007) the use of CM continued to expand as the nuclear industry followed in the footsteps of US DOD (2011) by implementing CM to track equipment changes affecting operational safety during the 1980s. Concerning the above, Kääriäinen (2006) argues that the roots of this type of management are in the defence industry environment. One of the reasons why CM was introduced was to reduce the amount of rework that had become prevalent and was costing a great deal. It was also a way to manage parts in stock as well as parts that did not fit properly, thus managing quality (Kääriäinen, 2006).

Many sectors, including the software development industry, have adopted the use of CM to manage version control by tracking software modifications. According to Kidd et al., (2014) CM expanded in the 1990s and extended into other sectors of the industry where it helped with managing the lifecycle of the product. The nuclear power generation industry followed in the footsteps of other sectors, such as the military and software industry, by implementing CM to manage changes and keep records of changes in their plant equipment (Admiari et al., 2010). The International Standards Organization (ISO) adopted and implemented CM in 1994, perhaps bearing testimony to the criticality of the method (Kidd et al., 2014).

2.2 Definition of the configuration management

The International Atomic Energy Agency (IAEA), 2003; 2010) defined CM as the process whereby physical facilities and data of the facilities are managed and documented. Such records should include information on planning, design, changes, approvals, auditing and installation procedures. The US DOD (2001) defines CM as a process by means of which the design of a facility, its operating data and all the changes of the facility are well documented and there is consistency between documentation and physical facilities from the start to the end of the life of the facility or product lifecycle.

Configuration management is also viewed in terms of operation and documentation (Müller, 2013). Smith et al. (2015) define CM as the management process of facilities and their systems by their identity using documentation. According to ISO (2003) CM is like a map that provides direction of where the final product must end - as defined from the start - with the requirements and must ensure that the correct data is available and stored. In addition to merely documenting the systems and physical facilities that have been installed, Kääriäinen (2006) argues that CM, as a discipline, is that aspect of management which deals with the management of the modifications and the changes that take place during the lifecycle of the product under surveillance and strict management. It also entails strict monitoring of technical and administrative activities regarding physical installations is maintained by identifying, documenting, auditing and controlling changes through record keeping and reports (Kääriäinen, 2006) is in itself a discipline where strict monitoring of technical and administrative activities regarding physical installations is maintained by identifying, documenting, auditing and controlling changes through record keeping and reports. Monroy (2009) supports this definition and states that monitoring and controlling changes and storing the information about them, in turn results in facilities, products and documentation being in accord with each other. In other words, the physical appearance of an installation is exactly the same as the documentation about it.

2.3 Significance of configuration management

In a view of the need for effective and efficient maintenance, it is imperative to maintain and manage information and data as facilities age (IAEA 2003). Configuration management ensures that, as the facilities age, information is still in place and all the changes and modifications that were made over the years have been captured and documented (IAEA, 2010). This in turn ensures that major maintenance should be implemented without overwhelming setbacks as information is available and the migration or retirement of the workforce has been documented to assist the new workforce to continue and operate the facility safely, including undertaking maintenance, (IAEA, 2010). The European Cooperation for Space Standardization (2008) also highlights the importance of and the need for CM and contends that CM is a plan that is used to identify what is needed in terms of systems and resources and how the configuration should be carried out on the product, to manage and trace changes throughout the operating life or on the design. It ensures that the relationship between the as-designed, as-manufactured and the actual as-built configuration of the final product is maintained.

Where CM processes are clearly defined from the beginning - during the planning phase, the construction, operation and maintenance of the facilities as well as during the commissioning - the eventual product will meet the design specifications as per the plan and the associated requirements (Lindkvist et al., 2013). Configuration Management ensures the availability of accurate documentation and that information is in line with the physical structure and plant. This in turn ensures long term data archiving, robust and proven information, limiting of operators' costs, provision of safety for human operators, safe plant operations and safe maintenance of the facility (Hwang, 2013). As a result, decisions will be made with accurate information that can be relied on.

2.4 Impact of configuration management on safety

According to NASA (2011) safety is a freedom from those conditions that can cause death, injury, occupational illness, damage to or loss of equipment or property, or damage to environment. The IAEA (2007) defines safety as the means for the protection of people and environment against harm. For many organisations, safety has become their number one priority. This is because neglecting safety may result in human fatalities, injuries and high costs for medical, insurance and penalties. In addition, accidents may result in loss of skills if there is a fatality or an injury, resulting in more than three days' absence from work. Business can also be shutdown resulting in loss of income (Kennedy, 1996).

