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ABSTRACT

Education-related titles among the 56 papers are "Panel Discussion: Plant Expectation of Training" (Sellman, Zach, Cross); "Managing Training AT&T" (Solomon); "Training Management Systems" (Waylett); "Managing the Training Function" (Wiggin); "Training Management" (Newton); Three Alternative Simulation Systems for Training Nuclear Power Plant Personnel" (Roman, Hine, Yeh); "Simulator Instructor Training" (Swander); "Panel Discussion: A New Performance-Based Exam Program for Licensed Reactor Operators" (Cooley, Guenther, Tipton); "Team Skills Training" (Coe, Carl, Jr.); "Lessons Learned from Three Years of Operator Team Skills Training" (Harrington); "Frustration, Challenge, and Victory of Team Building" (Brown); "Developing a Systematic Approach to Team Training for Emergency Response Personnel" (Derrer); "Relating Quality at Work to Quality at Home" (Hajek, Billings); "Changing Organizational Cultures" (Widen, Cowell); "Performance-Based Training for Quality Surveillance Personnel" (Edelman); "Application of Quality Principles to Training of Quality Assurance Audit Personnel" (Glasses, Espy); "Personnel Development Program" (Patrilla, Holden); "Using Computer-Based Training to Facilitate Radiation Protection Review" (Abercrombie, Copenhaver); "Computer-Based Training State of Art System" (McCauley, Weseman); "Indoctrination: Using Interactive Video to Teach Attitudes and Knowledge in General Employee Training" (Smigelski); "Managing Instructor Training to Achieve Excellence" (Norton); "Management of Training" (Mooney, III); "Use of Statistics to Monitor Quality in Training" (Helin, Gardner); "Feasibility of Quantitative Performance Measures for Evaluating Nuclear Power Plant Operators" (Carter, Connelly, Krois); "Adult Learning Techniques in Maintenance Training" (Roush); "Role of Environmental Qualification Training in Nuclear Plant Maintenance" (Krantz); "Evolution of Technician and Maintenance Training" (Clifton); "Radiation Monitoring Training System" (Boudreaux); "Motivation Is an Attitude"

(Mannering); "Evaluating Learning Strategies in Operator Training Programs" (Quinlan); "Development and Implementation of Quality Based Team and Diagnostic Skills Training at the Advanced Test Reactor" (Peterson); "Degree Education, On-Site, On-Line, and On-Time" (Mueller, Janke, Fisher); "Developing a Performance-Based Retraining Program for the Advanced Test Reactor (ART) Reactor Operators and Supervisors" (Betz); "Simulator Application in a Nuclear Technology Degree Program" (Sherrard, Burchill); and "Managing Training to Maximize Employee Articulation" (Rockwell). (YLB)

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*Proceedings of the Eighth Symposium on*

# TRAINING OF NUCLEAR FACILITY PERSONNEL

April 24-27, 1989
Gatlinburg, Tennessee

Sponsored by

**OAK RIDGE NATIONAL LABORATORY**

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THE AMERICAN NUCLEAR SOCIETY – REACTOR OPERATIONS DIVISION
THE AMERICAN NUCLEAR SOCIETY – EDUCATION AND TRAINING DIVISION
THE AMERICAN NUCLEAR SOCIETY – OAK RIDGE – KNOXVILLE SECTION

**PURPOSE:** To bring together those persons in the nuclear industry who have a vital interest in the training and licensing of nuclear reactor and nuclear fuel processing plant operators, senior operators, and support personnel for the purpose of an exchange of ideas and information related to the various aspects of training, retraining, examination, and licensing.



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# PROCEEDINGS

## EIGHTH SYMPOSIUM

## TRAINING OF NUCLEAR FACILITY PERSONNEL

April 24-27, 1989

Gatlinburg, Tennessee

Sponsored by:

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Date Published: April 1989

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## PROGRAM HIGHLIGHTS

Sunday, April 23

4:00-8:00 Registration....................................6:30-8:30 Mixer

Monday, April 24

Morning

8:00-5:30 Registration (Mon/Tues/Wed)

9:00-12:00 Welcome, Announcements, Opening Address

Afternoon (concurrent)

1:30 Session II-A: Operational Excellence

1:30 Session II-B: Management of Training

Tuesday, April 25

Morning (concurrent)

9:00-12:00 Session III-A: Control Room Simulators: Certification

9:00-12:00 Session III-B: Developing Effective Teams That Work Together

Afternoon

OPEN (Free for Individual Discussion)

Wednesday, April 26

Morning (concurrent)

9:00-12:00 Session IV-A: Creating Quality Achievers/Achieving Quality Through Training

9:00-12:00 Session IV-B: Technical Training -- General Employee and Health Physics

Afternoon (concurrent)

1:30-4:00 Session V-A: Quality Principles Applied to Training: The Need and the Payoff

1:30-4:00 Session V-B: Maintenance Knowledge Development/Hands-On Techniques and Devices

Thursday, April 27

Morning (concurrent)

9:00-11:30 Session VIA: Evaulation of Operator Training

9:00-11:30 Session VIB: Operator Training

11:30-12:00 Closing Remarks

## DEVELOPING NUCLEAR PROFESSIONAL FOR THE 90'S

CONTENTS

SESSION II-B. MANAGEMENT OF TRAINING

Chairman: C. L. Turner, Texas Utility Generating Company
Co-Chairman: Pete Walzer, Public Service Electric and Gas



SESSION III-A. CONTROL ROOM SIMULATORS: CERTIFICATION

Chairman: Tim Martin, Pacific Gas and Electric
Co-chairman: John Elin, Nuclear Regulatory Commission

SESSION III-B. DEVELOPING EFFECTIVE TEAMS THAT WORK TOGETHER

Chairman: Al Mangin, Institute of Nuclear Power Operations
Co-Chairman: Dudley Harrington, Duke Power
Co-Chairman: Brian Hajek, Ohio State University



SESSION IV-A. CREATING QUALITY ACHIEVERS/ACHIEVING QUALITY THROUGH TRAINING

Chairman: Terry Frizzell, Tennessee Valley Authority
Co-Chairman: Stan Fleming, General Physics

SESSION IV-A. CREATING QUALITY ACHIEVERS/ACHIEVING.......(continued)



SESSION IV-B. TECHNICAL TRAINING -- GENERAL EMPLOYEE AND HEALTH PHYSICS

Chairman: Roger Felthous, Resource Technical Services
Co-Chairman: Jay Spitulnik, Yankee Atomic

## SESSION VI-A. EVALUATION OF OPERATOR TRAINING

Chairman: Ron Bruno, Wisconsin Electric Power
Co-Chairman: Irv Marsden, General Physics



## SESSION VI-B. OPERATOR TRAINING

Chairman: Bob Keller, Department of Energy
Co-Chairman: William Burchill, Combustion Engineering

SESSION VI-B. OPERATOR TRAINING (continued)

# RESEARCH IN OPERATIONS: OPERATOR RELIABILITY EXPERIMENTS

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## ABSTRACT

The purpose of the EPRI Operator Reliability Experiments (ORE) Project is to collect data for use in reliability and safety studies of nuclear power plant operation which realistically take credit for operator performance in preventing core damage. Three objectives of this work are: (1) to develop a data collection and analysis procedure. This paper briefly discusses the background to this project, the data collection and analysis, and the quantitative and qualitative insights stemming from initial work. Special attention is paid to how this project impacts upon simulator use and assessment of simulator fidelity. Attention is also paid to the use of data collection procedures to assist training departments in assessing the quality of their training programs. (2) to obtain quantitative and qualitative data on operating crew performance in the control room for potential accident sequences using plant simulators; (3) to test the Human Cognitive Reliability (HCR) correlation.

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## BACKGROUND AND INTRODUCTION

The comprehensive treatment of human interactions is deemed to be a key to the adequate understanding of various accident sequences and their relative importance to public safety. There is an abundance of evidence to support the notion that humans play a dominant role in both causing and terminating accidents at industrial facilities. Such evidence comes in the form of acturial data (e.g. Chernobyl, TIM 2, numerous precursors) or results from various probabilistic risk assessment (PRA) studies.

In view of the importance of human interactions (HIs), EPRI[1] has sponsored a series of research projects over the past six years to increase understanding of HIs and to improve techniques for analyzing them. Although the principal aim of this research was to support PRA, the results and insights derived from it have proved to have applications in operator training, emergency operating procedures development, and human factors in design and point to expanded roles for simulators. This paper discusses how quantitative evaluations of crew responses can be applied to operator training and simulator operations. In addition, the paper describes the scope and results of initial work in the form of time-reliability curves of crew rsponses to key human interactions.

## ORE Project

The initial work has been mainly concerned with the testing of the human cognitive reliability (HCR) correlation (Spurgin[2], et al., 1984). The HCR correlation is intended to represent the behaviour of crews performing tasks in nuclear power plant control-rooms. The HCR correlation is a form of time-reliability curve which quantifies the probability of non-response of a control room crew within a specified time. Key features of the HCR correlation are reflected in the several hypotheses listed in Table 1. The testing of the HCR correlation entails carrying out experiments using large plant simulators, developing data collection and analysis methodology and examining the analyses to see if the basic HCR hypotheses are confirmed and to suggest modifications to HCR if necessary. The status of HCR hypotheses testing is seen in Table 1. Additional project work comprises refining of the HCR and applications of the refined correlation.

Table 1. Status of HCR Hypothesis Testing

| Hypothesis | | Status |
|---|---|---|
| 1. | Time Dependence | Valid |
| 2. | Single Parameter converts to non-dimensional time scale (Normalization) | Valid |
| 3. | Median‡ is suitable normilization factor | Valid |
| 4. | Discrete Correlation Groups Appear | Valid? |
| 5. | Skill, Rule and knowledge-based actions characterize groups | ? |
| 6. | Weibull or Lognormal | Valid |
| 7. | PSFs impact quantifiable | Invalid Thus Far |

‡ Median of measured response times for all crews at each plant.

## Simulator Facilities Used For ORE

Modern control room training simulators provide a considerable potential for making measurement of operator performance to improve understanding of the basic models and to provide support for human reliability estimates. This was fully recognized during development of the HCR model: the use of simulators for validation purposes became an obvious choice. Furthermore, experiments on simulators can take advantage of requalification training sessions with only minor perturbations to the utility. Currently, six U.S. utilities are participating in the program: Commonwealth Edison (La Salle), Pacific Gas and Electric (Diablo Canyon), Wisconsin Public Service (Kewaunee), Philadelphia Electric (Limerick), Pennsylvania Power & Light (Susquehanna), and Duke Power (Oconee). Electricite de France (EDF plants, Bugey and Paluel) and EPRI are collaborating closely in their respective programs of operator experiments including the design of the experimental method, statistical analysis of data and interpretation of qualitative observations.

It should be pointed out that EDF has pioneered the use of simulator experiments for emergency procedure and safety panel validation. A large number of experiments has been conducted since 1983 employing simulators at the three training centers: Bugey, Paluel and Caen. This background of experience provided a stepping stone for the EPRI project. The collaborative agreement provides cross-fertilization between the two programs. The two programs, if fully combined, would constitute the largest source of human reliability simulator data in the world, from which numerous nuclear safety insights could be derived.

The U.S. participants typically: a) make the full-scale plant simulators, with the associated equipment together with the operating crews, available for the conduct of experiments (typically in conjunction with scheduled requalifiations sessions); b) have close involvement in defining accident scenarios; c) perform programming of scenarios and assist in the conduct of experiments; d) share the information and insights being generated; and e) provide guidance via a steering group. This process often involved the collaboration of utility PRA groups and training staff.

## ORE Status

The status of EPRI ORE data collection is summarized in Table 2. Two or more scenarios were observed at each simulator with several crews being exposed to the same (or essentially the same) scenarios. Each scenario spans several pre-defined "key" human interactions for which timing data is collected and analysed. Preliminary data are reviewed (qualified) to assure that each HI measurement is representative of the population of licensed control room operators and is unaffected by simulator problems or trainer interference. To date, over 1,000 qualified data points have been collected.

Data collected during simulator retraining sessions with control room crews is performed by observer teams collecting response times of crews augmented by simulator records, such as data loggers, and video recordings. In addition to time data, post-transient interviews are also carried out to help define insights into operator decisions, such as which plant variables or alarms are used by the crews in given circumstances. This latter information is used along with information on operator experience and education to determine the influence of various performance shaping factors (PSFs).

Statistical measures are used to characterize crew responses to key interactions. Principal measures are a central point estimate (mean or median response time), and an estimate of spread or variability (variance or standard deviation). Voluminous raw response time data are reduced to a small set of statistical measures and subjected to preliminary evaluation for consistency and trend. The data was further organized and analyzed to test the HCR correlation. The seven hypotheses listed in Table 1 were examined using various analysis techniques. Later, data was aggregated in several ways to develop interim positions on the HCR correlation.

Table 2. Status of Simulator Data Collection

| Simulator | # of Scenarios | # of Crews | # of HIs | Total # of Qualified Data Points |
|---|---|---|---|---|
| PWR 1 | 3 | 10 | 10 | 95 |
| BWR 1 | 2 | 18 | 10 | 137 |
| BWR 2 | 7 | 3-6* | 13 | 125 |
| PWR 2 | 7 | 6 | 30 | 167 |
| PWR 3 | 8 | 5-7* | 12 | 130 |
| BWR 3 II | 6 | 9 | 15 | 125 |
| PWR 1 II | 6 | 16 | 16 | 250 |
| * Scenario Dependent | | | Total= | 1029 |

RESULTS

Results are reported for the ORE program to date. Project work is continuing, with additional and updated results forthcoming in the near term.

## Hypotheses

For the HCR correlation to be valid, the seven hypotheses have to be confirmed. Table 1 shows the current state of investigation for each hypothesis. The majority of the key hypotheses are confirmed. Hypotheses 1, 2, 3, and 6 are clearly confirmed. Hypothesis 4 can be viewed as partially confirmed.

The time distributions of crew responses show regular trends (Hypothesis 1) and are shown to fit either Weibull or lognormal distributions (Hypothesis 6). Hypotheses 2 and 3 relate to normalization by dividing actual response times of the crews by the median value ($T_{1/2}$) of response times for all crews. This produces a set of dimensionless response times. This process can be illustrated by showing that very similar human interactions with different actual times can yield close standard deviations after normalization. Table 3 shows two examples from the results. The corresponding curves for the PWR results are shown in Figure 1. These results indicate that underlying cognitive behavior for these HIs is similar (i.e. the shape of the curves are very close) and despite the existing plant-specific differences among the PWRs, the response curves moved closer together once normalized.

Hypotheses 4 is partially verified because data do suggest the presence of groups, but they overlap considerably. It has been found that the preliminary interpretation of skill(S), rule (R) and knowledge (K) based attributes for the human interactions involved (hypothesis 5) do not map the interactions unambiguously into one of the observed interaction groups. Further work is underway to find good labels for these interaction groups. Testing of hypothesis 6 is not complete and is continuing.

