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MEMORANDUM FOR: Rodney M. Satterfield, Chief
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FROM: Leo Beltracchi
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SUBJECT: TRIP REPORT - FOREIGN TRAVEL
(1) WORKSHOP MEETING, OPERATOR-PROCESS COMMUNICATION
(2) OECD HALDEN REACTOR PROJECT

The workshop meeting on Operator-Process Communication was attended on the 26th and 27th of February 1980, at GRS-Garching, Germany. The Halden Project was visited on the 28th and 29th of February. The following summarizes the major observations and conclusions drawn from the trip:

- The STAR System, a computer based disturbance analysis system will be tested as a prototype at the Grafenrheinfeld plant in Germany. The man-machine interface appears to be well designed and the results of field testing should be scrutinized for potential licensing criteria.
- The scope of operator-process communication projects being undertaken in Europe is impressive and well coordinated. The scope ranges from basic research to field evaluation of prototype systems.
- Sweden and Germany have each initiated efforts leading to the development of a Safety Status Panel.
- The RGB System at Halden is a practical solution to Regulatory Guide 1.47 and portions of technical specifications regarding safety system availability. As an operator aid, this computer based system has the potential for significant safety benefits at small costs.
- A technical exchange of personnel between the NRC and Halden has been proposed. Such an exchange would be mutually beneficial.

Additional details concerning these and other findings from this trip are presented herein.

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DETAILS

Workshop Meeting.

The "Halden Project Workshop Meeting on Operator-Process Communication" was attended on the 26th and 27th of February 1980, at GRS-Garching, Germany. The objectives of the workshop were to review current and planned work at the Halden Project in the Operator-Communication area with respect to:

- Operator's role in present and future control rooms
- Operator performance studies and human factor research
- Recommendations for design and layout of displays and operator-process interfaces to minimize human failures
- Recommendation for control room architecture
- Use of on-site simulator for diagnosis and training

Additionally, the matter of how current control rooms could be upgraded was to be discussed. Also, an exchange of information by workshop participants on activities in the operator - process communication area was conducted. The agenda for the workshop and a list of attendees is presented in Appendix A.

A summary of a demonstration of the STAR System and of the principal topics discussed at the workshop is presented in the subsequent sections of this report.

STAR SYSTEM DEMONSTRATION

The STAR System is a disturbance analysis system cooperatively developed by the Halden Reactor Project and by Gesellschaft Fur Reactorsicherheit (GRS). The main purpose of the STAR System is an alarm filter and operator aid in defining the causes of disturbances with regards to feedwater anomalies. The system is digital computer based and computer programs have been developed to define and analyze alarm patterns and to present the results of the analysis to the operator. A prototype of the system is being installed for tests at the Grafenrheinfeld plant in Germany.

The operator interface with the STAR System demonstrated consisted of three moderately sized screens (CRTs). Each screen had dedicated keyboard controls. Functionally, the three screens were arranged to display:

- A schematic of the subject system
- An alarm display
- Analysis results

It was relatively easy to scan each of the screens and integrate the information being presented.

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The schematic display was color coded for normal (green), pre-alarm (yellow) and alarm (red) conditions. Portions of a schematic would automatically change color to indicate a change of operational state. Blinking of an alarm state was not used, but this would have been an additional mechanism for obtaining the operator's attention.

The alarm ~~siren~~^{screen} was also color coded and presented alarm states in text form to the operator. The symptoms of the problem were also presented in text form. This type of information could be extremely beneficial to the operator in evaluating a disturbed state of the plant.

The analysis screen presented, in text form, potential primary and secondary causes of the disturbance. An important feature of the analysis screen was messages to the operator indicating that the disturbance was beyond the scope of the STAR System. In the latter cases, operator training and knowledge would be required to solve the problem.

The in-plant prototype evaluation of the STAR System will assess the degree of feasibility and utility of this system as an operator's aid. It is recommended that the NRC closely monitor this evaluation for safety issues, impacts upon operator training and potential licensing criteria, such as man-machine interface requirements that may develop from test results.

OPERATOR - PROCESS COMMUNICATION

This subject matter was basically discussed by the personnel from the Halden Project. The scope of the discussions ranged from subjects on operators role and function, information presentation, color codes for screens, operator automation versus manual operation, performance experiments, organizational structure of a shift and the non-technical aspects of an operators role. The nature of the work being performed in these subjects ranged from fundamental research to prototype development. These subjects are discussed in the Halden Project Program and Progress Reports, thus only subjects worthy of further mention will be discussed.

One form of operator - process communication being studied is the use of form coding and alpha numerics on screens in lieu of or in addition to color coding. For example, the form of a piping schematic can vary as a function of the energy content of the contained fluid. Also, the status of a pump may be indicated as follows:

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The structure and symbols for form coding are being studied. The appeal of form coding is rapid and easily understood communication of plant status to the operator. It is recommended that NRC monitor these efforts as control room display standards can be imparted.

SAFETY STATUS PANEL

Three distinct efforts were defined with respect to the safety status panel. Representatives from Sweden stated that they were in the process of developing specifications for the panel and intended to install the panel in their plants. A representative from KWU in Germany stated their efforts were directed towards the development of a panel for abnormal situations. The objective was to present the operator with the maximum amount of information regarding the situation. The information is to be presented to the operator by a bank of screens.