Lack of CM has been cited to be a contributor to accidents and fatalities. An example is described in an investigation that was undertaken by Hastings (2009) into the collapse of the Interstate 35W bridge, resulting from the failure of gusset plates which were wrongly sized on the original design and ultimately led to 13 people losing their lives and a further 100 people being injured. It was found that adequate CM could have identified the incorrect thickness of the plates and the designs. In his findings, Hastings (2009) explained that the accident could not be faulted on construction or quality issues, but instead on the failure in CM, in so far as there was lack of information about the previous design and installation. In another example, three people lost their lives, with a number of injuries recorded, when a blast furnace exploded in UK Wales at the Corus Steel plant in 2001 (Curry, 2001). The findings on the cause of the explosion ranged from document control that affected maintenance quality to lack of updated documentation coupled with an aging plant.

Other studies supported that without auditing or verification was documented in terms of the changes that were not made or updating of standard operating procedures and drawings done and poor record-keeping of any changes, accidents can occur (Dhillon, 2002; Bierbrauer et al., 2013). Safety during maintenance stage of projects also depends on effectiveness of CM processes (Dhillon, 2002; IAEA, 2003). Effective maintenance procedures which can be undertaken in good time and safely, depend on known information about the physical configuration of the component or the section of a facility where maintenance has to be performed. Maintenance teams depend on accurate information from As-built drawings and the operating documentation to order spares and to do proper quality maintenance.

Ravi (2006) summarised the benefits of having a good CM in place as assisting teams to overcome operational problems, improving the archiving of information regarding plants, helping reduce costs, improving efficiency in reliability, availability and maintainability and complying with legal requirements.

3. Methods

3.1 Research design

This study adopted a qualitative research design approach in the form of case studies. using interviews, document search and observations. The case study methodology was adopted for the current study because, as elaborated by Rowley (2002) case studies are useful in providing answers to "how? And why?" type questions and therefore results can be used for a descriptive research, such as the current one. The case study entailed using a variety of evidence from sources, such as documents, artefacts, interviews and observation as suggested by Rowley (2002).

Interviews were conducted with professionals within the steel manufacturing organisations including engineers, project managers and draughts persons, on the implementation of CM and its impact on safety performance in the organization. The selection of respondents was based on their expertise, experience and the involvement in decision making in operations by the selected interviewees. Document analysis and observations were also used to study and gather information on specific events in the organization. The researcher collected the data by observing how projects and the operations were executed. Observations were also made through the observations of plant personnel during normal operating activities. The data collected during interviews, documentation and observations was then analysed using case studies from literature and comparisons were made to establish if there was a pattern in the failures and if CM had any hand in the failures.

Anonymity and voluntary participation were ensured before interviews commenced (Teddlie, 2009; Leedy et. al., 2014). Content analysis was used to analyse the collected data to establish the required result. Findings from one of the cases studies is presented here because it was directly related to safety performance.

4. Findings - Electrocution of the maintenance personnel

In this case, an electrician was electrocuted. Two electricians were requested to remove a broken crane. The electrician and his colleague responded to the call concerning a breakdown on the gantry. Isolations were carried out and the two electricians began with the maintenance of the gantry's electrical problems. As they were remedying the faults, both men were electrocuted and one died of his injuries.

According to the reports filed with the company and investigators, the two electricians first disconnected and secured the 500-volt electricity supply before they attempted to replace the damaged ends of the supply cables. After the electricians had undertaken this initial task, they noticed another breakdown: a ground connection of a busbar used to supply a 40-tonne auxiliary hoist stator circuit.

It was reported that before they could start any work on the 40 tonne auxiliary busbar, they had to make sure that the line was safe. Therefore, the electrician, who had the responsibility of isolating the line, communicated with his colleague, using a two way radio to warn him about the next operation. After warning his colleague, the first electrician (No.1) entered the crane cabin and disconnected the 230V supply voltage, so that they could establish the busbar's status; namely, whether it was energised or not. Shortly after the disconnection, the first electrician (No.1) heard a noise like a falling helmet. According to the reports, he, the first electrician, (No.1) on hearing the sound, stepped out from the cabin to check what could have happened. To his dismay, he saw his colleague, the second electrician (No.2) lying on the working platform which was used for maintenance of busbars. The reports indicate that the first electrician (No.1) immediately informed the head of the shift upon realising that his colleague had died.

Findings

In terms of the investigations conducted at the time, it was reported that the events that might have contributed to the fatality included the following:

- The power distribution of the crane had been modified a few days prior to the incident. After this modification, temporary lighting was installed on the crane; however, no one documented these alterations.
- The process for updating technical documentation on installations and informing the workers concerned after a temporary modification appeared to be ineffective; the results of the changes that took place led to the safety incident where a fatality was recorded.