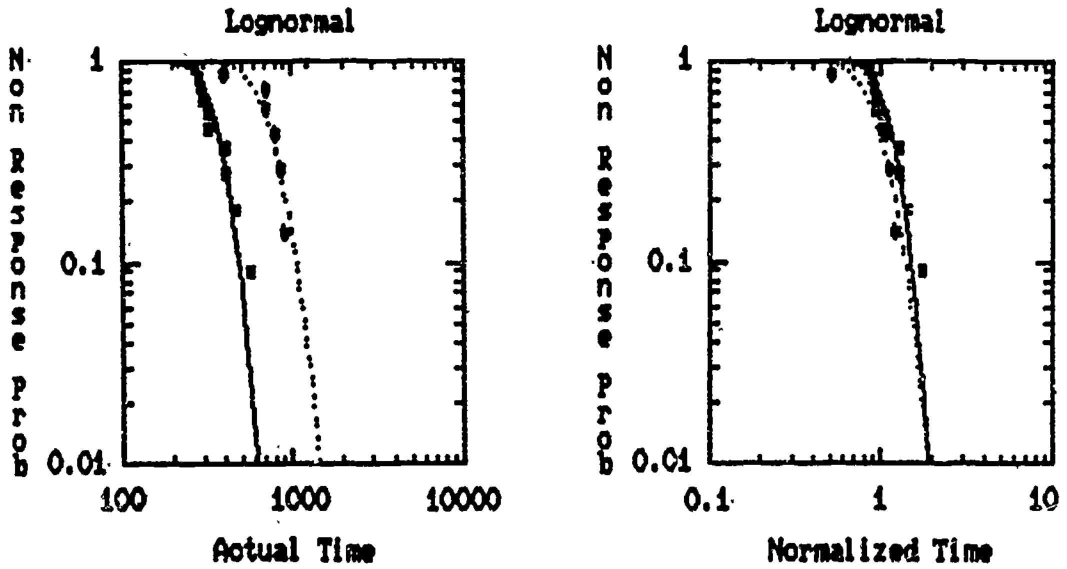


Figure 1. Comparison of Time Reliability Curves of Non-Normalized and Normalized Data for Isolation of Faulty Steam Generator in a SGTR for two PWRs.

Table 3. Comparison of Response Time Parameters For Similar Human Interactions for Different Plants

| HI | Plant | Median Response+ (Seconds) | Normalize Sigma Value* |
|---|---|---|---|
| BWR | | | |
| ATWS: | A | 79 | 0.71 |
| Suppress | | | |
| Pool | B | 145 | 0.74 |
| Cooling | | | |
| Initiation | C | 138 | 0.85 |
| | | | |
| PWR | | | |
| MSLB//SGTR: | A | 323 | 0.24 |
| SG Isolation | B | 766.5 | 0.30 |

‡Median of measured response times for all crews at each plant.

* Standard deviation of normalized response times for each plant, where normalized times equal actual times divided by the median response.

## QUALITATIVE OBSERVATIONS

In the course of participating in the experiments, the observer teams made qualitative observations relative to the response of the crews. Records taken during the experiments provide not only information for use in the program, but also provide a useful data base for trainers, operators, procedure developers and human factors personnel. Observations below are grouped into five categories: Simulator Limitations, Training, Human Factors, Procedures, and Crew Structure and Communications.

### Simulation Limitations

A simulator's capacity to accurately model actual plant conditions is crucial to the collection of comprehensive and reliable data. While testing the scenarios it was observed that some simulators could not model all scenario variables. In addition, as the model of the plant is upgraded, older digital computers may be incapable of modeling the plant correctly.

Areas which need attention in PWRs are mainly associated with thermal-hydraulic modeling. These cover modeling of void formation, hot leg behavior from "bubbly" flow to high void, and reflux cooling in the steam generator. Some steam generator models seem to be in need of improvement. One area that seemed to be particularly deficient in the minds of the crews was the modelling of auxiliary operators by the trainers. There did not appear to be consistent criteria applied to the time taken by the auxiliary operators in performing tasks. Also, there were no criteria for when they could be expected to be successful. EPRI expects to examine the potential for including actions of auxiliary operators and maintenance technicians outside the main control room in the same quantitative framework as the HCR model in the near future.

## Training Aspects

### Use of Scenarios

The scenarios used in the operator experiments have been designed so as to pose varying levels of complexity to the crews. At some simulators the experiments were the first PRA-oriented scenarios experienced by the crews. These crews were unused to dealing with the more complex scenarios. However, the training staff noted that the crews became very comfortable with complex scenarios over the course of the experimental program. On the whole, crews were generally favorable toward the challenges afforded by such scenarios.

### Training Program Evaluation

By and large, training staffs evaluate the crews on qualitative performance measures such as application of correct procedures and intra-crew and extra-plant communications. It is believed that routine timing of crews on key human interactions in simulator scenarios along with commentary to characterzie the crew response with respect to use of procedures, slip/errors made and recovered, and other factors could provide a means under utility control to evaluate training effectiveness. Crew response times for human interactions could be used as one indication of training effectiveness for time-critical tasks. Reduction in median response time could be used as an indication of crew improvement and training effectiveness. Such records and trending of the crew's performance would enable objective evaluations to be made of all the crews' performance. The training group could then evaluate how to improve the training program or suggest what improvements should be made to the procedures or control-room displays.

## Human Factors

Control room design reviews and task analysis programs have, or seem to have, obviated most human factors deficiencies. During the EPRI experiments, however, observers noted several items that seemed to affect the crew response time and accuracy. This suggests utilities should encourage training and operating staffs to use simulator training as another means to identify potential problems. Typical human factor items identified by observers were: a) instrument location; b) instrument/panel design; c) control handle location and labelling;

d) display characteristics and design; e) alarms/annunciator design; and f) SPDS validity and reliability.

## Crew Structure and Communications

### Organization

Training practices of augmenting crews and/or random personnel absences resulted in variability in crew structure during the respective experimental series, although the latter is viewed as representative of actual plant practice. Essentially constant across the plants is the use of at least two licensed reactor operators (RO) who manipulate controls; one PWR uses three RO's. Also constant is the assigned responsibility of one licensed Senior Reactor Operator (SRO) to be in charge of executing Emergency Operating Procedures. Beyond these two areas of responsibility, crew size and organization varies significantly from plant to plant. The quality of the response seemed mainly to depend on the quality of the procedure reader (SRO) and his ability to see where the plant was headed and what the procedures said. It is not clear what crew size and organization is optimal from these experiments.

### Communications

During training at all simulators, intra-crew communications are emphasized and evaluated as part of the requalification exercises. What is observed, however, is that crews often do not communicate in the desired fashion during the first time back on the simulator; after being reminded in trainer critiques, most crews attempt to follow the desired style even while noting that to do so is "acting" for them. Those who express some resistance note that they know their crew members well and are able to communicate well in their "normal" mode.

The human factors form used during scenario observations asks to characterize the crew leadership style on a five-point scale ranging from "authoritarian" to "democratic". Qualitatively, it appears that the most efficient crews, in terms of response times, tend to be more "authoritarian" so long as the true leader understands the plant state and does not force the crew to make poor decisions. Most crews, however, are characterized as "participative" in which the ultimate decision maker is clearly understood but crew members feel free to challenge the SRO as a way of checking the diagnosis.

## Procedures

The emergency operating procedures (EOPs) provide the backbone of crew responses to accident scenarios. The current vintage of both BWR and PWR EOPs are considered to be "symptom based" so that crews may react as dictated by the EOPs to various symptoms indicated by displays and instrumentation. It is noted, however, that the PWR procedures tend to be a hybrid of symptom-and-event based. In general these procedures, which help diagnose and make decisions, are intended to evoke "pure" rule-based cognitive behavior on the part of the crews. The results tend to confirm that responses in general are biased to rule-based and show that the procedures are accomplishing their desired objective.

The observer records quite clearly show where the crews have difficulties with the procedures and how many of the crews suffer from these problems. Training staff and the procedure developers can help resolve these problems.

## QUANTITATIVE OBSERVATIONS

### Aggregated Curves

Data aggregation in the ORE program means that operator response times for individual HIs among various scenarios and various plants or types of plants are combined (pooled) in various ways. Data aggregation is peformed to enhance the statistical database, and provide bases for comparison of results at different levels of aggregation for between-plant comparisons and for comparisons of BWRs to all PWRs results.

Figure 2, for example, shows the respective aggregate curves for all-BWR and all-PWR data. It also shows the aggregate of these two as the "all-data" curve. The results indicate that aggregated curves correspond roughly to "rule-based" behavior with the PWR curve slight / to the left and the BWR curve slightly to the right of the "all-data" curve.

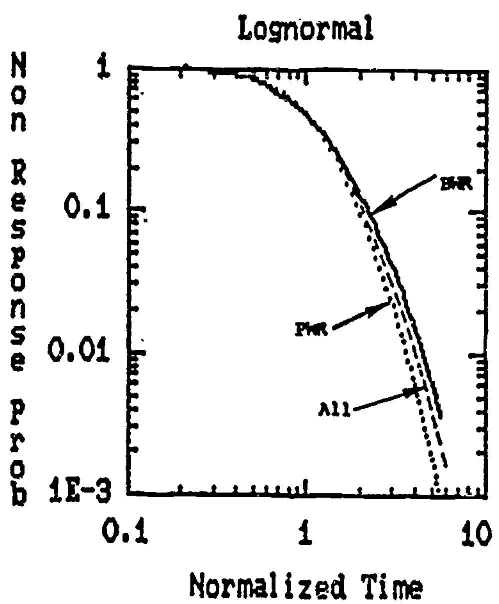


Figure 2. Aggregate curves for all BWR and PWR data

## Analysis

In general, the responses of crews are grouped close to specific ORE curves and large deviations from such a curve may indicate differences in the performances of groups of crews or individual crews. For example, crews may implement different strategies in response to an event and this shows in the shape of the curves. The differences in strategies may be due to differences in cues or indications that crews act upon or the order of tasks that they perform. Often the trainers are only peripherally aware of these different strategies and do not usually know the effects on performance. The operations group may wish to selectively modify how the crews carry out the tasks based on this information, since one strategy may be considered more risky than another.

The average (or median) time spent by crews on various HIs differ significantly. This is often due to differences in plant response to different transients, although there are often marked differences between median response times for similar transients at different but similarly designed plants. The latter may be due to familiarity with the actions, degree of complexity of specific procedures, etc. The measured crew median response times on various HIs could yield useful perspective to trainers, procedure developers and human factors persons. In general, a small number of operator errors (slips/mistakes) was observed. These will be further examined later in the program. The results suggest that crew experience does not have a significant effect on crew response. This is intuitively puzzling, but could be due to the fact that all the operating crews undergo similar training/requalifications and use the same procedures.

## SUMMARY

The combination of a quantitative method for collecting performance data together with a systematic method for recording qualitative data relating to aspects of crew performance (such as communications) can build an information base to help utilities refine training programs and plant operations. It can provide information on how training programs impact on crew performance. It can be used to provide information evaluating how successfully changes in training programs improve crew performance. Simulator fidelity in crew operations can be assessed using the data base to compare obtained results to expected results. The data can also provide information on which parts of plant procedures cause difficulties which affect crews, and on difficulties individual crews have with some aspects of plant operations.

We expect the results of these experiments to have far reaching effects, not only on risk estimates, but also on how training effectiveness and simulator fidelity is measured and monitored. EPRI's research program is turning to these issues. It appears that the area of operator training can benefit greatly from focused R&D that has the goal of improving the operators' ability to respond to accident situations.

The qualitative steps that the industry has taken in these technical areas are already yielding quantitatively measurable performance improvements. Increased crew perfotmance improvements are to be expected as this methodology is expanded to encompass simulator operations and operator training programs.

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1. Joksimovich, V. and D.H. Worledge, 1988. "Using Simulator Experiments to Analyze Human Reliability for PRA Studies. "Nuclear Engineering International, (January).

2. Spurgin, A.J., G. W. Hannaman, Y. Lukic andD. H. Worledge, 1984. "Impact of a Behavior Model of the Control-Room Crew on Plant Transient Analysis, "Paper Presented at the International Conference on Power Plant Simulation. (Cuernavaca, Morelos-Mexico, November).

## REARCH IN OPERATIONS: LESSONS LEARNED

J. E. Molden

### ABSTRACT

Over the past several years, increased attention has been focused on control room resource management. Although the need has arisen from a variety of circumstances, the mission has always been clear. We must both pursue new methods and continue with existing approaches which will provide measurable improvements in the control room team performance. A key factor in succeeding is our ability to quantify acceptable performance. Once this is achieved, we will better understand what changes are needed to make improvements. The purpose of this paper is to discuss an Electric Power Research Institute (EPRI) project that Diablo Canyon has been involved in which has already resulted in improved team performance.

### BACKGROUND

Since October 1986, Diablo Canyon Power Plant has been involved in an EPRI Operator Reliability Experiment (ORE) Program. The ORE program goals were to develop, evaluate, and validate a methodology which would enable operator performance to be factored into a utility's probabilistic risk assessment (PRA). The program intent was to ultimately validate a "human correlation model" which could be consistently applied to PRAs. The goal was to be able to incorporate the expected performance results into the PRA whether or not the actual performance had been observed.

Diablo Canyon agreed to participate in this program because we were definitely interested in taking credit for operator performance. However, even more compelling, it was an opportunity to examine operator performance in a manner which we had not previously considered.

The thrust of the project was to develop very specific "human interactions" and to accurately measure the time required to perform each interaction. The response time information would then be used as a basis to validate the human correlation model. In support of this project, detailed simulator scenarios were developed which incorporated current PRA sequences. Evaluation guides were then produced which listed each human interaction to be measured. The Emergency Operating Procedure flowpath was used as the basis for determining the specific human interactions.

When we signed on to this project, we certainly understood the benefits this type of project could have on future PRA work. What we came to realize very quickly, however, was the training significance this proiect would have on improving team performance.

## TRAINING IMPACT

### PRA Team Impact

The Diablo Canyon Training and Operations Departments have been involved in a number of PRA studies over the years. Our experience with previous PRA teams was one that I would characterize as being "mechanical". We wrote scenarios, ran them on the simulator with operating teams and let the PRA people take their data and hoped they would vanish from our existence. From our perspective, the PRA team was not interested in communicating the results to us so that we could both benefit from the experience and factor the results into reducing the risk involved. We understood that our PRA project had to be accomplished, but we also understood the manpower impact it would have on other work activities. For this reason, we entered the ORE project with a great deal of apprehension. Also, because of our previous experiences with PRAs, we did not involve our PRA people. Based on our experience with this project, we won't make that mistake again.

When the EPRI project was kicked off and we began working closely with them, we developed a bond which is now irreversible. For the first time, we were working with a team that was interested in making sure we received added value for our efforts. It was through this mutual arrangement that we soon realized that this project was more beneficial than either of us envisioned. A renewed vision of PRA efforts was certainly one of those benefits.

