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Introduction

The Safety-Related Operator Actions (SROA) Program, completed in FY-1983, was designed to provide information and data for use by NRC in assessing the performance of nuclear power plant (NPP) control room operators in responding to abnormal/emergency events. The primary effort involved collection and assessment of data from simulator training exercises and from historical records of abnormal/emergency events that have occurred in operating plants (field data). These data can be used to develop criteria for acceptability of the use of manual operator action for safety-related functions. The program also included studies of training simulator capabilities,¹ of procedures and data for specifying and verifying simulator performance,^{2,3} and of methods and applications of task analysis.^{4,5} This paper summarizes the major results of the program pertaining to the development of criteria for safety-related operator actions.

Simulator and Field Data

The initial impetus for the SROA Program was the need for data to assess proposed design criteria⁶ for the choice of manual versus automatic action for completion of safety-related functions during design basis accidents. After a preliminary assessment of available data,⁷ a program of data collection during "quasi-controlled" exercises was initiated in March, 1980. A parallel program was initiated to collect field data which could be used to "calibrate" simulator results. The approach taken in the proposed design criteria was that if the designer chose to rely on manual operator action, he had to allow certain time margins, depending on the severity of the event, complexity of actions, etc. If those time margins were not available, the actions should be automated. Consequently, the emphasis in the SROA Program has been on collecting data on the time required for operators to take correct action, despite the recognition that a more comprehensive approach to allocation of functions is desired and that other measures of performance may be equally or more important in many cases. This simple approach was felt to be reasonable for interim use in a design standard until some basic changes are made in the approach to NPP control room design and a more comprehensive research and data base exists.

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A sizeable base of data on operator performance has been accumulated including primarily operator response times but also some error data. Data on operator response times, i.e., the time from the activation of an alarm or observable cue until the time of initial correct operator action, have been recorded for a series of preliminary simulator exercises on a pressurized water reactor (PWR) simulator⁸ and boiling water reactor (BWR) simulator,⁹ and a more extensive series of exercises on a PWR simulator was completed in FY-1983.¹⁰ Response times are quite variable but tend to be correlated more to "operational" characteristics of the event, e.g., how rapidly it develops and how specifically it is annunciated than to the severity of the event. Initial comparison of field data to simulator data¹¹ suggested that for highly experienced operators, response times in the simulator will be "on the average" considerably less (as little as one-sixth to one-seventh) of typical response times in the field. However, there is obviously a question of the possible effects of stress during an actual event, which is probably not reproduced in the simulator.

In FY-1983, the field-data-collection methodology was modified to provide a much richer analysis of events that have occurred, and this methodology is being employed in a new program of simulator experiments which was initiated in late FY-1983. An extended form of the task analysis methods developed under this program and the NRC Crew Task Analysis¹² Program is used to document operating sequences which are verified in training simulators, calibrated to field data at the NPP and then used as controlled scenarios during simulator experiments.

Proposed Model for SROA Criteria

Based on results of the simulator and field data collection, through early FY-1983, the applications of task analyses methods described in Refs. 4, 5, and 12, and on reviews of existing human performance models,^{13,14} a simplified and preliminary model of NPP operator performance during abnormal/emergency performance has been developed and tested. The model is computerized and programmed into the SAINI¹⁵ simulation language to take advantage of an existing computer-based structure. It is proposed for further development and use to predict operator response time and performance during critical safety-related sequences. Given a quantitative system reliability goal, these predictions could then be used to evaluate existing systems (or in the design of new systems) to determine the suitability of assignment of safety-related actions to the operator. The model could also provide a focus for continued research on operator performance.

Conclusion

The Safety-Related Operator Actions Program has included a number of separate but related studies concerned with NPP operator performance, task analysis techniques, and the use of simulators in operator training. The program is one of the earlier NRC research programs in the human factors area, having begun prior to TMI-2, and has in some ways "evolved" with the

NRC research effort. The central task - development of criteria for safety-related operator actions based on simulator and field data - was completed in FY-1983 and this terminated the program as scheduled. An initial but substantial base of performance data has been accumulated, and a model of operator performance has been developed and tested which is proposed as a tool to help evaluate the acceptability of assignment of safety-related actions to the operator.

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