Analysis of results

The electrocution of the maintenance men could be attributed to the following proximal factors as in figure 1. The gas plant failure, a newly constructed gas plant was merely able to operate for less than a year before a major overhaul was undertaken. Operations at the gas plant ceased after it experienced numerous outages and extensive maintenance requirements. These problems prompted management to shut down a newly constructed plant because there was clearly a problem.

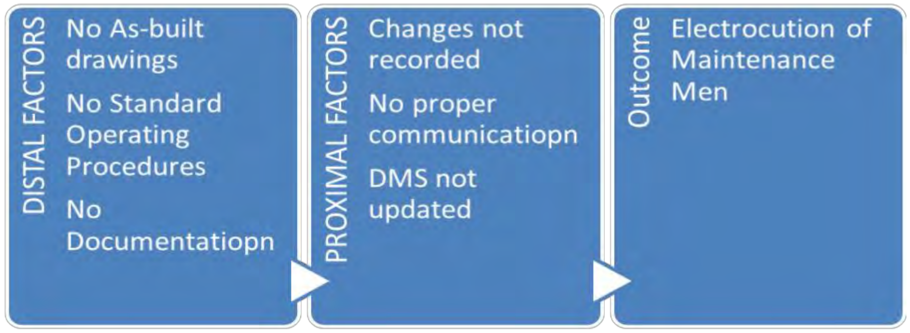

Figure 1: Constraint-restraint method detailing electrocution of maintenance personnel (Suraji et al., 2001)

Changes to equipment

Key findings from interviews revealed that lack of updating documentation, lack of training, cultural behaviour and deficiencies in implementation of CM may have been the factor in the failure of the gas plant. Feedback from engineers and plant people revealed that during construction of the gas plant changes that were made by procuring low cost equipment to replace more expensive equipment to save costs might have been the cause of the gas plant to fail. The changes have not been documented, there were no records indicating if there were changes recorded. The As-built drawings were not similar to what was installed in the gas plant as observed. Data was not found to suggest that the replacement equipment were tested to see if they met operating conditions.

Training was not provided to everyone involved in the gas plant. There was no documentation proving if training was done. The feedback that training was done was provided by top management and some of the operators verbally. A handful of operators were trained and were requested to train the rest of the plant of the gas plant operations. The operators or personnel trained have since left the gas plant.

From observations it looked like there is a culture of care free. The gas plant was operated and maintained without procedures and documentation. The observations highlighted a lack of discipline and fear, albeit the hazards and dangers that comes with the gas plant.

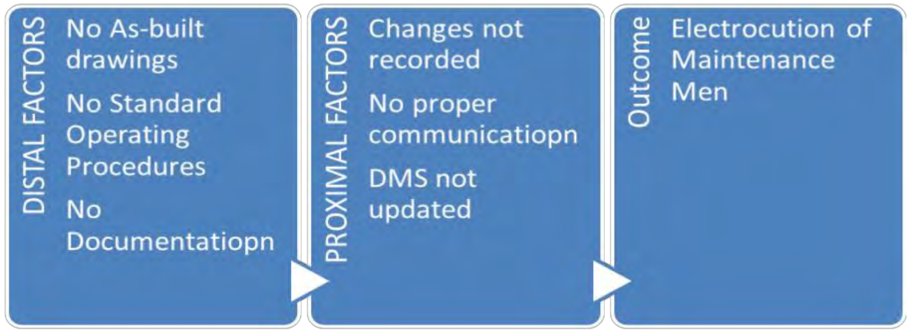

Figure 1: Constraint-restraint method detailing electrocution of maintenance personnel (Suraji et al., 2001)

Documentation from investigations and interviews revealed that changes to the power circuit were not recorded. There was no documentation or paper trail of what work was done by changing the power circuit. Communication was said to be lacking.

Interviews also revealed that the DMS system was not updated and there was no information on the request to do maintenance. The distal factors reveal that information suggest lack of proper communication, accountability and communication which is an aspect of CM. The Swiss model reveals that the factors and conditions all created a perfect environment and background for the fatality to occur. See figure 2 for schematic explanation.

5. Discussion - Impact of Configuration Management on Safety

In the fourth case reviewed in this study, the maintenance man died because no one had informed him or his colleague of modifications that had been made to the electricity supply; hence he proceeded to work, based on the assumptions that he was dealing with the original installation. Safety depends on the extent to which appropriate information is provided to the workers about a particular job, especially about dangerous jobs. Therefore, a lack of information could have been handy during the maintenance work.