## Human Correlation Model

Since the goal of this project was to validate a "Human Correlation Model", the first task for the EPRI team was to teach us, in simple terms, the validation process and our responsibilities in performing it. By putting a time measurement on specific human interactions, they were able to plot the response time of each crew and the plant as a whole. Before we look at a plant specific results, it will be helpful to look at a composite graph which illustrates the human cognitive responses measured with the tests (see Figure 1-1).

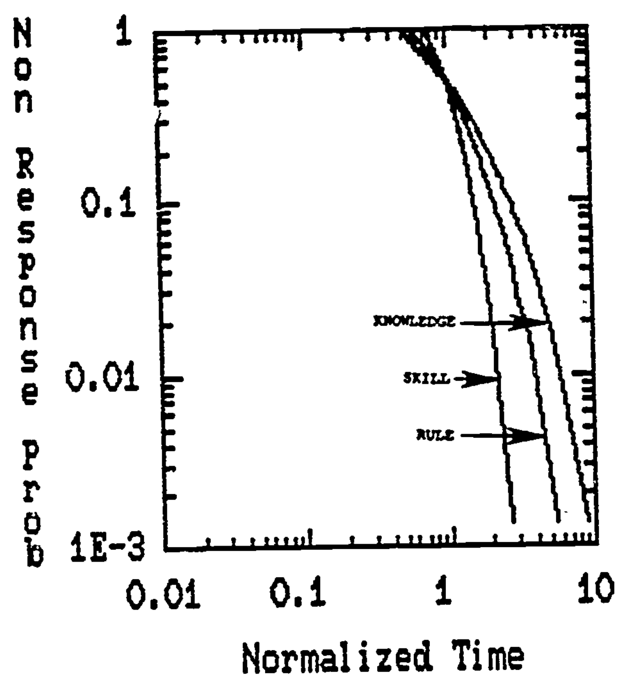


Figure 1-1 Normalized Crew Non-response Curves for Skill, Rule, and Knowledge based Cognitive Processing

Figure 1-1 illustrates that three levels of cognitive behavior were identified. During the project we observed that performance shifted from a knowledge based behavior toward a skill based behavior as learning occurred. The distinction between each category are defined as follows:

> Skill-based behavior involves man performance that is so well learned and internalized that it is a smooth, automated, integrative sequence.
>
> Rule-based behavior takes place when a rule or procedure is applied to a familiar work situation. With training and experience related to a rule based behavior, the behavior may subsequently become predominantly skill-based.
>
> Knowledge-based behavior occurs during unfamiliar work situations in which skill-based or rule-based behavior is not available. The individual applies general knowledge to the situation, however does not have situation specific rules. If the individual has an opportunity for guided practice of knowledge based behavior, the performance can be categorized and rules can be generated. As this occurs, the behavior begins to move toward rule or skill based behavior.

The information needed to draw the curves is the time measurements of each specific human interaction for all the teams. For example, a scenario may require each team to manually trip the turbine when the main feedwater pumps trip. The human interaction time measurement would be the time it took each team to trip the turbine. This information can then be plotted and a curve can then be drawn which intersects the plots. This concept is illustrated in more detail later in this report.

EXAMPLE RESULTS FROM PROJECT

Emergency Operating Procedures

Procedure Change Example

One of the scenarios used in the program involved an anticipated transient without a scram (ATWS) with a stuck open pressurizer safety valve. One of the human interactions we measured during this scenario was the time it took each team to recognize that the safety valve was stuck open. A portion of the team times were:

| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|---|---|---|---|---|---|---|---|
| 404 sec | 263 sec | 437 sec | 115 sec | 403 sec | 248 sec | 346 sec | 168 sec |

When we saw these results we were surprised. As we began to analyze the reasons, we came up with several hypotheses or conclusions. The first and easiest of these was that the status of the safety valves was not required to be checked in the emergency operating procedures. After TMI-2, considerable attention was placed on power operated relief valve (PORV) status as a depressurization means. No attention was given to the safety valve status. Our simple fix was to check the safety valve status in the same step that the PORV is checked. Since we added this step, we have reduced the recognition time for a stuck open safety to 30 to 45 seconds.

Now that we fixed our immediate concern, we faced the challenge offered in our second hypothesis. We asked ourselves these questions: What is the root cause for it taking so long to discover the only mechanism which is causing the depressurization? Have we become so procedure oriented that it has reduced our capacity to focus on critical plant parameters and diagnose the problem efficiently? Have we given our team sufficient training to be able to both execute the emergency procedure while at the same time diagnose plant conditions? These questions do not have hard and fast answers. We believe these questions need to be asked continually as team performance and training methodologies are analyzed.

I want to emphasize that we wouldn't necessarily have been able to ask these questions or make the emergency procedure change without objective data. This data has given us the ability to make a conscious choice about what we want our performance to look like. We can show this data to the Operations Department and they can begin to understand what changes are needed in resource management and procedure changes to improve performance. Additionally, as new data becomes available, it begins to affect the simulator instructor's ability to observe performance from a different viewpoint. For example, our instructor is now more likely to look at situations like the safety valve recognition problem and try to search for the underlying cause.

Finally, implementing an objective measuring system will enable us to more effectively evaluate the strengths and weaknesses of our training program. If for example, we sample a human interaction of a team in initial license training and compare it to our current license staff, we can determine if our requal program provides the appropriate emphasis to maintain the skill level we want.

## Emergency Procedure Execution

We found that execution of the emergency procedures was one of the most significant impacts on team performance. Performance in this area is highly complex because it encompasses so many variables. These variables include: 1) team participation, or lack thereof, 2) skills required of the procedure reader, 3) who should be the procedure reader, or 4) does the structure of the procedure hinder successful mitigation of an event. Again, I will stress that it was through our analysis of the data that we were able to objectively measure and understand the impact these areas were creating.

To illustrate how we were able to pinpoint some of these problem areas, it is first important to show some examples of the data provided from the project. One of the data sets provided was a normalized time matrix (see Table 1-1). The following is a portion of the matrix information. Since the data is incomplete, the average and standard deviation information won't look accurate, even though it is.

NORMALIZED TIME MATRIX

| HI# \ CREW # | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| 1 | 1.06 | 1.11 | 3.44 | 0.61 | 0.81 | 0.89 |
| 2 | 2.62 | 1.15 | 2.48 | 0.34 | 0.35 | 0.56 |
| 3 | 0.4 | 0.2 | 2.28 | 2.97 | 0.9 | 0.73 |
| 4 | 1.1 | 0.83 | 1.58 | 0.71 | 0.82 | 1.21 |
| 5 | 0.9 | 2.02 | 0.93 | 1.44 | 1.54 | 2.17 |
| Average | 1.09 | 1.24 | 1.84 | 1.02 | 0.94 | 1.08 |
| Std Deviation | 0.53 | 0.55 | 0.80 | 0.57 | 0.31 | 0.32 |

Table 1-1

The matrix illustrates the normalized time it took each team to complete a given human interaction. First, a value of 1.0 is the norm. Values less than 1.0 indicate fast response, while values greater than 1.0 indicate a slower response than norm. The "Average" row at the bottom works the same way. Secondly, the "Standard Deviation" row provides an indication of the variability of the team. A high standard deviation is indicative of team inconsistencies, while a low standard deviation is indicative of consistent team performance. A high variability can be achieved by having an overall fast response time with infrequent slow response times. This closely resembles Team 1. A high variability can also be achieved by having an overall slow response time with an infrequent fast response. This closely resembles Team 3. In general, the bes team would have a low average time and a low standard deviatio . This would imply that they are fast (skilled) and consistently repeat this performance. This closely resembles Team 5.

From Table 1-1, it is apparent that Team 3's performance is vastly different than the other teams. This was one method which caused us to more closely examine Team 3 to determine why the performance differed from the other teams.

Another method used to provide an indication of performance was the data plotted on the human correlation model curve (similar to Figure 1-1). This information is provided in Figure 1-2.

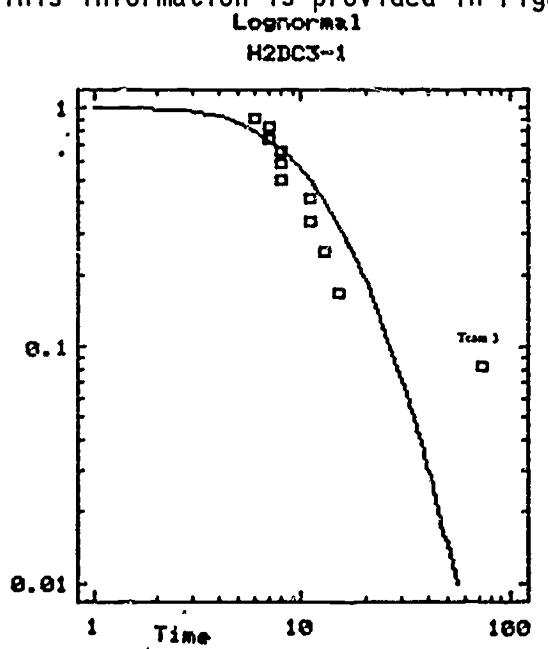


Figure 1-2 Median Response times for a specific human interaction illustrating abnormal performance for one team

Once we examined this data, it reaffirmed that Team 3's performance was abnormal. It was then a matter of studying Team 3's performance to determine the root cause. However, before this issue is addressed, it is noteworthy to illustrate effect on the previous curve when Team 3's data is excluded (see Figure 1-3).

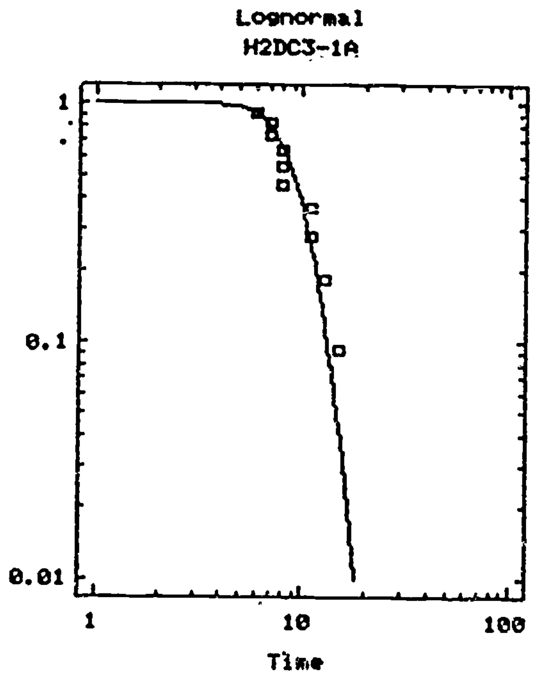


Figure 1-3 Median Response times for a specific human interaction with Team 3 excluded.

As you can readily observe, the overall plant performance markedly improved when Team 3 data was removed. That is, the curve shifted from a knowledge based operating style toward a skill based operating style. Since our job is not as simple as removing the "bad" apple, we had to revert to plan B, understand the problem and effect a cure.

Video-tapes of Team 3's performance during accident scenarios were reviewed. It was obvious that two major reasons contributed to the poor performance. First, the reactor operator did not involve himself in the scenario. He restricted his area of responsibility to the boards he controls during normal operation. His responsibility was fundamentally limited to silencing the alarms. Secondly, and more importantly, neither the senior operator reading the procedure nor the supervisor in charge, directed the reactor operator to perform a single operation. All of the operations were performed by the balance of plant operator. The procedure reader was reading the steps as fast as the balance of plant operator could perform them. Equally interesting was that two very qualified simulator instructors and an excellent consultant were observing the team performance during the scenarios and none of them observed this occurring or the impact it was having. This reinforces the benefits that objective, measurable data provides. Also, since instructors have now been briefed on this particular event they are more skilled at observing and correcting the problem.

When the data on Team 3 was initially presented to me, my immediate reaction was the procedure reader was slow. However, after viewing the tape, it was obvious that this was not the problem. Jumping to conclusions also reinforced the importance of not drawing conclusions from the data alone. The data only indicates that the performance is different. Once the data supports an anomaly, the performance must be analyzed to determine the cause. Video-taping the performance proved extremely valuable in assessing the problem, but by no means is it the only method.

By utilizing the data collection system, it is also possible to observe whether learning has occurred. To determine this, the same scenario was rerun with the same human interactions measured. When the data was plotted, the curves shifted to the left, from the rule/knowledge based behavior to the rule/skill based behavior. The shift in the curve illustrates that learning is measurable. This is illustrated in Figures 1-4 and 1-5.

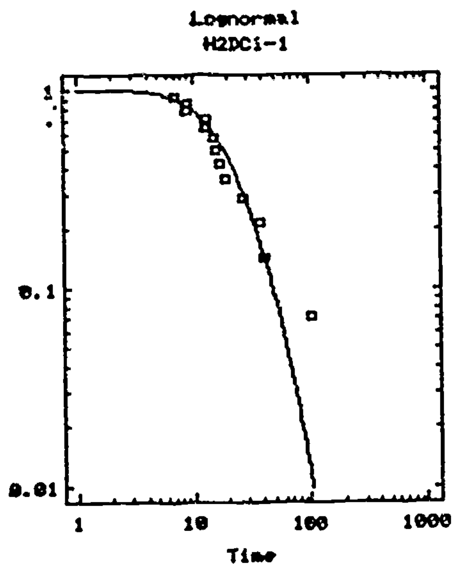


Figure 1-4

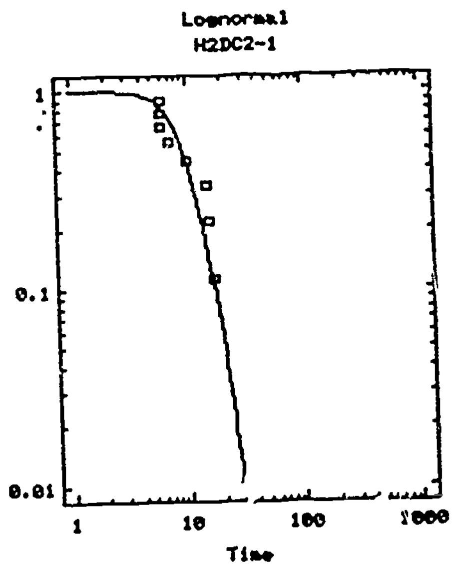


Figure 1-5

While participating in the project, many issues surfaced regarding the effectiveness of the procedure reader. A poor procedure reader introduced significant, measurable delays in the team's performance, while an excellent procedure reader greatly contributed to the team's efficiency and cohesiveness. There were occasions when a majority of the Shift Supervisor's time was consumed ensuring the procedure reader was on the right step because the supervisor lacked confidence in the senior operator's ability to execute the procedure correctly. This should not be construed that the supervisor lacked confidence in the senior operator's ability to operate the plant. What is clear, however, is that procedure reading requires skills which some individuals may not inherently possess. Our philosophy to date has been to assign this job to our senior control room operator. That is, the job has always been assigned by position not by individual. The issue of who should read procedures and what skills are required is being closely evaluated at Diablo Canyon as a direct result of this project.

