XXVI IJCIEOM 2020

International Joint Conference on Industrial Engineering and Operations Management- ABEPRO-ADINGOR-IISE-AIM-ASEM (IJCIEOM 2020)

Maintenance planning in large hydroelectric plants using a novel technique to differentiate between the influences of operational and maintenance actions

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Abstract Adequate maintenance planning is vital for ensuring continuous equipment operation in order to reduce costs, comply with regulations, and satisfy strict demands from clients and other interested parties. This work discusses the use of Operational & Maintenance Causal Tree Analysis (OMCTA), a new expert knowledge-based technique capable of providing a clear-cut distinction between consequences deriving from operational and maintenance practices, and accordingly their bearing upon maintenance requirements, so as to help maintainers discriminate between the different influences of operational and maintenance actions on maintenance needs and planning.

Keywords: Operational & Maintenance Causal Tree Analysis; OMCTA; Maintenance Management.

1 Introduction

Good practices in maintenance and operation of systems and their component items are essential for a safe, reliable, and efficient performance in power plants or any other high-consequence industry. Particularly, adequate maintenance planning is vital for ensuring continuous equipment operation in order to reduce costs, comply with regulations, and satisfy strict demands from clients and other interested parties.

Despite their proven value, tree-shaped techniques such as the popular Fault Tree Analysis (FTA) (Kabir, 2017) are not capable of providing a clear distinction between the effects of inadequate operational and maintenance practices upon maintenance requirements. They do not offer an entirely convenient distinction between human occurrences, poorly handled tasks (during the design or the production phase), inadequately specified materials, and work environment constraints.

On the other hand, Causal Tree Analysis (CTA) is a powerful technique that shows the chain of events leading to a failure or to the loss of equipment capacity, based on the idea that incidents and accidents result from process variation (Vasconcelos, Senne, and Marques 2013). CTA displays in a logical, hierarchically structured all the actions and conditions that were necessary and sufficient for a given consequence to have

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occurred, i.e. it provides a method of analyzing the critical human errors and technical failures that have contributed to an incident or accident in order to determine the root causes.

This work discusses how a new technique — Operational & Maintenance Causal Tree Analysis (OMCTA) traits from both FTA and CTA — allows failures to be thought of as deriving from two different types of causes: operational wear-and-tear and operational/maintenance flaws. The former type of cause is the very object of maintenance, be it corrective, preventive, or predictive. The latter is much less taken into consideration when studying maintenance matters using well stablished maintenance related techniques. This work considers the possibility of developing OMCTA to help maintainers discriminate the influences of operational and maintenance actions on maintenance planning in large hydroelectric plants.

2 Operational & Maintenance Causal Tree Analysis

OMCTA is a new technique recently presented by Murad et al (2020). In OMCTA, the operation and maintenance of power plant items, particularly of those that are critical for performance and continuous operation, should be considered as activities and subdivided into four components: individual (I), task (T), material (M), and work medium (WM), providing a great flexibility for a comprehensive analysis of both operational and maintenance aspects, as well as a method of ranking items in relation to their likelihood of causing system failures that would be originated by either operational or maintenance actions. As a consequence of such a breakdown of operation and maintenance activities, a team of experts could then grade each activity component according to established criteria.

Ranking criteria for component (I) must be devised in order to take into consideration the degree of expertise and experience required from individuals to perform any operational or maintenance tasks, and could vary, e.g., from "requires low expertise and experience" to "requires high expertise and high experience". On the other hand, ranking criteria for components (T), (M) and (WM) are different for operation and maintenance actions. For (T) they are thought up to allow for the essential differences between the respective effects of operational and maintenance tasks on equipment life and performance, as revealed by failures and their consequences. While frequency and demand seem to adequately characterize the impact of operational tasks, complexity and duration provide a better assessment of the influence of maintenance tasks. Ranges from "sporadic and normal working conditions" to "continuous and strenuous working conditions" for operation, and from "low complexity and short duration" to "high complexity and long duration" for maintenance seem adequate. For component (M) the key term is "resources", meaning to include both human and material resources of any kind whose lack of availability may be detrimental to the performance of the intended operation. These human and material resources may include hardware, software, processed materials, and information. A suitable range for operation probably be from "requires few resources with high availability" to "requires resources with low availability", and for maintenance from "requires resources with high availability and ordinary tools" to "requires resources with low availability and complex tools". Finally, for (WM) ranking criteria designed to take into consideration the unfavorable influence of external aspects on both operational and maintenance tasks. Basically, some physical aspects capable of impairing tasks are suggested, but the analyst may find it suitable to consider whatever other external factors may be applicable to his application. In addition, it should be noted that on the maintenance side the term "confined" also implies the idea of reduced mobility due to any cause, cramming included. Ranges for operation and maintenance go respectively from "no external interferences such as vibration, magnetic field, high temperature, high humidity, air contamination, etc." to "at least one external interference of high magnitude", and from "clean air, non-confined space, and easy access" to "contaminated air and confined space".

After having graded all four activity components, the analyst will be able to multiply the independent grades for each component, thus providing overall values that will represent the "separate contribution" as it were of operation and maintenance activities to the occurrence of the considered item failure.

3 Conclusions

Although intended to be developed for helping maintainers in their arduous task of adequately planning and managing maintenance activities, with a view to reducing maintenance costs, it is not difficult to see that OMCTA may have the potential to be used in many contexts and applications.

It is believed that one of the main applications of OMCTA will be to remove as much as possible the true causes of failures. In so doing, maintainers will certainly be on the right path to significantly reducing the need for maintenance interventions.

Although basically built on the tradition of tree-shaped techniques, OMCTA will derive its analytical essence from two major disciplines with which engineers and managers should always be concerned, to wit, strategy and logistics. In other words, with timely acquiring, receiving, and preparing all the human and material resources needed to take a vantage point before the moment of action.

4 Acknowledgements

This study was financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Brasil (CAPES) - Finance Code 001. The authors thank the financial support of FDTE, CAPES and EDP for the development of the present research.

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