According to the IAEA (2003), smooth operations and good maintenance are based on having a clear set of procedures in place as stipulated by the CM standards which allow for information to be in place when needed for maintenance or emergencies such as shutdowns, which in turn would assist with planning of maintenance and safe work procedures. This view is also supported by Jonathan, (2015); ETS, (2013) and Dhillon, (2002).

Safety is assured on a project if CM is done correctly, because as Hass (2010) puts it, CM is a summary that explains what is there, what must be there and what is actually there. Configuration Management implementation has a positive effect on safety performance.

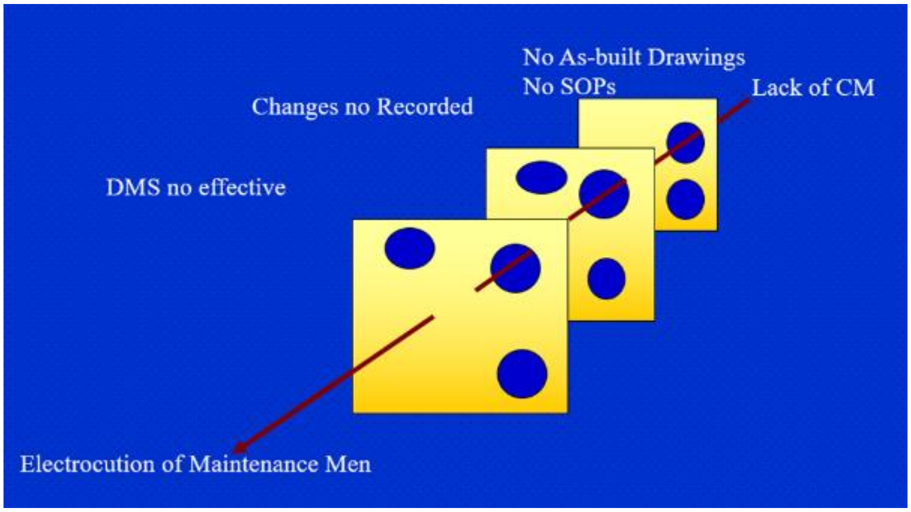

Figure 2: Swiss Cheese Model for the electrocution of maintenance man (Reason, 1998)

Conclusion and Limitations

Literature has demonstrated that CM has been in use for many years, its success has been proven in the nuclear industries, the military and many other high reliability industries (Admiari, 2010:25). Literature has also provided evidence that those who neglected it have paid a costly price with undesired results.

The current study also revealed that there was a relationship between CM and safety. The electrocution of the maintenance worker due to undocumented changes which were not communicated led to his death. Kääriäinen (2006:30) explains that CM ensures that changes are documented. In this case, changes were not recorded, leading to poor CM that ultimately resulted in an unwanted fatality.

Inadequate funding entailed that only what has been documented in the current study was achievable. Further, there is very little information from major industries in South Africa on CM and those that were engaged were not willing to share some information and this may have affected the results.

References

Ali, U. & Kidd, C. 2014. Barriers to effective configuration management application in a project context: An empirical investigation, International Journal of Project Management 32:508-518.

Aberdeen Group. 2007. The configuration management benchmark report. Formalizing and extending CM to drive quality. Boston, Massachusetts.

Bierbrauer, S. & Reymann, T. 2013. A cross-industry configuration management, maturity assessment, industrial case study. P3-group. Institute for information management in engineering.

BMC Software. 2006. Best practices white paper.

Buckley, F.J. 1992. Implementing configuration management: Hardware, Software and Firmware, library of congress cataloguing-in-publication data. ISBN 0-7803-0402-0.

Crabtree, B.F. & DiCicco-Bloom, B. 2006. The qualitative research interview. Making sense of qualitative research. Blackwell Publishing LTD, pg. 314-321.

Document Management Systems: A Buyer's Guide, Business News Daily, http://www.businessnewsdaily.com/8026-choosing-a-document-management-system.html. Date of access: 4 January 2016.

Driscoll, L.D. 2011. Introduction to primary Research: Observations, Surveys, and Interviews. Library of Congress Cataloging-in-Publication Data.

Earing, A. 2009. Configuration management: Sometimes change is a bad thing, manufacturing headlines and news. http://www.manufacturing.net/articles/2009/01/configuration-management-sometimes-change-is-a-bad-thing. Date of access: 1 March 2015.