## Control Room Design Review Change Validation

The data collection process also has the potential of measuring the impact of control board changes implemented from a control room design review. For example, we ran a series of ATWS scenarios in January 1987 which were repeated in January 1988.

The data collected showed a degradation in the response time. After studying the operators performance, we observed a hesitation in operating specific switches. This was not a problem during the first series of scenarios. What we discovered was the control rcom design review changes had relabeled the switches and caused confusion and hesitation. Although this particular circumstance represents a relatively minor impact, correctable by repetitive training, it illustrates a positive application of the process.

## HOW TO IMPLEMENT AN OBJECTIVE PERFORMANCE MEASURING SYSTEM

Diablo Canyon is still wrestling with the ability to implement a performance measuring system which provides both valid, useful information while at the same time is not overly instructor intensive.

### Data Collection Concept

Data to be analyzed would come from two existing sources currently available as outputs from the simulator. First, our intent is to use the TEAM function on the simulator. This function provides timed information for every switch manipulation made by the operators. Secondly, to identify critical plant parameters for each scenario. Both of these data sources are currently capable of printing to a lazer printer. However, to improve the usefulness in compiling and calculating the results, we are investigating the feasibility of outputting the information to a computer disk. The final data hurdle will involve designing a computer program to massage the data.

### Performance Monitoring Concept

Each simulator scenario will be video taped and cataloged by scenario and operating team. The video tapes will be used to analyze the performance disparities the collected data identifies. As appropriate, the video tapes will then be reviewed with the operating team involved and simulator instructors to improve operator performance and instructor observation and critiquing skills.

## SUMMARY

The ability to collect timed data on critical human interactions offers the opportunity to objectively measure a variety of performance variables. Understanding the reasons for the variables will enable us to ultimately improve plant performance. I have already illustrated several applications which have corrected specific problem areas in instructor observation skills, plant procedures, design changes and team performance. Through the continued use of these processes, we envision that additional improvements will be forthcoming.

IMPLEMENTING EXCELLENCE

John Reeder
Southern California Edison

PAPER NOT RECEIVED AT TIME OF PUBLICATION

# P A N E L   D I S C U S S I O N

## PLANT EXPECTATIONS OF TRAINING

Mike Sellman, NSP
James Zach, WEP
Jim Cross, FP & L

# TRAINING: EXPECTATIONS OF AN OPERATIONS SUPERINTENDENT

Michael B. Sellman

During INPO's 1988 CEO Conference, Hiroshi Nirita, President, Central Research Institute of Electric Power Industry, gave a speech on "Japan's Approach to Promoting Professionalism." In that speech he said:

> "Operating personnel do not simply follow orders in the performance of their duties. Personnel are expected to take responsibility for their duties and to individually think through and understand what is required to perform their duties without error and to achieve outstanding results. The key being to think through and understand what is required to perform one's duties."

The end product of all our training, initial license, and requalification, has to be operators who are able to think through and understand what is required to perform their duties.

About 10 years ago, we had a very good teacher at Prairie Island. He couldn't wait to get through systems and fundamentals because then he could start teaching integrated operations. He spent months at this last phase, and it was almost exclusively "what if's":

"If you have a turbine control valve swing open, with control rods in manual and the turbine in imp-out, what will happen to reactor power and T-ave?"

"If the same thing happens with a positive moderator temperature coefficient, what happens?"

He had hundreds of questions like that. To get through his course, the student had to be able to think through and to understand what was happening in the plant. When asked about priming his students to pass NRC exams, this instructor (who was a former NRC examiner) would scowl and say, "I teach understanding - that's sufficient."

For awhile, he was right. But then in the early to mid-1980's, shortly after the NRC regionalized their license examining process, we began to get failures. People that had developed a thorough understanding of the reactor and the plant were failing NRC exams. We looked at the exams, which were "objective," and concluded rather simply that the exams were becoming exercises in trivial pursuit - not tests of one's understanding. Rather naively, we affirmed our faith in our teacher of understanding and told him to persevere, that the NRC was experiencing growing pains, and that sooner or later they would get back to examining for understanding.

It did not happen. We put up with bad exam results for a few years and then were forced to admit that teaching understanding was not sufficient. By mutual agreement, we replaced our teacher of understanding with three or four less-experienced instructors. The new instructors may not have understood a lot about the intricate workings of the plant, but they knew what sort of questions the NRC was asking. They knew what "K-A's" meant, and they knew what "Job and Task Analysis" meant.

I suspect all of us associated with training and operations in the 1980's have experienced "growing pains." Training sections have grown from 1 or 2 people to 40 or 50. At the same time, the NRC has gone from a handful of examiners, all working out of the same office, to 5 separate groups of examiners. INPO has stepped in with a new method of constructing training programs and an independent way of evaluating them.

What have we gained? What was our vision in 1980 and what is it now?

In my opinion, our vision has changed since 1980. In 1980, the nuclear industry as a whole - and operator training in particular - was under attack and we developed a survival strategy. Our 1980 vision might have been phrased, "make dramatic improvements in operator training so that we can continue to operate." In 1989, we can probably be a bit more precise. I would suggest the following:

> "Through shift management and training, provide operators who can think through and understand what is required to perform their duties. Do this in a way that is cost-effective, so that we can continue to profitably operate our plants."

The key is thinking, and we need to focus on that in operator training during the 1990's. It will take a unified effort b the utilities, INPO, and the NRC, because we have to face facts - utilities are forced to tune their training programs to address exam questions and also to attain INPO accreditation. A qualified operator is more than one who has been trained on all of the tasks listed in the Job and Task Analysis. A qualified operator is more than one good at trivial pursuit. A qualified operator is more than one who can follow cookbook Emergency Operating Procedures. A qualified operator is one who can think through and understand what is required to perform his/her duties.

## EXPECTATIONS FOR TRAINING

J. J. Zach

ABSTRACT

At Point Beach Nuclear Plant, we try to address our training expectations to satisfy the various classes of customers that our Training group has. For example, one group of customers would include the students. They may feel satisfied if the material they are presented is understandable, applicable to their jobs, and made interesting. Another customer would include senior management. They may be satisfied if the training program results in high marks from INPO and/or the NRC and is implemented in a very cost-effective manner. Another class of customers is the regulators and the evaluators. They may be satisfied if the training program is regimented, documented, and structured. Finally, we arrive at the last group of people concerned, the plant managemen. They will be satisfied if all the other customers are satisfied, particularly those who happen to be exerting the most pressure on them at any given time.

### BACKGROUND

Point Beach Nuclear Plant is a two-unit, pressurized water reactor plant, located about 100 miles north of Milwaukee, Wisconsin, on the shores of Lake Michigan. The plant is owned and operated by Wisconsin Electric Power Company. Unit 1 went commercial in 1970, and Unit 2 went commercial in 1972. When the original staffing was considered, it was thought that the plant could be operated and maintained by less than 80 people. In fact, both units were started up with a total staff of only 80 Wisconsin Electric full-time employees. Training existed only for the licensed operators. They spent half a day in the classroom and half a day on the job in the plant. While in the plant, they were verifying the construction and developing operating procedures.

The first person with any focus on training was a former operator who was assigned to training in 1974. He had a corner in an office area. His total function was to ensure the proper material was available for license candidates.

The size of the training staff started growing with the addition of two more individuals in 1979, so we had a grand total of three. In 1981, we hired a superintendent of training, and now we have 31 full-time employees in the group, plus two Operations supervisors assigned on a rotating basis and five contractors.

At Point Beach Nuclear Plant, the Training group has various classes of customers. For example, one group of customers would include the students. They may feel satisfied if the material they are presented is understandable, applicable to their jobs, and made interesting. Another customer would include senior management. They may be satisfied if the training program results in high marks from INPO and/or the NRC and is implemented in a very cost-effective manner. Another class of customers is the regulators and the evaluators. They may be satisfied if the training program is regimented, documented, and structured.

Finally, we arrive at the last group of people concerned, the plant management. They will be satisfied if all the other customers are satisfied, particularly those who happen to be exerting the most pressure on them at any given time.

## STUDENTS

As a member of the management/technical group, I am part of the first group of customers (the students). While we have gone a long way from teaching the six-factor formula and excore detector response to inadequate core cooling, we still have a way to go before I am satisfied. At Point Beach we have tried to establish a training program which is based upon the needs of the individual employee. As part of continuing training, we ask the employees what training they feel they need to better do their jobs. One problem we face is that while we have moved away from some "extraneous" material, we have not been able to eliminate it all. It seems as if there is never enough time for me to learn what I want as a student.

In the Operations Continuing Training Program, we have at least eight weeks of training every year. One would think that would be more than enough time to devote to the information that the operators feel they need. However, to assure our operators are aware of the plant status, we have to spend some time in each training cycle providing a plant status update, which includes the modifications and significant procedure changes that have occurred in the last six weeks. We also are required to spend some time at the simulator performing specified casualties. We have to maintain fire brigade qualifications by spending time in a smoke tower at one of the local trade schools. The annual exam is given during the training week. This, of course, is a several day affair including preparation and exam execution. Of the forty days for training, there is not much left for what each of the 50 operators wants to learn.

We feel it is a good idea to alert our employees to events which happen elsewhere in the industry. Events come to us through INPO SOERs or Emergency Information Notices and Bulletins. These operating experience reports may seem remote to the employee and it is Training's challenge to make them interesting and applicable.

Finally, we arrive at the material that the operator feels is important to him. We receive requests from employees to be trained on dozens of items. We can fit in a few per year. Obviously, some employees will remain unfulfilled. Those employees will feel frustrated that their "legitimate" requests were not met.

As with any communications program, we face the difficulty in presenting material to a spectrum of employees. In one classroom, there may be a repairer who has been with the company for less than two years and a mechanic with 18 years experience, including plant startup and experience with many transients. We must try to assure that we are not talking over the head of the "rookie" and boring the seasoned mechanic.

Or we may be presenting material from an event that has occurred at another nuclear plant. We must assure that we make it relatable to possible occurrences at our plant facility, otherwise, employees will quickly turn off. While we try very hard, we still have a ways to go before we hit the mark and make the information presented understandable, applicable, and interesting.

## SENIOR MANAGEMENT

The second group of customers is senior management. I know some utilities have senior management who are very much bottom-line oriented. It is almost impossible to demonstrate to somebody that is against training, that a multi-million dollar training program is cost effective. Can we prove that a unit shutdown was averted because of the knowledge of people at the control board, or did they respond in a common-sense approach?

There is a different concern that our senior management has. A few years ago, we looked at the age and experience of our craft workers and the expectations we had of new employees. We knew some of the old timers with 15 years experience at changing reactor coolant pump seals would be retiring in the early 1990s. We had three choices in assuring that the replacement employees could do the same skilled job in the late 1990s: 1) develop prescriptive procedures with very little need for thought on the part of the worker (note I did not say craft worker), 2) rely on the old hands to train the new workers on the job, or 3) develop a systematic, formalized training program. We felt the first approach (procedures) would take as many resources as the last (training), and would demoralize the workers in the process. The second option was too hit or miss, and relied on the worker to be an effective communicator, which is not always the case.

While we are doing an excellent job in meeting the expectations of senior management to develop new employees in some areas (as a couple of examples, our Chemistry and I&C technicians have learned much from the training program); in other areas, more work is needed (our Storekeeper Program and our QC Inspector Program are taking a long time to finish, and our Responsible Engineer Program is not yet implemented).

Based on isolated events, senior management does have concerns about whether the training program is hitting the mark. While these events are obviously not attributable only to the training group, it is disconcerting when, during an outage, the operators' focus is on the shutdown unit. We had an event in which they did not recognize that some of the equipment they were deenergizing also affected the operating unit. Could training have precluded the event?

## OFFSITE AGENCIES

The third group of customers includes the offsite agencies such as INPO, insurance companies, and the NRC. There are obviously correct ways of accomplishing training. There are standard techniques that the instructor should use to effectively communicate with his/her students, appropriate content of the material presented, adequate documentation to assure that the material has been presented, and so forth. At times, some of these desires may be in conflict with other demands. At times, it would be nice to be able to react more quickly and informally to a perceived training need than the bureaucracy would allow. Very often, we also receive the comment that we are doing training because of INPO or the NRC. This occurs most frequently when the offsite organization points out a deficiency and we react to it; even though the deficiency may be real, and if we had known about it, we would have taken the same corrective action. However, our employees' perception is still that we are being motivated by those offsite groups, and that robs from the time available for training on what they want.

## PLANT MANAGEMENT

As part of plant management, I have been disappointed when some of the other customers express concern. A personal observation that upsets me is when training is perceived as not part of the plant. We have spent a lot of time and effort to assure that training is functionally and physically part of the organization. To assure accountability, training people report to the plant manager rather than to some offsite group. We dedicated some prime real estate inside the protected area for training.

A while ago, I was talking to an employee in Training, and he said his career goal included becoming part of Operations so that he could "get back into the plant." I immediately corrected him and told him that he is part of the plant, his office is inside the protected area, and the Training group reports to me.

I am disappointed when the training group cannot establish a rapport with the students. At Point Beach we are making special efforts to do this, including having two senior reactor operators from Operations rotate through training. The amount of rapport seems to be related to the experience of the instructors. Obviously, the Training group has grown significantly over the last five years. We have maintained a blend of PBNP personnel and people from the "outside," including other areas of the company. These instructors are becoming established, and their credibility is improving to where I feel most of the problem is behind us.

It seems that the training programs within nuclear power plants are similar to the academic programs in our schools whereas there was very little emphasis on the thought process. Now with the industry's "discovery" of cognitive tasks, we are trying to address that need.

## CONCLUSION

Has the establishment of a training organization met my expectations? Are all the customers happy? We have made significant gains in our training program. But, as in any endeavor, we need to strive for improvement or we will stagnate and lose ground. Each class of customers shares its expectations through feedback (direct or indirect). Training evaluates the input and adjusts as it can, considering or modifying resources. We have the system to continually improve because each time another class for initial training or a new continuing training program is implemented, a new set of indicators (pass/fail, operating performance, etc) is generated. The customers check the indicators against their expectations and provide new feedback; then the cycle starts again. The challenge in front of Training is balancing expectations which are conflicting.

Where is Point Beach in the process now? The students need to feel their needs are being met more than today. We have made progress, but we need to make the material more relatable to their day-to-day work. Company senior management will continue to monitor whether our low forced outage rate continues or we have to replace reactor coolant pump seals immediately after an outage. I feel that although we do not have a perfect system, our regulators and evaluators are pleased with the significant strides we have taken. We are able now, as an industry, to put the NRC on hold on some initiatives because we have a program in place.

MANAGING TRAINING AT AT&T: ONE ORGANIZATION'S PERSPECTIVE

By Gail S. Solomon

AT&T employees numbered close to 305,000 at the end of 1988. Their training needs are as diverse as their jobs. Technical, financial, secretarial, financial, computer, and management are just some of the areas of training required.