The last effort on the Safety Panel involves the Halden Project. Halden stated that they have been asked by NSAC of EPRI to assist in the development of the Safety Status Panel. As each of these efforts is worthy of additional monitoring, correspondence has been initiated with key personnel on these projects.

CORE SURVEILLANCE

GRS reported on a Core Surveillance System code named SCORPIO. This system is being developed in cooperation with the Halden Project. The system is to operate in a core follow mode or a predictive mode. In the core follow mode, the objectives are:

1. Evaluate current core state.
2. Establish trends of core state.

In the predictive mode, the system is to:

1. Allow the operator to evaluate optimal load following strategies.

The utility of this system will depend upon the degree by which the core simulator in the system synthesizes reality. These efforts are to be undertaken in the near future and are worthy of monitoring by the NRC.

DIGITAL COMPUTERS

During the discussions of the workshop, a representative from GRS stated that they were in the process of standardizing on a computer language. The language they chose was a version of PEARL. One of the reasons for standardization of language was ease of program verification. This is a worthy objective and should be given further evaluation by the NRC in a tradeoff of review resources versus licensing criteria and standards.

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A second note on digital computers concerns a recommendation made by the workshop chairman Dr. Bastl. The workshop chairman recommended that the Halden Project investigate how improvements in data presentations from current plant process computer can be achieved. A specific example stated was the trending of process parameters. The NRC could benefit from this effort should results develop within our current schedule for control room backfit modifications.

HALDEN PROJECT

The Halden Reactor Project was visited on February 28th and 29th. At Halden, several demonstrations of digital computer based system for operator-process communication were witnessed. Detailed technical discussions regarding the subject were also conducted with the Halden staff. The major findings from the demonstrations and discussions are presented herein.

RGB SYSTEM DEMONSTRATION

This system is a user oriented digital computer based system that provides the reactor operator with a real time survey and analysis of the status of various safety systems, supplemented with advice regarding counteractions required when a safety subsystem is in a degraded state. Similar information is available in operations manuals. The computerized solution offers faster presentation of the guidelines and reduces the risk for misjudgment by the operator. See Reference 1 for additional details.

This system is the equivalent of Regulatory Guide 1.47, "Bypassed and Inoperable Status Indication for Nuclear Power Plant Safety Systems" plus portions of technical specifications for operation of the safety systems. Color code logic diagrams, piping, schematics, and an overall safety system status display were individually displayed on the screen. Furthermore, remaining time to repair/replace a facility safety component was also displayed to the operator. Also, a shutdown message would appear if insufficient safety systems were available in the plant. It appeared that the only deficiency in the system was the ability to print an LER upon a violation!

The RGB System required three man years of effort to develop to its current state. The system is to be installed in a Swedish plant this fall and will be operational by next winter. Based on this information, it is concluded that for the cost, significant safety benefits could be achieved with this operator aid.

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OPERATOR - PROCESS COMMUNICATION SYSTEM

An operator - process communication system consisting of three screens, (each with keyboards) was also demonstrated. This system was driven by a computer based nuclear power plant simulator. The system was being used to evaluate digital control of the power plant, operator - process communication, and operator performance. This system represented a considerable advancement in the state of the art of operator process communication with respect to previous systems seen in 1975 at Halden. Details on these systems may be found in Halden Progress Reports and Topical Reports.

With respect to the Operator - Process Communication System and the RGB Systems, it is recommended that other NRC personnel, in particular Operator Licensing personnel, and Inspection and Enforcement personnel view demonstrations and evaluate the utility of these systems. These additional viewpoints could be important to shape NRC policy regarding control room modifications.

TECHNICAL DISCUSSIONS

Several technical discussions were conducted with the Halden Staff. The major elements of these discussions are presented in the following sections.

1. Figure 1 is a diagram which is being prepared for use in a Technical Paper. The diagram was found to be useful for the technical conversations in that operators aids were being developed in several of the surveillance task:

Safety System Availability: RGB System
 Alarm/Disturbance Analysis: STAR
 Safety of Plant Operation: Safety Status Panel
 Core Surveillance: SCORPIO

2. Halden is considering development of a modified, modularized type of disturbance analysis system as a means of expanding the utility of such a system and reduce development effort.
3. Halden is also considering the development of a computer based power plant maintenance system as a means of improving administration of plant maintenance. A short discussion was also held on the feasibility and potential benefits of computerizing the status of interlocks/permissions as an operator's aid.
4. A short discussion was also conducted on the use of artificial intelligence for operational reactor safety. The objective would be to monitor plant operations for anomalies relative to previously learned normal patterns, similar to what is expected from an operator. No conclusions were drawn about the feasibility or utility of such a system.

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PERSONNEL EXCHANGE

In conversations with the Halden administrator, an exchange of technical personnel between Halden and the NRC was proposed. Such an exchange would produce many mutual benefits, such as:

- Improved awareness of current Halden Projects regarding operator-process communication
- Practical experience in computer based system development
- The impact of practical experience in the formulation of display guidelines
- Assistance in conducting control room audits

It is recommended that this exchange be given serious consideration and approved.

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