Socio-technical factors that affect the maintenance of nuclear instrumentation: an approach based on specialists estimation and probabilistic ordering

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Socio-technical factors are present in operational and maintenance procedures, which may compromise the reliability of systems and contribute to the occurrence of incidents and accidents. According to the NBR-5462 [1] norm, availability is defined as the "capacity of an item to be in condition to execute a certain function at a given instant or during a determined interval of time, taking into account the combined aspects of its reliability, maintainability and maintenance support, assuming that the required external resources are guaranteed". MTTR (Mean Time to Repair) is defined as a parameter that expresses the mean time elapsed during the maintenance. Human reliability methods consider the probability of a human error occurring as a function of the factors that affect worker performance (PSFs). Through an analysis of these factors in different work environments and considering the opinions of specialists, it is possible to determine which factors most contribute to human error. Work situations adequately projected and considering human requirements, human beings capacities and limitations, taking PSFs into consideration, may create conditions that optimize worker performance and minimize human error. The lack of combination of these factors may affect human performance, triggering the human error mechanism [2]. This study explores a socio-technical approach, focusing on the working conditions of the maintenance technicians of the nuclear instrumention of a research nuclear reactor. Experts with notable experience in the electronic maintenance were elicited in order to select the human and organizational factors with the most influence on the critical modules of the nuclear instrumentation [3]. The expert opinions were aggregated with the assistance of fuzzy logic, and a similarity aggregation model with probabilist ordering (FUZZY-SAM method).

The joint probability measures indicated the influence percentages of each socio-technical factor on the availability of the nuclear instrumentation system and therefore MTTR MTTR (Mean Time to Repair). Table 1 identifies the socio-technical factors of greatest influence during maintenance service of the critical modules of the nuclear instrumentation system. In the study, the following factors stand out, in order of preference: lack of resources to acquire components and materials (A); lack of training (B); poor conservation of the tools and instruments used in performing tasks (C); physical restrictions in the workplace(D) and lack of organization adequacy in necessary infrastructure to perform tasks (E).Thus, the principal socio-technical factors selected by the specialists were calculated with the following percentages of relevance: factor A (0.5230145), factor B (0.2246342), factor C (0.1899626), factor D (0.00292692) and factor E (0.059443). Therefore, it is possible to probabilistically order the factors for the context established in this research: P(A)>P(B)>P(C)>P(E)>P(D).

Table 1 - Socio-technical factors

Socio-technical Factor	Socio-technical Factor	Socio-technical Factor
Task complexity.	Noise in the workplace.	Difficulty visualizing equipment controls and components.
Stress in performing tasks.	High temperature in the workplace.	Lack of decision making conditions.
High work load.	Inadequate illumination in the working environment.	Poor conservation of the tools and instruments used in performing tasks.
Lack of experience.	Lack of organization adequacy in necessary infrastructure to perform tasks.	Physical restrictions in the workplace.
Lack of training.	Absence of procedures that assist in the performance of tasks.	Absence of administrative control.
Little knowledge for performing tasks.	Conflicts of priorities in the performance of tasks (i.e. productivity v safety).	High number of simultaneous objectives for performance of tasks.
Lack of or poor communication between team members.	Lack of resources to acquire components and materials.	Inadequate layout of the working environment.
Lack of aptitude for working in a team.	Inadequate supervision in the performance of tasks.	Absence of standardization in the instrumentation project.
Little time available to perform tasks.	Inappropriate planning of tasks to be performed.	Absence of identification of instrumentation controls and components.
Lack of availability of work tools.	Difficulty accessing equipment controls and components.	Absence of testing points in the instrumentation project.

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