At AT&T, this training is provided through 33 separate training organizations that employ a work force of about 3,200. Network Operations Education and Training (NOET) is the second largest of these.

NOET is the education and training arm of the Network Operations Group (NOG). This is the group within AT&T that is responsible for maintaining the AT&T Long Distance network, as well as premises products and services.

Development and delivery are split into two separate divisions, each of which reports directly into the Director. The development division is also responsible for professional development and education. Support functions for the Director and the Divisions are performed by the planning and management systems district, which reports into the Director as well.

Training for network operations and services was combined with training for customer-based premises products and services under NOET's auspices in late 1987. They merged into a single organization with a shared culture and commitments.

Statement of purpose

NOET's mission, as stated in its business plan, is:

> "To be a key partner in the evolution of NOG by designing, developing and delivering the training, education and other performance improvement aids which meet the needs of NOG employees, and embed NOG strategies and directions into all training programs."

This mission statement defines the key role NOET plays in its organization.

First, NOET is a vehicle for communicating corporate strategies to its customers. NOET is uniquely positioned in NOG to both understand the strategies and direction of the corporation and transmit it quickly to the broad body of NOG employees. The education organization helps make sure that all NOG employees hear, understand and enroll in NOG's key initiatives.

Second, NOET is the educational interface for whatever type of training NOG needs. NOET is NOG's educational representative. It does whatever is necessary, be it teaching a course, designing a course, or providing some other form of education that is not, strictly speaking, a course at all.

Quality

But broadly speaking, NOET is more than just a training organization. It is first and foremost a customer service organization. Customers can be co-workers at AT&T or end users of our products and services. Expectations are our customers needs and wants.

NOET views its success in terms of its ability to meet its customers' needs. To that end, NOET has been spearheading the implementation of Quality Improvement Process, a set of principles, policies, support structures, and practices designed to continually improve the efficiency and effectiveness of our work and our work life.

The core of the Quality Improvement Process is the interrelationship between customers and suppliers. Everyone is both customer and supplier, depending on the circumstance. NOET tries to see things as its customers do and measures its success by the extent to which it meets its customers' needs. The organization defines quality as "meeting customer expectations" and designs a quality message into all courses.

Customer initiative

All AT&T technicians must understand the importance of the customer interface and the power over AT&T's future that is placed in their hands every day. The company is going to succeed or fail because of them.

Recognizing the importance of successful customer/employee interactions, NOET is building a customer interface segment into all of its courses.

Think of these interactions as "moments of truth" for the company. A moment of truth is any interaction during which the customer has an opportunity to form an impression of AT&T. AT&T has hundreds of thousands of moments of truth every day, and one unfortunate incident outweighs thousands of good ones.

Supporting role

AT&T is in the Information Movement and Management business. All of its training programs exist to support that business.

This means that one of NOET's key roles is to understand AT&T's business strategies and communicate the strategies in the courses that it develops and delivers.

The first leg of AT&T's strategy is to protect and maintain the Core Business. Core businesses are those businesses on which the company was founded. They include providing domestic and international long distance services; manufacturing and selling telecommunications network equipment; and manufacturing and selling certain customer-premises telecommunications equipment, such as PBXs, key systems and telephone sets. Most of NOET's courses relate to AT&T's Core Business, so most of NOET's personnel are supporting the Core Business.

Data Networking is the second strategy. Data networking means giving customers integrated systems of equipment and services that get them the right information when they need it, wherever they need it, in whatever form they need it.

In designing those systems, the key word is connectivity. Businesses today have a substantial investment in both communications and data processing equipment. AT&T is working to protect that investment by designing systems that connect with equipment from other suppliers as well as its own -- systems that link all the information sources a modern company needs.

AT&T designs data networking solutions to individual customer needs. NOET develops the courseware for training the personnel who support these solutions.

The third strategy is globalization. Customers' information needs are becoming increasingly global as more and more firms find it necessary and profitable to enter markets outside their home countries. Likewise, competition in the information movement and management market is becoming increasingly global as the industry attempts to meet their customers' needs and also to maintain the scale of operation necessary to compete effectively in a rapidly changing environment. NOET has done some things in this arena but is s[illegible]l playing only a bit part. For example, NOET designed training for Olivetti, which [illegible]ells all of

AT&T's 3B computers and System 75s in Europe. Olivetti trains their own technician force in Italy and throughout Europe, but NOET shared its training with them.

In its first fifteen months in existence, NOET has fulfilled on a host of key commitments in support of its own business plan, including:

o Educational Consultant.--This job was created to provide clients with a full time consultant on their educational needs. It reflects NOET's commitment to be a customer-focused organization. Educational consultants (ECs) interface with every second level line manager to help them plan a training program for their organization. The EC interviews line managers about their training needs. The EC might lead off, for example, like this: Let's talk about your training needs. Let's understand the skill level of the force that you have today, the skill level that is necessary to do the jobs that you not only have today but that are going to be coming at you, the skill level of the new folks that you might be getting in, and what your force plans are, so that, together, we can build a training plan for your organization and a training program for each of your people."

The Educational Consultant's role is not to get people to sign up for NOET's courses. Rather, it is to act as an advisor to line managers to help them bring their work force skills up to the necessary levels. Training may not always be the answer, and NOET's own courses may not always be the answer. Rather than reinvent the wheel, NOET taps into existing courses offered through other AT&T training organizations to meet its training needs.

NOET's goal is to plan training one year ahead. Right now, too much of its training is planned only three months ahead. Planning ahead will enable NOET to forecast what courses are needed, what demands will be made on the organization, and how many instructors will have to be trained in what courses. In short, advance planning is the key to effective management of the organization's resources.

o Training Records Data Base.--NOET is the custodian of training records for NOG. An effort is currently underway to update the training records of all NOG employees to ensure an accurate training data base. This is critical in order to maximize the effectiveness of the Educational Consultant, who must be able to reference, on-line, the entire training profile for that district or second level group of first level group. By comparing the an individual's training record with the prescribed curriculum for his or her job function, the educational consultant is able to structure a customized training plan for every employee.

o Forecasting Training Demands.--Educational Consultants are helping to assess long term training needs, which helps NOET anticipate instructor needs and classroo utilization. Forecasts come in from both the consumer side as well as from the supplier side. For example, suppliers may advise NOET of a product introduction set for July '89 so that NOET can begin developing the requisite courses in support of that product.

o <u>Budget Process</u>.--NOET drives accountability for budget down to the lowest appropriate level. For most of NOET, that means the second level manager. Generally in NOET, second levels supervise anywhere from five to 15 people.

o <u>Meaningful Measurements</u>.--On the delivery side, student days is an important measure. NOET delivered 288,000 student days in 1988. That's the equivalent of putting 2,400 people though one year of college. Student days is a good measure of total demand for NOET training. It's also a good measure for the NOG line manager, because every student day is a day that they have to replace somebody in the office. Yet, student days is probably not a good measure for an individual instructor.

If one instructor teaches a course that averages only six students per session, and another teaches a course that averages 20 people, the first instructor would lose out in the comparison.

Other useful measures for delivery are classroom days -- the number of days a classroom is going to be in use, and key instructor days -- the number of days an instructor spends doing development work.

On the development side, we look at the fraction of time spent on course maintenance -- how much course maintenance is done per course.

o Customer Satisfaction Measures.--NOET uses telephone follow-ups on a sampling of students two months after they have completed a course. Students' bosses are also surveyed and are asked such questions as: "Would you send another one of your subordinates to this course? Why or why not?" "Was the course too long?" "Was the course too short?" If a boss thinks a course is too long and the subordinate thinks it is too short, that course is probably the right length. If the student says a course is too long, some adjustment is probably necessary.

o NOET People Plan.--Everyone in NOET, from the Director on down, must have a People Plan. This constitutes a commitment to both one's supervisor and to one's subordinates to provide communication, recognition, feedback and appraisals, affirmative action, professional development, planned staffing, and team building.

-- Communication. The Director opened two-way communications with the organization through skip level lunches, attendance at district meetings, national teleconferences, and the "Know-It News," a newsletter designed to keep NOET personnel informed about developments within the organization. He also has worked to create a network between NOET and other organizations within AT&T.

-- Recognition. Recognition figures in everyday life at NOET, from formal award presentations to casual comments of appreciation for a job well done. There are formal awards at the vice presidential, director and district levels.

-- Feedback and Appraisals. Every NOET employee receives written mid-year and annual Performance Appraisals. These are designed to provide feedback and guidance to employees so that they can develop to their fullest potential.

-- Affirmative Action. NOET is committed to continuing to foster equal opportunities for all. Employees are encouraged to attend two courses designed to sensitize them to discriminatory actions: "Race," and "Gender Issues in the Work Place."

-- Professional Development. The NOG Professional Development (NPD) Process was created to increase the technical and professional capabilities of NOG management employees. Working through four core sections or modules -- People, Quality, Customer Interface, and Technology -- managers develop and enhance their leadership skills through a variety of experiences that include but are not limited to formal courses, such as on-the-job activities, videotapes, lectures, etc. Additional modules address the special needs of particular job families through core curricula and enriching experiences.

-- Planned Staffing. Every NOET employee receives a written Career Plan agreed to by both themselves and their supervisor. The Career Plan recaps employees' job history, describes their training program, and defines a choice of career paths. Employees identify three five-year plans for themselves and, together with their supervisor, agree on reassignment dates.

The Career Plan is very important for the organization as well as the individual. It enables the organization to do its force planning on a more logical and orderly basis.

-- Team Building. Forging a close knit organization is the final element of the People Plan. Group meetings at all levels are encouraged as a way of creating a common culture and unified sense of purpose.

Future Directions: Employee and Labor Force Demographics

Affirmative action-related issues are likely to play an increasingly important role at AT&T, given the changing demographics of the employee body. The average age of an AT&T employee right now is 39. Within 10 years, 45 percent of present employees will be retirement eligible.

What's happening is that the "Baby Boom" generation is moving through the work force. Baby Boomers constitute the bulk of AT&T's work force today. This group will start to retire in 1995, but the replacements are not there in the same number.

In the mid-1970s, births dropped to about 2 million a year; about half of what they were 10 years earlier. Today's seventh grade class across the United States is the smallest it has been since the Depression. This carries tremendous implications for a company like AT&T and will have a big impact on the role of training in the future.

About 80 percent of the people entering AT&T employment in 1995 are expected to be women or minorities. Moreover, the background of many of these new employees is expected to differ from that of the majority of today's employees; many will come from backgrounds in which childhood education was not stressed.

The company must understand how to train people who have not necessarily been oriented towards education. This places a tremendous responsibility upon training at AT&T because training is going to have to meet the challenge of bringing these new employees up to speed. It also makes affirmative action a cornerstone of corporate success in the 1990s.

Training Shortfall

Last year, an AT&T study showed that traditional classroom instruction alone is incapable of meeting NOET's training needs. A serious training deficiency in NOG is expected to persist through 1990 despite aggressive training plans.

This "training gap" amounts to an estimated 847,000 training days. It represents the amount of training that would be necessary to:

o equip current employees with the skills needed for the 1990s

o bring new employees entering the organization up to speed on the skills required for the 1990s

o keep up with training demands created by new products and technologies.

This shortfall is spurring NOET's to increase the amount of training offered through advanced delivery techniques (ADT). ADT encompasses any form of delivery other than traditional, instructor-led training. It includes computer-based training (CBT), PC teletraining and videotapes.

These innovative techniques save both time and money. CBT is self-paced, so students can conveniently work it into their schedules. Learning time is greatly reduced. Moreover, by eliminating travel and lodging expenses, the cost of training is reduced.

Training is transitioning from the classroom into the workplace. That makes sense for it is in the workplace, after all, that the true test of learning occurs. Learning must carry over into the workplace if it is to be effective.

PERSPECTIVES ON TRAINING FROM AN EX-TRAINING MANAGER

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PAPER NOT RECEIVED AT TIME OF PUBLICATION

# TRAINING MANAGEMENT SYSTEMS - A COMPARISON

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## ABSTRACT

The rapid growth of training programs in the nuclear utility industry over the past five years has challenged training management personnel to meet our customer's needs for effective training delivered when needed. Simultaneously, nuclear utility executives are concerned that the training process be cost-effective. The result of these forces has been the establishment of two training management systems: (1) a decentralized training management system that reports to the site senior manager in order to stay close to customer needs; and (2) a centralized training management system that reports to a corporate training manager in order to be cost effective. This paper will compare the advantages and disadvantages of each training management system and will suggest methods for enhancing each system through the application of quality improvement principles.

## INTRODUCTION

The Sixth Symposium on Training of Nuclear Facility Personnel was one of the first functions in which I participated four years ago when I was selected as Florida Power & Light Company's Manager, Nuclear Training. One of my objectives at that symposium was to determine whether there was any compelling evidence favoring one type of training organization over another. I quickly determined that there were two basic organizations in use: 1) a decentralized training organization, wherein the training manager/superintendent reported directly to the plant manager, and (2) a centralized training organization, wherein the site training manager/superintendent reports to a corporate training manager.

The decentralized training organization could have a corporate training staff which supports the sites, although this staff is missing in many utilities, particularly utilities with a single nuclear site. Since Florida Power & Light Company (FPL) was committed to a decentralized organization in 1985, I felt a need 1) to better understand the advantages and disadvantages of each organization, and 2) to formulate plans to "engineer success" as a corporate staff training manager. My comments are a synthesis of my personal experience and frequent discussion with other training managers.

## QUALITY PROGRAM LESSONS LEARNED

In 1985, FPL was in the fourth year of a major Quality Improvement Program which was evolving toward a total quality system. Today, FPL has applied for the International Deming Award, sponsored by the Japanese Union of Scientists and Engineers (JUSE). FPL is the first company outside Japan to have advanced in quality processes to the level necessary to challenge for this award.

The Quality Improvement Program has helped me focus on some key elements that affect the success of a training organization. I would like to share four principles of quality management with you in the context of comparing the differences between centralized and decentralized training organizations.

### Four Principles of Quality Management

Customer Satisfaction. There are many customers of training: plant management, corporate executives, employees and regulators immediately come to mind. Each customer wants the training product to be "fit for use," using the terminology of Joseph M. Juran, a pioneer in the development of quality systems in Japan. In the simplest of terms, the customer wants the successful graduate of a training program to be capable of performing all assigned tasks to standard. In FPL's quality system, we strive to meet the customer's needs and reasonable expectations. From the trainer's perspective, the most important customer is plant management, since they have the line responsibility for operating and maintaining the plant using the graduates of our training programs. The decentralized organization favors establishing and maintaining this customer contact, since the training manager/superintendent reports to the plant manager. The customer valid requirements of nuclear training also include cost control and timeliness. The decentralized organization is clearly responsive to plant management's training needs; the cost control requirement is less effect. under a decentralized organization. There are several reasons why a decentralized organization is less likely to be cost effective. For example:

1. Plant management will generally keep a resource constrained training staff (training does not directly contribute to the generation of megawatts); consequently, all special or unanticipated training requires the training staff to work overtime, or defer other important work
2. There is less concern to optimize training delivery costs; classes may be conducted for small

groups of students to meet plant management's desires, when larger classes, held less often are more cost effective.

