ANALYSIS AND ESTABLISHMENT OF THE ROOT CAUSES OF INCIDENTS WHEN WORKING WITH CRITICAL INFRASTRUCTURE

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Abstract: *This paper investigates the analysis and determination of the root causes of incidents occurring when dealing with critical infrastructure. Through detailed examination of cause-and-effect factors, including human errors and organizational issues, the paper emphasizes the importance of fully understanding and addressing these causes. Utilizing tools such as the Root Cause Tree®, the paper demonstrates how these incidents can be analyzed down to their most basic causes. For instance, the analysis identified four root causes for a high temperature problem in one incident: the need for improvements in vigilance monitoring, shift planning, choice of a tired worker, and implementation of a "no-sleeping at workplace" policy. The results from this analysis underline the significance of human factors management, specifically in terms of training, procedures, and engineering solutions when dealing with critical infrastructure.*

Keywords: *chemical additives, concrete, testing*

Introduction

Understanding and managing incidents related to critical infrastructure are key to various aspects of our society, ranging from safety and economic stability to national security and societal well-being. As our reliance on these infrastructures deepens, and the complexity of these systems grows, determining the root causes of such incidents becomes an essential task to improve resilience, reliability, and efficiency. The aim of this paper is to delve into the detailed process of analysis and understanding of the root causes of incidents related to critical infrastructure.

I. METHODOLOGY - ROOT CAUSE ANALYSIS:

The analysis of the root causes of incidents involving critical infrastructure requires a comprehensive, systematic, and complex process. The investigator must carefully navigate a complex network of contributing factors, examining each aspect to understand its role and impact on the final incident [1]. The primary tool for such analysis is the Root Cause Tree® diagram (Figure 1). This visual tool provides a framework for systematically identifying and assessing causal factors, aiding in the structuring of the analysis process.

To make this process more understandable, the paper will focus on the analysis of a single, representative causal factor: "The operator failed to eliminate the cause of high temperature"[2].

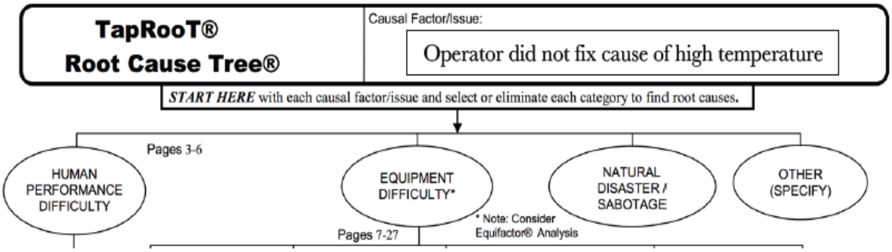

Figure 1 - Root Cause Tree® Diagram

II. ANALYZING THE CAUSAL FACTOR:

Analyzing the causal factor necessitates a detailed and systematic understanding of incidents and the processes leading to them. In this regard, investigators engage in an intensive procedure of interviewing, observation, and studying of the processes and incidents[3].

In this particular example, the causal factor is identified as a difficulty in human work (Figure 2). This leads to a detailed analysis of seven primary categories related to human effectiveness[4]:

- Procedures;
- Training;
- Quality control;
- Communications;
- Management system;
- Human Engineering;
- Work direction.

Upon identifying the difficulty in human work, the investigator uses questions to deeply investigate the seven primary categories of causes related to human work. These categories include:

• Procedures: Were the procedures properly executed? Were they adequate to handle the situation?

Training: Was the staff adequately trained to handle the situation? Was suitable training provided?

• Quality control: Were the impactful factors identified and controlled effectively?

• Communications: Were the communications between teams and individuals effective and accurate?

• Management system: Was the management system strong enough to prevent the incident?

• Human Engineering: Was the design of the equipment or system good enough and well understood?

• Work direction: Was work management adequate and effective?

After identifying possible areas for improvement, the next step is to analyze the impact of these factors and suggest appropriate improvement measures. This process emphasizes achieving a resilient operational environment where the likelihood of incidents is minimal.