Easterbrook, S. 2014. ACDM conference March 4, 2014, CMPIC LLC.
Goodrick, D. 2014. Comparative case studies. UNICEF. Methodological bricks, impact evaluation no.9.
Guarnieri, F. & Larouzee, J. 2015. From theory to practice: itinerary of Reasons` Swiss Cheese Model.
Guess, V.C.2014.Institute of Configuration management and CMII research institute.
Gurule, A.L.2009.decision making in a bad economic climate. Pg.6.CMPIC.
Hastings, A. 2009. The value of configuration management. https://www.cmcrossroads.com/article/value-configuration-management. Date of access: 10 November 2015.
Heckman, J. 2008. Why document management: A white paper, Version 1.
Heruc, Z. & Podhraski, M. Configuration, Some aspects of configuration management (CM) at nuclear power plant Krsko (NEK). http://www.iaea.org/inis/collection/NCLCollectionStore/_Public/31/051/31051366.pdf. Date of Access: 1 October 2015.
IAEA (International Atomic Energy Agency). 2003. Configuration management in nuclear power plants. TECDOC-1335.
IAEA (International Atomic Energy Agency). 2007. Terminology used in nuclear safety and radiation protection. Configuration management in nuclear power plants. Vienna.
IAEA (International Atomic Energy Agency). 2010. Application of configuration management in nuclear power plants. Vienna.
INSAG-7, The Chernobyl accident: Updating of INSAG-1, A report by the International Nuclear Safety Advisory Group, International Atomic Energy Agency, Vienna, 1992.
Institute of configuration management, the home of CMII. 1998-2004. Configuration management paradigms and CMII principles.
International Association of Oil and Gas Producers. 2000. Glossary of HSE Terms
International Organization for Standardization. 2003. ISO: 10007:2003. Quality management systems – Guidelines for configuration management.
ISO (International Organization of Standardization). 2003. Quality management systems-guidelines for configuration management, ISO: 1007, 2nd ed.
Jonathan, C. 2015. What Volkswagen's next CEO can learn from GM's Mary Barra. 12:51P M EDT. Fortune Magazine. Date of access: 30 May 2015
Johnson, C.W. Fletcher, L.L. Michael, H.C. & Shea, C. Configuration management as a common factor in space related mishaps. http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.299.5318&rep=rep1&type=pdf. Date of access: 30 July 2015.
Kääriäinen, J. 2006. Practical adaptation of configuration management. Three case studies, ESPOO. VTT Publications 605.
Leedy, P.D. & Ormond, J.E. 2014. Practical research planning and design, 10th ed., Pearson New International Edition.
Lindkvist, C. & Statis, A. & Whyte, J. 2013. Configuration management in complex engineering projects, 2nd International Through-life engineering services, pages 173-176.
MIL-HDBK-61A (SE).2001. Superseding MIL-HDBK-61. 1997. Military handbook, Configuration management guidance.
Minzenmay, T. & Zeiss, M. Niknam, M. & Ovtcharova, J. 2014. Performance indicators for configuration management: International Federation for Information Processing, pp 277-286.
Mogalakwe, M. 2006. The use of Documentary Research Methods in Social Research, African Sociological Review, 10, (1), 2006, pp. 221-230.
Müller, P. 2013. Configuration management – a core competence for successful through-life systems engineering and engineering services, 2nd International Through-life Engineering Services Conference, pg187-192.
Neale, P. & Thapa, S. & Boyce, C. 2006. Preparing a case study: A Guide for designing and conducting a case study for evaluation input.

Quigley, J.L. & Robertson, K.L. 2015. Configuration management: Theory, Practice, and Application. Auerbach Publications, Pages 185–234.
Raju, A. & Williams, P.E. 2010. A study of configuration management implementation in the construction industry, Center for Advanced Infrastructure and Transport. Rutgers University.
Reason, J. 1998. Achieving a safe culture: theory and practice. Volume 12 No 3, pg 293 -306.
Sorrentino, J. 2009. Configuration Management: Implementation, Principles and Applications for Manufacturing Industries, CRC Press.
Suraji, A. & Duff, A.R. & Peckitt, S.J. 2001. Development of Casual Model of Construction Accident Causation. Journal of Construction Engineering and Management. July/August 2001.
US Department of Energy Washington. 2003. DOE standard configuration management.
Vissak, T. 2010. Recommendations for Using the Case Study Method in International Business Research. The Qualitative Report Volume 15. Page 370-388.
Wais, K. 2004. Successful Projects LCC. UW-Platteville Masters in Project Management Course.
Wasson, J. 2008. Configuration Management for the 21st Century, CMIIC, PMP®.
Zainal, Z. 2007. Case Study as a Research Method. Faculty of management and Human Resource Development, Universiti Teknologi Malaysia. Journal Kemanusiaan Bil.9.