3. There is a tendency to customize training to meet plant management's desires, even though off-the-shelf training is available that will meet plant training requirements.*

4. There is greater resistance to change, such as the use of interactive learning systems in place of classroom instructors, or efforts to standardize training curriculum with other nuclear sites.

5. There is a resistance to sharing resources between nuclear sites, principally because of resource constraints, but also because of the high degree of site "ownership" in the local programs.

6. There is a tendency to "reinvent the wheel," rather than using the lessons learned at another site, again because of a desire for site ownership.

As you can see in the examples cited above, the decentralized organization fosters a closer customer relationship that results in requested training delivered in a timely manner, but can also cause training management

* Juran describes this costly phenomenon as striving for perfection instead of fitness for use.

to be tasked to provide more service with less resources and at a high cost.

Plan-Do-Check-Act. Plan-Do-Check-Act (PDCA) is an abbreviated description of the dynamic process of change focused on continued improvement. The Systems Approach to Training (SAT) is a process that models PDCA. If the SAT process is properly implemented and adequately supported, there should be no difference between a centralized or decentralized training organization. I believe there is more exposure to deviating from the SAT process in a decentralized organization. The site training department may be under pressure (with limited resources, as previously discussed) to deliver the product - trained personnel; this pressure may even manifest itself as a request to short change the trainees by reducing the scope of training without justification. The pressure may not be overt; the desire to satisfy the customer can override the sanctity of the process. The Nuclear Regulatory Commission has expressed a concern in this area; some utilities have been challenged to demonstrate the independence of the training department. A centralized training organization can better maintain the purity of the process because of independence from site management; the risk in a centralized organization is a bureaucracy that uses the process as an excuse to be inflexible and unresponsive to valid customer needs.

An essential element of PDCA and our SAT process is evaluation of training to ensure that the desired results are obtained. Both types of training organization should have the necessary skills to properly perform evaluation in a narrow sense (subject to possible resource constraints in a decentralized organization). I believe there is another dimension to evaluation that distinguishes the centralized from the decentralized training organization: the scope and focus of evaluation. A decentralized training organization tends to be tactical in scope and focus; i.e. the evaluation system focuses on the day-to-day delivery of training to meet the plant customer's stated need. The risk is that the decentralized training organization will not do any strategic planning, and thus will find unanticipated activities being imposed on the organization with the resulting crisis management response. The types of things a tactical focus will miss are changes in the expectations of the external customers (INPO, NRC, NUMARC, etc.), lessons learned from other sites or utilities, and even additional requirements (and sometimes resources!) within your own utility. A centralized organization should better maintain a strategic focus because of the independence from plant management.

In summary, the centralized training organization appears to have an advantage in process implementation and strategic focus, when compared to the decentralized organization.

Management by Fact. Management by fact complements PDCA because the emphasis is on collecting objective data in any activity then using data to set goals and make decisions. Data, once collected and presented in an appropriate indicator format, is communicated (published) to all affected groups so that a common framework for goal setting and decision making is established. I believe the centralized organization is better able to manage bv fact because the training manager is not in the chain of command of the plant manager. Delivering "bad news" to the boss is rarely a pleasant experience! Unfortunately, failure to collect and report data has caused problems for training organizations, most noticeably in the area of training program implementation. Managing by fact can help us set realistic goals and reduces our exposure to the errors caused by assumptions based on subjective opinions. Goal congruence between sites and within the training department is a definite benefit in the centralized organization. Unfortunately, I don't have facts to support my contention that the centralized training organization performs better in the collection and display of essential performance data.

<u>Respect for People.</u> Respect for people is a management attitude that fosters team work and individual accomplishment. We value the contribution of each member of the team and expect them to perform at their best. Mutual respect is a key element of this attitude. Strong ownership and pride are typically found in an organization that has respect for people. The training organization structure may not have much impact on this key principle, since the culture of the organization and its leadership determine whether there is respect for people.

### Summary of Organization Structure Comparison

The decentralized training organization is characterized by the following attributes:

- trainers are able to stay close to their customers in the plant due to physical location and a common chain of command;
- the training organization may be lean in staffing and budget due to competing for resources with plant departments;

- there may be more customizing of training to meet customer desires;
- there may be resistance to sharing due to resource constraints and pride of ownership;
- there may be resistance to change due to resource constraints and pride of ownership;
- the SAT process may not be rigorously implemented due to customer pressure to deliver "product";
- there may be less focus and contact with external customers;
- the trainers tend to have a tactical focus due to meeting the day-to-day customer requests; and
- goals are set to meet plant requirements.

The centralized training organization is characterized by the following attributes:

- trainers may be more remote from their customers in the plant due to physical separation and separate chain of command;
- the training organization may be better staffed and funded because training is not competing directly with plant departments for resources;
- there may be significant standardization of training courses;
- there may be innovation and strategic planning due to less focus on daily plant problems;

- the SAT process tends to be rigorously implemented, which may cause problems with inflexibility due to bureaucracy;
- there may be more involvement with external customers (NRC, INPO, NUMARC, etc.);
- there may be a high concern for cost effectiveness and efficiency; and
- goals are set to meet corporate and industry objectives, as well as meet plant requirements.

In summary, there are advantages and disadvantages with each organization model; therefore, we need to look at methods for ameliorating the negative aspects of each model, a process we call countermeasures at FPL.

## COUNTERMEASURES RECOMMENDED

I believe that either training organization model can be effective if there is a careful assessment of strengths and weaknesses inherent in each model, followed by implementation of countermeasures to balance the identified weaknesses. The following recommendations are again based on my personal experience and the experience of many of the training managers in attendance at this symposium.

### Decentralized Organization

Budget Constraints. The most important countermeasure for budget constraints is to develop, promote and implement a performance-based budget process. Some utilities have attempted to use zero-based budgeting for this activity, wherein each budget activity is quantified in terms of resources (people, facilities, money) and prioritized by the customer. Management then determines what resources are allocated, draws a line on the prioritized list of activities, and disallows all activities "below the line." The risk in this method is that some of our accredited training programs may be ranked too low by our plant customers and end up below the line! Therefore, we need to provide for a modified budget system that sensitizes management to the resources required to deliver our product, trained employees, while also protecting training commitments so that they do not get cancelled. Another advantage of this type of system is that changes (new or revised activities) during the year are also quantified and prioritized so that management can decide whether to defer/cancel lower priority activities, increase resource allocations, or cancel the proposed revision.

<u>Staffing Models.</u> A recurring problem associated with budget justification is properly defining staffing needs. A staffing model should be developed that includes these critical elements as a minimum:

- manhours required to deliver each training course offered at the nuclear training center, including time for class preparation, classroom delivery, student remediation/counselling, test preparation and grading, and record keeping;

- manhours to perform generic administrative functions that are not directly linked to a training course, such as performance evaluation preparation/review, equipment maintenance, or staff meetings; and
- manhours for training staff qualification, including continuing training.

The model should be keyed to student throughput, so that a customer request to train more employees will generate a training request for additional or reallocated resources.

C4. Process Procedures. The requirements necessary to fully implement the Systems Approach to Training should be documented procedurally and approved by the highest level of nuclear management. An NRC Post-Accreditation audit that identified a poorly implemented SAT process would be an embarrassment to our industry and could lead to new pressure for regulation.

Independent Review. The emphasis by senior management on proper SAT process implementation can be reinforced if senior management also endorses periodic independent review. An assessment or audit can be performed by the

Quality Assurance Department, corporate training staff personnel, other utilities (mutual support), or even outside contractors.

Innovation and Strategic Planning. Normally, staff personnel interact with outside customers and suppliers to identify emerging issues and technology, then develop project plans or issue management strategies. This function may also include the accountability for training efficiency and cost control, resolution of chronic training deficiencies, goal setting with external customers and standardization efforts. If a corporate training staff is not available to perform this function, there should be resources identified on the site training staff to be accountable for this function. These personnel may be assisted by site licensing personnel. This person or group thus counterbalances the tendency toward tactical thinking on the training staff and can assure that the training organization is responsive to change in our industry.

## Centralized Organization

Training Review Group. Plant customer contact can be managed successfully through the use of a training review group structure. Peer levels in the organization (plant and staff training) should meet on a periodic basis to discuss customer needs and to assess training department performance. Periodic meetings between the training manager and the plant manager, with attendance by plant and training department managers, is strongly encouraged. Customer surveys are also recommended since they provide an informal, anonymous input to the training department.

Site Presence. Training personnel need to be visible on site both to maintain customer contact and to verify plant conditions (configuration management). Staff training development specialists should also visit the site regularly to visit with supervisors and subject matter experts. A formal method for documenting these visits and the problems uncovered should also be required so that plant customer concerns or complaints receive followup.

Independent Review. Independent review for a centralized training organization should be expanded to include periodic plant customer review of the corporate staff. The plant customer expectations of training should be captured so that the training department performance can be assessed by senior management. Bureaucracy and customer insensitivity are the targets. The independent review functions discussed under the decentralized organization are also necessary for the centralized organization.

## CONCLUSION

I stated initially that I was given a decentralized training organization structure, a structure that remains today. We at FPL believe we have a successful training organization; our Quality Improvement Program has been a critical aide in helping us identify barriers to success and then create and implement proper countermeasures. Most of the countermeasures identified by me today have been implemented at FPL and were successful in helping improve training performance. We are continuing to improve, with current projects evaluating interactive learning systems, training effectiveness models and communications interaction models. I was advised early in my term as corporate training manager that dynamic staff organizations thrive and survive, while static staff organizations die! I am confident that new opportunities for innovation and improvement will continue to arise and thus help me keep my organization dynamic.

Thank you for the opportunity to share these thoughts.

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## MANAGING THE TRAINING FUNCTION

Neal A. Wiggin

ABSTRACT

A great many developments over the last five years have made the management of training more and more complex. As we have begun to serve a larger clientele, we have also upgraded our training staffs and facilities; in addition, many training departments are now providing laboratory, simulator, and structured OJT, whereas before the advent of accreditation, we were providing very little training in some of these settings. The improved staff, facilities, and delivery have led to more requests for training on tasks for which there are no existing programs, requiring the training manager to evaluate priorities and resources, and to re-allocate manpower and other resources for needs not planned for at budget time.

We need to have a means of responding to current needs, a means of getting cooperation from supervisors and managers in identifying in advance those training needs which can be anticipated, and a means of getting commitment from senior management to allocate the resources for development and delivery of the training, including the assignment of workers to the training once it is ready for delivery.

At Seabrook Station, New Hampshire Yankee has instituted the concept of a Training Advisory Council and Curriculum Advisory Committees. These two bodies (the former with fixed membership, and the latter with changing membership) are part of every phase of the Training System Development process. The Council is made up of senior management personnel, or their authorized designees, to review all training programs, including making recommendations about what is required and what is optional training. Both bodies have a charter. The Council membership is designated in corporate procedures and meets regularly to advise on training program and processes.

The Curriculum Advisory Committees are made up of representatives of the departments for which training is developed and implemented. These committees begin with the validation of the lists, the selection of items for training, the training settings (i.e., OJT, lab, classroom) and the initial approval of all phases of the development process. They review the design, the development, and the evaluative instruments on all the training programs. They recommend to the Council the acceptance of newly developed programs, and as necessary, the deletion or discontinuation of any program. These committees are the "nuts and bolts" level of the Training System Development process. Because they are made up of plant personnel, the process provides for the active involvement of the "customer" in determining training needs, directing the content, approving the objectives, and evaluating the effectiveness of the training. This requires a substantial commitment of manpower in any

given year, but having participated in the development proce ,. the receiving department now has a vested interest in making the program successful. Their involvement also helps to insure that they will commit the manhours necessary to attend the training as it is delivered. This paper describes how these committees were developed, how we got the commitment, and a description of one program as it passed through the process.

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## MANAGING THE TRAINING FUNCTION

### The Committee Development Process

The training of control room operators at Seabrook Station was the first curriculum to be involved in the Curriculum Advisory Committee process. It was a natural development growing out of the need to plan for the hiring, training, and integration into the workplace of new graduates. As early as 1979, the first Operations Training Programs began. The trainees were those who nc ··· ·m the management group of the Operations Department. During that period, the Nuclear Reactor Fundamentals course was provided on site by a vendor. During that period also, the simulator was being built offsite by a vendor. The trainees were experienced reactor operators from other plants, training to be licensed on our reactors. These nuclear "veteran·" constituted a highly critical cadre of professionals to give feedback about what is necessary and what is superfluous in the training materials and delivery. They wanted, and they got, useful, purposeful training. To whatever extent they wanted, they were involved in contributing to the content and the structure of the training process. They d ·ermined when the next group of trainees would be needed; then they gave their input on how long the training period should be, what the major components were, and what policies and procedures would govern the training process. They had a "piece of the action" from very early on in the process. During and after each training program, they provided feedback to the process. Program changes were made to reflect t. ··r comments. This was <u>not</u> a case of ceding the management of the training process to the client; it was a matter of involving the "customer" in the design and delivery of the service. It was, and is, a process for quality improvement, very much like what we know as Quality Circles. This involvement extended to i... ·e Operations management in the counseling and decision making involving individual trainees.

## Performance Review Board

It became evident that a formal process needed to be developed for the situation in which a trainee is showing performance problems. We formed a joint committee of Training and Operations personnel. This committee helped develop the procedures governing performance reviews and the steps in the process. Since unsatisfactory performance in the training program is both a training problem and a management problem, it needed to involve representatives of both groups. This joint participation was a natural outgrowth of the already ongoing process which involved Operations management in the entire training process. What in fact occurred was a broadening of the governance of the training system development process, extending through all five phases. All of this occurred before we became actively involved in the accreditation process.

## Technical Training

Technical training programs did not undergo the same process. Although there was a planned annual review of training in those areas as well, the managers of the technical training areas had not themselves gone through the training program that their employees were attending. In those areas a much more standard approach was used: Training was developed from vendor manuals, from the experience and training of the technical instructors, and from courses which instructors attended at vendor facilities or provided by vendors on site. In chemistry, for instance, the first chemistry department supervisor asked for and received college courses in radiochemistry, quantitative and qualitative analysis, and laboratory practices. Maintenance supervisors were experienced mechanics and electricians and had no need themselves for basic courses in pumps, valves and motors. But they gave advice to develop courses in basic mechanical maintenance that could be given to inexperienced employees. Then they found that they needed to hire experienced employees, because they needed people who could start immediately, developing the hundreds of procedures that would be needed.