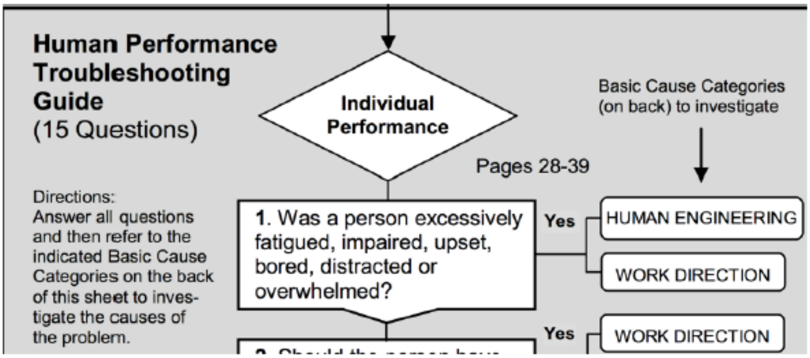

Figure 2 - Part of the Root Cause Tree® diagram investigating human intervention

III. RESULTS:

The results from the analysis of the human factor include an overview of various primary categories of causes. In this particular case, based on the 15 questions, the researcher is directed towards the following primary categories of causes:

• Human Engineering
• Management system
• Work direction
• Procedures

Each of these categories is analyzed in detail to identify specific root causes. For example, the "Human Engineering" category may include an analysis of how the design and layout of the equipment could have influenced the operator and led to the incident in question. As seen in Figure 3, upon completion of the analysis on Human Engineering, the researcher identifies the following root causes:

• Need for improvement in vigilance monitoring;
• Need for improvement in shift planning;
• Choice of a tired worker;
• Need for a realistic way to implement the "no sleep at work" policy.

These results underline the importance of suitable human engineering when working with critical infrastructure. It's essential to take into account human factors when developing and implementing procedures, and to ensure training and support to enhance the work environment and reduce the risk of incidents [5].

CONCLUSION:

The ultimate goal of such analyses is to establish a stable and resilient operational environment where incidents are less likely to occur, by systematically examining and improving all aspects of operations. Through this article, we hope to contribute to this aim by providing valuable insights and recommendations, encouraging safer, more reliable, and resilient critical infrastructure systems. This analysis is not only important for critical infrastructure but can also be applied to other areas, paving the way for improved systemic performance, safety, and reliability across various sectors.

In particular, understanding the role of human factors in critical incidents can lead to significant improvements in the design, management, and operation of infrastructure systems. This requires a continual learning process that includes analyzing past incidents, implementing corrective measures, and regularly reviewing and updating procedures and training programs.

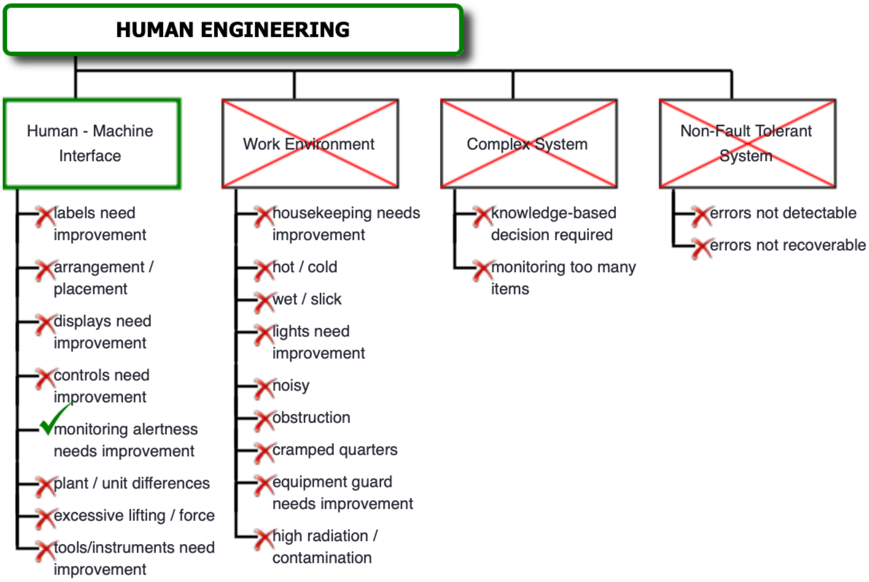

Figure 3. Completed analysis for Human Engineering.

Additionally, the focus on human factors and the potential for error underscores the need for a culture of safety within organizations. This includes encouraging open communication about errors and near-misses, a non-punitive approach to mistakes that emphasizes learning and improvement, and leadership that prioritizes safety and well-being. By enhancing our understanding of the root causes of incidents and implementing robust, systemic improvements, we can increase the safety and resilience of critical infrastructure, ultimately protecting communities and promoting societal well-being.

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