

## **Human Factors in Design and Preliminary Safety Assessment of Research Reactors**

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Human Factors Engineering has become an integral part of INVAP's design process for research reactors. The experience acquired with the operation of nuclear facilities for the past 60 years has shown that the operator cannot be ignored in the safety assessment of a reactor and it cannot be "added" to the analysis once the design of the facility has been finalized.

Over the years, numerous techniques have been developed for Human Factors Analysis. Most of this methodology has been developed for the investigation and assessment of events that have already occurred. We have adapted these techniques and implemented them at the design stage and made them an integral part of the preliminary safety analysis of the facility. Developed in parallel with the preliminary design the analysis provides feedback to the designers on whether a system can be operated safely as designed or it needs modifications in order to minimize the likelihood of operator-caused incidents. The process continues through the detailed engineering and commissioning stages. Thus, an integrated Human Engineering methodology has been developed and inserted into the design and assessment of a Research Reactor with a graded approach.

### **Human Factors Engineering in the design and construction process**

Incorporation of Human Factors Engineering in the design encompasses different aspects of the design and operation of the facility. At the facility design stage, the operating actions and procedures are being also designed. Thus, proposals for operation actions and procedures can be analyzed to identify events, likely error precursors or flawed defences.

The strategy includes:

- Systematic identification of initiating events related to human actions in operation;
- Identification of initiating actions, error precursors and error enabling context;
- Evaluation of flawed defences;
- Incorporation of human actions in the safety assessment;
- Identification of events involving human action that require redesign and feedback to designers;
- Identification of events involving human actions that are not amenable to redesign. Proposal for administrative barrier. Feedback to designers and to operation design team;
- Quantification of the contribution of human actions to the risk of the facility;
- Identification of equipment and tasks that may require prototyping to better solve human factors issues;
- Identification of human factor issues that require specific attention during training;
- Identification of human factor issues that require specific attention during operation;
- Validation of human factor aspects of the design during commissioning.

### **Conclusions**

An integral strategy to Human Factors Engineering is proposed for the design process for facility with a graded approach. This strategy encompasses different aspects of the design of the facility and its operation. Analysis in parallel with the detailed engineering phase allows for feedback to the designers and manual and procedures writers for their optimization.

This treatment of Human Factor Engineering contributes to the design of a safe and robust facility and to the implementation of procedures that contribute to its safe operation.

### **References**

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