We put the first technicians through a broad array of basic courses, to give them a well rounded background; then we found we needed to be more efficient in the training process: we needed to focus on some in-depth training on the areas in which these employees would be spending the most of their time; they would not all be HVAC mechanics or welders, or anything else for that matter. Management identified certain numbers of people that they would require trained in each discipline. We then provided the existing courses and created some others in the needed disciplines. Over a hundred special courses have appeared in the Training Manual. Some are one hour long and some are weeks long. Beyond some initial guidance, plant supervision had very little involvement. As a result, some courses were much more in-depth than they wanted or needed; some were very sparsely attended, indicating a lack of commitment on their part to the training. Then we adopted the Curriculum Advisory Committee process.

## The Evolution of a Process

Our Instrumentation and Control training program consisted of the following basic elements: G.E.T. and Radworker Training; Review of Mathematics; Logics, Prints, and Diagrams; Nuclear Power Plant Fundamentals; AC/DC Electronics; Semiconductor and Digital Electronics; and Process Instrumentation and Control. This we considered the initial training. There is additional training on specific systems, such as NIS; Digital Rod Position Indication; Westinghouse 7300 Process System and the like. We also have courses in Analytic Troubleshooting, soldering and circuit board repair, wire wrapping, and so on.

Then we began our correlation of the I&C task lists to the existing courses, using a table top session with job incumbents; we found that nearly three quarters of the tasks on the list were not taught in any existing courses, though the knowledge factors were covered. A large number were designated for OJT; others required further analysis. Time for the Curriculum Advisory Committee!

One of the systems which was identified as needing training was the Security System. Training personnel made the first attempt at designing the training program to address all the tasks on the task list that related to this system. It looked like it would have to be a five week course. We brought in the working foreman of the crew to have a look. He immediately reacted that there must be something wrong; it shouldn't take anywhere near that long! Our overview of the system involved as much as three days. He thought the whole program ought to be accomplished in about a week. Why were we so far apart?

A committee of three incumbents, including the working foreman, and two training instructors, took another look at the task list and found that many of the tasks are not actually performed by the trainees for whom this program was being developed. The technicians need to troubleshoot down to "the board level," leaving further diagnostics to others. With this change, it became apparent that the course objectives were much too broad and deep for the program under development. The Curriculum Advisory Committee analyzed every objective, asking one question: Does the trainee need to know how to do this? I sat in on this process and watched the department being served provide a very clear design for the service they needed. The working foreman told me that he is confident that his people will get good training, and they will get what they need to service that system. When I asked him what he thought of the process, he said he knows it is manpower intensive on the front end, but that it will be more than made up in the long run, because the training will be focused; it will address the tasks directly instead of hitting all around them.

When I asked what he would do if he found that there were shortcomings in the program after his people got back on the job, he said what I hoped he would say, "I'll pick up the phone and we will get back to the table." The I&C Department will continue to use the Curriculum Advisory Committee process, I have no doubt. First, they now have ownership of the program; they have an interest in making it succeed. Second, the technicians have a training course which gets directly at the tasks they have to perform without a lot of superfluous lecturing. Thirdly, the Training Department knows that real commitment to good training programs is a result of this broadening of the governance of the program. After all, plant management is responsible for insuring that the people they send to do a task are qualified to perform it. It should be obvious that they are the ones who should be telling us what a person needs to know and be able to do in order to be qualified; this is not the sole prerogative of the training department.

We have Curriculum Advisory Committee meetings for one program or another almost every week. The membership changes, depending upon the particular program being developed or evaluated; but the process is the same. We commit the proceedings to the record, and we use the information to write our annual program evaluations and the program descriptions for the new year. One important result is a much better working relationship with the plant – a sense of teamwork. Better training is inevitable.

## Summary

The Curriculum Advisory Committee process is nothing more than a device for insuring that those who need training services have a voice in analyzing their own needs, a review and approval process in the design and development stage, a personal commitment to assign the resources in the implementation stage, and the knowledge that they have a means for getting a program modified, when it falls short in any respect.

There are some other benefits. As a Training Manager, I have seen how relations between departments can become strained, and how easy it is to find yourself defending an extensive, indeed, expensive program that the client neither wants nor appreciates. Managing the training function can be a lonely process, leading to the US/THEM status. It is not only a whole lot easier to involve the receiving department, it is also a sharing of the responsibility, the commitment, and the satisfaction of a job well done.

# TRAINING MANAGEMENT - LESSONS LEARNED

S. L. Newton

## ABSTRACT

There has been a tremendous emphasis, rightfully so, on the incorporation of lessons learned into our training programs for operators, technicians, and maintenance personnel. This paper will provide an opportunity to apply the lessons learned regarding training management based on observations of training organizations at over 40 plants. It will address those traits most commonly exhibited by strong training management and will provide examples of the practical application of those traits. The focus of the paper will be on the training manager and the actions he or she can take to lead an effective training organization. The premise will be developed that, in fact, the effective training manager must be more leader than manager.

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In the last ten years there have been many changes in the nuclear industry, but perhaps none so great as in the area of training for nuclear plant personnel. The ramifications of providing training that is less than excellent [illegible]e it imperative that one be as effective and efficient as possible in the management of this vital function. Significant resources in terms of personnel and money are invested in training. One way to help ensure that training organizations meet their responsibilities in this regard is to apply some of the same criteria to managing the training function that are applied to the training programs conducted for operators, technicians, and maintenance personnel. There has been a strong emphasis on the incorporation of lessons learned into these programs, and it is equally important to apply lessons learned regarding training management as many of these organizations mature into their second decade of operation. In my almost four years at INPO, I've been fortunate to be able to visit approximately 40 plants, attend numerous training-related meetings, and participate in a few accreditation boards. This exposure to training organizations and to numerous individuals involved with training has offered me the opportunity to observe experts in action. I also have had the advantage of having the perspective of a former training manager, and since I, like everyone else, am blessed with 20-20 hindsight, I have been able to see how I would have done some things differently. While the stronger training organizations exhibit similar characteristics, the most common one is that they have an effective manager. The purpose of this presentation will be to identify some of the things that effective training managers do well, how they do them, and those personal characteristics necessary to be an effective training manager.

To establish a frame of reference, when I use the term training manager, I am referring to the individual who heads the site training organization. His areas of responsibility include operator, maintenance, and technician training. Also, I am assuming that this training manager has a staff of three or four direct reports, each of whom may have an additional line of supervision between them and the instructor.

There have been many books written on management principles, and I think that there are no new or unique managerial concepts involved in managing today's training organization. However, that does not mean that I endorse the concept of a universal manager, one who is formally educated in the techniques of modern management and therefore capable of running any job without having to know much about the work to be managed. It is just that the principles involved in managing training have not changed appreciably in recent years, even though the job has grown more complex with the advent of accreditation and the existence of site-specific simulators.

I recently found a book in our library by Otto and Glasser[1], dealing with the management of training, that was written in 1970. While a lot of the information in the book deals with subject matter typically used in our instructor training courses, and sections regarding media and training equipment are somewhat dated, the first chapter is very pertinent. For example, it contains a list of the major responsibilities of the training manager of any organization that includes the following applicable tasks:

- Maintains a continuous audit of organization's training needs.
- Develops training philosophy, policy, and procedures in writing.
- Prepares objectives for department's work and communicates them to his staff.
- Prepares department's budget and periodically evaluates value received from budget expenditures.
- Develops and applies administrative controls to the work of the training department.
- Researches learning theory for applications to organization's teaching/learning problems.
- Supervises the work of the training staff.
- Plans developmental activities for his staff and periodically appraises their professional growth.
- Arranges for training materials, equipment, and facilities.
- Supervises and assists in the production of audiovisual materials for training.
- Edits all written materials produced by the training department.
- Analyzes and refines the organization's systems.
- Develops and applies methods for checking the effectiveness of all training programs.

From this detailed list the authors more broadly characterize the training manager as being a:

- learning specialist

- o system analyst
- o communications expert
- o consultant to his organization
- o administrator
- o teacher
- o planner

Although INPO has guidelines addressing the conduct of activities such as operations, maintenance, technical support, and radiation protection, it currently has no equivalent document for training per se. However, a review of Principles of Training System Development, INPO 85-006, and The Accreditation of Training in the Nuclear Power Industry, INPO 85-002, reveals a strong similarity to the above lists if one ascribes the requirements in these two documents to be the responsibility of the training manager. Additional criteria for the management of training are now contained in Maintaining the Accreditation of Training in the Nuclear Power Industry, INPO 88-001, which has included line management responsibilities regarding training.

How does the training manager most effectively perform these responsibilities? What can he do to make a positive difference? During INPO's Senior Nuclear Plant Management Course, the attendees are exposed to numerous speakers, each of whom touts the importance of his topic, be it operations, chemistry, quality assurance, or whatever. Each speaker also stresses that it is of utmost importance that the plant manager devote some personal time to that particular subject on a routine basis; until one can only wonder whether there are enough hours in the day. Their message is that personal involvement is the key. My message is the same. The training manager must be personally involved in the detailed daily activities as well as the big-picture, long-term projects of his organization. How much involvement and where it should be focused depend upon several variables, not the least of which are the capabilities of his direct reports. But there must be some involvement; the laissez-faire approach does not work! In my opinion, the weakest training organization that I have observed was one where the training manager said he spent his time on other company projects and did not get involved in his department's affairs unless his section heads had a problem they could not solve. For the most part his section heads were capable, but they were not receiving any direction, nor were they held accountable. Furthermore, experience suggests that there are some very important areas where personal attention is applied by the more effective training managers that are independent of variables such as subordinate capabilities.

Two areas go hand-in-hand. They are the selection, training, and qualification of the subordinate supervisors and instructional staff and the conduct of training. It is frankly appalling how little time some training managers spend on these two vital areas. They are the most important aspect of the job! How well training is conducted is the proverbial "bottom line," or to use another cliche, "where the rubber meets the road." Most, if not all, training managers are involved in the selection process for new instructors, but the involvement needs to be more than an approval signature on the personnel requisition form. It should normally include an interview and, if a trial presentation is involved, participation in it. And it should not stop there. While a few good instructors appear to be "born" to the task, most are "made." Participation by the training manager in the instructor training course pays dividends. New training managers and their subordinate supervisors, especially those with a limited training background, should attend the course as students. Training managers should also serve as instructors in the course and should participate as observers to critique practice presentations. This involvement provides the manager with a first-hand knowledge of what his people are being taught, allows him to insert his standards into the course, and sends a message to his staff regarding the importance that he attaches to the course. Lastly, the training manager should conduct the final interview with the instructor prior to qualification to reinforce the overall process.

The training of subordinate supervisors is equally important. Just as a top operator or mechanic does not automatically make a good foreman or a good instructor, a good instructor does not automatically become a good supervisor. In addition to traditional supervisory skills training, the manager can enhance his subordinates' development by ensuring that they participate in most of the same types of activities regarding involvement that I am advocating for the training manager.

Now, having ensured that he has a well-trained staff, the effective training manager must still spend time in the classroom, laboratory, and simulator observing training and evaluating and coaching his staff. An article by T. Gilbert and M. Gilbert[2] in Training magazine last year dealt with the value of observation as a means of "winning." Because they noted a preference for managers to hear sports analogies, the authors used the late Bear Bryant as their subject. They observed him in action and compared their observations with what he said in interviews regarding the secrets of his success. They found that his success was based on thorough observation of his players and coaches, both from his tower on the practice field and through extensive use of cameras. He acknowledged as much, saying, "We have to observe them, inform them, and train them. And you can't do this sloppily. The winning coach is the one who does these things extremely well." When the authors asked him about the values of motivation, inspiration, love, and caring that he frequently espoused in media interviews, the Bear replied, "Aw, people like to hear that stuff; .... winning inspires my players."

How often should these observations and evaluations be conducted? At a presentation given during a Westinghouse Institute Day a few years ago, I heard Neal Wiggin say that it should be often enough that the manager's presence in the classroom is taken for granted. For him, this translated to observing each instructor weekly, even if only for five or ten minutes to evaluate one specific item. For me, with a staff of about 50 instructors, this translated to once a year for an hour or two. Even though I was only there once, other supervisors were involved in the program such that each instructor was formally observed at least eight times a year. The purpose was to make certain that the managerial staff was aware of what was happening in their courses, more than a necessity to evaluate instructors that frequently due to performance problems. I used to think that my own annual requirement was a heavy load, but it really equated to about only an hour a week; so that even if one has a hundred instructors, he's only talking about two hours a week. What else is there that one does as a training manager that is so important that he cannot spare an hour or two a week to watch training? Think about it! Using two hours a week as a yardstick, most of us would probably agree that that should be a minimum for our counterparts in the plant to spend watching their people work. The observations of training should include occasionally watching an examination being administered. The training manager should find out for himself how well his plant's policy or procedure on examination security is being followed. Being involved in a cheating issue is a very painful experience for all concerned. While observing, evaluate and provide feedback, personally. Any supervisor's presence or involvement should add value to the activity.

Another facet of involvement with the conduct of training is the review and approval of training material. The depth of involvement on the part of the training manager should be based on the value added by his review. Review of every individual lesson plan can be terribly time-consuming, to the point that the manager can become a bottleneck for the instructors, or a "rubber stamp" approval where no value is added by his review. Also, if it is required that the training manager approve one group's lesson plans, it is hard to justify not approving each group's, and it is a rare training manager that has a background broad enough to add value to each lesson review. In most cases, it seems that the manager's time is better spent in the classroom observing. If he is there frequently, review of the associated lesson plan for the session he is observing should provide an adequate spot-check of this aspect.

There are two other areas where effective training managers allocate their time. The first is in fostering good relationships with the plant line organizations, especially if the training manager does not report to the plant manager. As a starter, the training manager should attend the plant manager's staff meetings, always being alert to situations where the training department might provide assistance, be it in the form of training or manpower. He should also spend time in the plant, perhaps as a participant in activities during an outage or as a monitor in a periodic tour program that some plants employ. Tours provide a good opportunity to observe on-the-job training and to talk to the workers on their own turf, where one will hear some things that he might not otherwise hear in the training center. As with some other activities, the impression or image that is created with the plant staff may be as valuable as the specific information gathered. Furthermore, building these relationships helps to establish an environment where the line managers get productively involved in their people's training programs.

Effective training managers are also personally involved in relationships with external organizations such as regional training groups, other training organizations and associations, and INPO. In grading my own performance as a training manager, this was probably my weakest area. Since coming to INPO, I have learned that most training problems are not unique, but many solutions are, and that there are a lot of very competent and capable people out there who are more than willing to share their information or expertise. The effective training manager works with his regional training group to make it meaningful, attends meetings such as this one, and learns what INPO can do for him. A training manager is cheating himself and his organization if he does not periodically participate on accreditation teams to stay abreast of the latest issues.

Thus far I have discussed some of the responsibilities of the training manager and some specific examples of areas where effective training managers concentrate their efforts. I am sure that I am preaching to the choir when I say that he has a full load. So, it might be instructive to reflect on some personal characteristics that training managers should possess. Otto and Glasser[1] describe the following traits for training managers of any organization:

- ability to speak articulately
- ability to write correctly and conveniently
- ability to organize the work of others
- capacity for frustration
- willingness to submerge his own ego
- inventiveness
- persistence
- strong interest in the growth of individuals and organizations
- ability to inspire others to greater achievement
- flexibility

Quite a list! Perhaps I have been using the wrong word to describe the individual. Is he a manager, or should he be more than that? Webster's defines the word "manage" to mean:

- handle or direct with a degree of skill
- alter by manipulation
- succeed in accomplishing

That is not particularly instructive. Roget's Thesaurus characterizes it a little differently. It says to manage is to:

- o progress or perform adequately, especially in difficult circumstances
- o have charge of the affairs of others
- o control the course of an activity

Perhaps more telling are some of the synonyms used for manage: do, fare, get along, get by, make out, shift, stagger, or my favorite, muddle through.

Without boring anyone to tears with more definitions, I submit that what is needed is not a muddler, but a leader. Keeping in mind the personal traits required by the head of the training organization that are listed above, compare them with what several others have said are personality traits or skills ascribed to effective leaders. In an article in a Performance and Instruction journal, Wagner[3] summarized the results of two other works:

> Bothwell (1983) suggested that 1,400 discrete personality traits have been identified which are positively correlated with effective leadership. Included among the top 11 of these traits were:
>
> - o intelligence
> - o getting along with others
> - o technical competence
> - o motivation of self and others
> - o emotional stability
> - o self-control
> - o planning and organizational skills
> - o a strong desire to achieve task
> - o ability to make use of group process
> - o ability to be effective and efficient
> - o ability to be decisive

Hickman and Silva (1984) described six skills needed by a leader to attain excellence, including the abilities to:

- o set goals and to establish policies and procedures
- o organize, motivate, and control people
- o analyze situations and formulate strategies and operating plans
- o respond to change through the development of new strategies and reorganization
- o implement change by issuing new policies and procedures

Interestingly enough, even the term "leader" may fall somewhat short if one follows definitions strictly. In their work that I have quoted previously, Otto and Glasser[1] referred to the individual as a director, so I researched that term and found to my surprise that Roget's combines all the definitions that it had listed for both "manage" and "lead" under the term "direct." But, I will settle for leader, because in the effective conduct of the training organization's business, the people involved are the ultimate factor in determining success, and, to quote from a message originally published in The Wall Street Journal titled, "Let's Get Rid of Management" and reproduced by Wagner[3]:

> People don't want to be managed.
> They want to be led.
> Whoever heard of a world manager?
> World leader, yes.
> Educational leader.
> Political leader.
> Scout leader.
> Community leader.
> Business leader.

They lead -- they don't manage.

The carrot always wins over the stick.

Ask your horse.

You can lead your horse to water,
but you can't manage him to drink.

If you want to manage somebody,
manage yourself.

Do that well and you will be ready to stop managing --
and start leading.

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## SIMULATION FACILITY EVALUATION PROGRAM

Neal K. Hunemuller

### ABSTRACT

As a result of Section 306 of the Nuclear Waste Policy Act of 1982, the NRC developed a requirement for nuclear power plants licensed by the NRC to have a simulation facility appropriate for conducting operator licensing tests. Such simulation facilities would be required to be available by March, 1991. These requirements are included in the revised 10 CFR 55 effective May 1987. Other guidance is located in Reg. Guide 1.149, NUREG-1258 and ANS 3.5, 1985.

The evaluation program requires that a plant-referenced simulator be certified to the NRC as meeting the guidance of ANS 3.5, 1985, or that a plan be submitted for a simulation facility using alternative methods to meet the requirements of conducting an operating test.

In the case of certifications to ANS 3.5, 1985 the NRC may review these certifications and, if necessary, conduct on site inspections of the simulation facility. Plans for simulation facilities which are not in accordance with ANS 3.5 must be approved by the NRC. Once a facility has a certified or approved simulation facility and an accredited requalification program based on a systems approach to training, they would no longer be required to submit details of an operator licensing applicant's training, experience and education.

## REQUIREMENTS AND GUIDANCE

The requirement to have a simulation facility is found in 10 CFR 55.45(b). This regulation states that the operating test will include two portions, a plant walkthrough and an evaluation utilizing a simulation facility. The simulation facility may be an "approved" simulation facility or a "certified" plant-referenced simulator.

Guidance for compliance with the above requirement may be found in Regulatory Guide 1.149, ANSI/ANS-3.5-1985, NUREG-1258, and NUREG-1262. Regulatory Guide 1.149 describes one method acceptable to the NRC for meeting 10 CFR 55.45. That method is to comply with ANSI/ANS-3.5-1985 subject to the conditions given in the Regulatory Guide. ANSI/ANS-3.5-1985, hereafter called the Standard, provides the minimum requirements for a plant-referenced simulator. These requirements will also be applicable to "approved" simulation facilities to a large extent. NUREG-1258 describes the NRC's procedure for the review of "certified" simulators. Like the Standard, this procedure will be applied to "approved" simulation facilities to the extent possible. NUREG-1262 presents questions and answers from public meetings regarding the implementation of 10 CFR 55. Questions 155 through 237 deal specifically with simulation facilities.

## OPTIONS

As stated above, the simulation facility may be "certified" or "approved." Certification means submittal of NRC Form 474 on which an authorized representative of the facility licensee attests that the requirements of 10 CFR 55.45 are met through the use of a plant-referenced simulator which meets the criteria of the Standard as endorsed by Regulatory Guide 1.149. Form 474 is due by March 26, 1991. It is worth noting that this Office of Management and Budget (OMB) approved form includes the following statements just above the signature block: "Any false statement or omission in this document, including attachments, may be subject to civil and criminal sanctions. I certify under penalty of perjury that the information in this document and attachments is true and correct." Approval means that, after the facility licensee submitted a plan by May 26, 1988, and subsequently submits an application by November 26, 1990, for use of the simulation facility in accordance with that plan, the Commission finds the simulation facility acceptable for use in the conduct of operating tests. This option is not available to those who did not submit a plan by May 26, 1988 unless they seek an exemption. Note that certification does not require NRC review or sanction prior to using the simulator for operating tests but approval does. After May 26, 1991, operating tests will only be conducted on a certified or an approved simulation facility.

## BENEFITS

The most tangible benefit of certifying or receiving approval of a simulation facility comes in conjunction with the facility licensee's response to Generic Letter 87-07. If the facility licensee has a certified or approved simulation facility and has submitted a letter, in compliance with Generic Letter 87-07, indicating that it has an INPO Accredited Training Program and that its requalification program is based upon a Systems Approach to Training, then those license candidates who have completed such a program may omit documenting the specifics of their training, education and experience on their applications. Less tangible but perhaps more important benefits are better training, a more realistic and discriminating examination process, and ultimately, improved operator performance.

## DESCRIPTION OF THE PROGRAM

The status of the industry as of January 30, 1989 with respect to simulation facilities is shown on Table 1. Table 2 shows only those plants which have submitted certifications, plans for application for approval, or Generic Letter 87-07 submittals as of January 30, 1989. At the time of this writing only Maine Yankee, Vogtle 1, 2 and Wolf Creek had met both requirements needed to omit documenting specifics of training, education and experience on license applications. Also, only one on-site review of a simulation facility had been conducted and that was at Maine Yankee.

Nearly all facility licensees have chosen the certification route. A number of facilities have already submitted certification packages. A review of these packages has indicated a need for additional guidance for certification submittals.

## Certification

First, NRC Form 474 itself should be discussed. On Form 474 the facility certifies three things:

1. It is using a simulation facility consisting solely of a plant-referenced simulator that meets the requirements of 10 CFR 55.45.

2. This simulation facility meets the guidance contained in ANSI/ANS-3.5-1985, as endorsed by NRC Regulatory Guide 1.149 (exceptions may be taken to this item).

3. Documentation is available for NRC review in accordance with 10 CFR 55.45(b).

Along with the Form, the facility needs to submit performance test abstracts and a description of performance testing completed and scheduled.

What is the NRC's role in reviewing these certification submittals?

As previously stated, these submittals do not require NRC review and they are not approved by the NRC. It is emphasized here that by signing Form 474 the licensee certifies and accepts the responsibility for regulatory compliance. Actual reviews will be conducted as determined appropriate by the NRC Staff based on licensee performance.

Where reviews and inspections appear appropriate the first phase would be the desk-top audit or "off-site phase." For this phase the review would most likely be conducted by the simulation facility evaluation program administrator at NRC headquarters including consultation with a license examiner cognizant with the particular facility. The intent of this review would be to identify any major problems related to the conduct of operating tests. This will be done by reviewing examiner supplied Simulation Facility Reports and subjecting Form 474 and attachments to review against 10 CFR 55.45, Regulatory Guide 1.149 and the Standard.

The NRC Regional Office may be notified if major problems are identified. When numerous or complex major problems have been identified NRC Headquarters with concurrence from the Regional Office may determine that an on-site inspection is warranted. Otherwise the NRC Regional Office may simply follow-up on the identified problems in future operating tests. If the identified concerns are reinforced in these future tests then it may be determined that an on-site inspection is needed.

If an on-site inspection is to be conducted additional team members will be identified. Additional team members could include an Operations Specialist, a Human Factors Specialist, and an independent industry peer advisor. The licensee will be contacted as necessary to arrange scheduling. This inspection will be conducted essentially as described in NUREG-1258.

The key factor in determining whether an on-site review is necessary is examiner feedback. That is not to say that negative examiner feedback will automatically result in adverse actions taken against the utility. It is simply that since the regulation only addresses the ability of the simulation facility to be used for the conduct of operating tests, the only pragmatic trigger for an on-site review must come from the personnel conducting those tests. Decertification or other adverse consequences related to the simulation facility evaluation can only result from the outcome of an on-site review done by a multi-disciplinary review team. However, as stated on Form 474, the discovery, at any time, of any false statement or omission in the certification submittal may be subject to civil and criminal sanctions.

The Maine Yankee review, as stated earlier, was the only on-site review conducted as of the writing of this report. This review was conducted during the week of August 29, 1988. The Maine Yankee review was not based on any particular problems identified at the facility but rather was performed more as a test of the certification process. Prior to arriving on-site the staff reviewed the materials which were submitted with Maine Yankee's certification, and evaluated information which Maine Yankee (MY) provided in response to staff questions raised as a result of their initial submission.

The review team consisted of a Team Leader, a License Examiner, a Human Factors Specialist, a Peer Advisor and Operations Specialist, and an NRC observer. The review was conducted in accordance with the guidance in NUREG-1258. Four major areas were reviewed:

A Performance Testing

B. Physical Fidelity

C. Control Capabilities

D. Configuration Management

The following describes the review of each area:

A. Performance Testing

Eleven performance tests were run on the simulation facility. As discussed in NUREG-1258, these tests were chosen to represent a balance of normal, abnormal, and emergency events in the conduct of an operator licensing examination. Tests were selected to be operationally oriented to the greatest extent possible. Abnormal and emergency events were chosen to reflect actual operating experience at the plant wherever possible.

Documented events which have occurred at similar plants, and events with broad industry implications were also used, as applicable. The tests conducted at MY consisted of the following categories and events. The note in parenthesis after a test, where shown, identifies the source for the test, or the reason why it was chosen.

1. Normal Operating Events

   a) Main turbine latching and roll-up to 1800 RPM, phasing generator, synchronization to the grid, and matching reactor power.

   b) Power change using direct boron addition.

2. Abnormal Events

   a) Dropped Control Element Assembly (CEA) (Maine Yankee Unusual Occurrence Report No. 29-88).

   b) Turbine Valve Control Malfunction (Maine Yankee LER No. 85-19).

   c) Heater Drain Pump Trip (Maine Yankee LER No. 88-001).

   d) Excess Flow Check Valve Closure (Maine Yankee LER No. 86-003).

   e) Reactor Coolant Pump Trip (Maine Yankee Start-Up Test Data)

   f) Loss of Control Air (Shearon Harris LER No 87-041).

3. Emergency Events

   a) Steam Generator Tube Rupture (North Anna LER No. 87-017).

   b) Loss of Off-Site Power with Natural Circulation (Maine Yankee LER No. 88-006).

   c) A test based on a natural circulation cooldown with upper head voids event was performed to evaluate the limitations of the simulation facility to fully model an event resulting in the formation of a head bubble. (St. Lucie, June 11, 1980 event resulting in multi-plant action MPA-B-66).

B. Physical Fidelity Evaluation

The segment of the inspection concerned with physical fidelity was performed in four parts: 1) a general human factors assessment of the simulation facility in accordance with the guidance given in ANSI/ANS 3.5, 1985 and in NUREG-1258; 2) a review and assessment of those differences between the plant and the simulation facility which had been identified by the facility licensee in its certification; 3) a review of a representative sample of simulation facility control board components to determine the degree of fidelity to the corresponding control room components; and 4) interviews with MY operators for the purpose of understanding how their concerns for physical and functional fidelity problems were dealt with by the facility licensee.

C. Control Capabilities

The capability of the simulation facility to freeze the simulation, and to alert the instructor when the simulation progresses outside the known modeling limits, was verified to function as required.

D. Configuration Management

This phase of the evaluation consisted of a review of the facility licensee's configuration management system, with a spot check of the status of specific items. In addition, items identified in examiners' simulation facility reports were verified to have been included in the system. Facility documents were reviewed to verify that changes in the plant, or discrepancies identified in the simulation facility, were assessed and dispositioned within the required time as specified in ANSI/ANS 3.5, 1985, as endorsed by Regulatory Guide 1.149.

Maine Yankee On-Site Review Summary

The Maine Yankee simulation facility was found to be acceptable for use in the conduct of operator licensing examinations, and to meet the requirements for certification set forth in 10 CFR 55.45(b) of the Commission's regulations. Justification for exceptions to ANSI/ANS 3.5, 1985 were found to be acceptable.

As a result of the physical fidelity review, one item was found discrepant. Additionally, this item was shown in the facility licensee's tracking system as a discrepancy that had been resolved and closed. As a result of this finding, the facility licensee has reopened this item in its configuration management system.

A change to the RCP heat-up rate had been in an open status in the facility licensee's configuration management system for a longer period of time than permitted by the Standard. It was determined that this open item had little or no impact on an examiner's ability to conduct a licensing examination. This item was therefore resolved.

As a result of performance testing, it was determined that the simulation facility was unable to model a reactor head steam void during natural circulation/low pressure conditions. This modeling limitation was determined to be neither a hindrance to the use of the applicable emergency operating procedures (EOPs), nor a constraint to the conduct of operator licensing examinations. Further, it was confirmed that there is a provision to alert the simulation facility operator/instructor when a testing or training scenario has progressed beyond the model limits of acceptability. Therefore, this item was resolved with no action by the facility licensee required. An analysis of the training value resulting from improving the simulation facility's ability to model this event, would be at the discretion of the facility licensee.

Regarding performance testing, the following information is provided as informal guidance resulting from the NRC's experience to date with the review of simulator certifications submitted under Part 55. This is provided for information only; it has no regulatory impact, and it is subject to change at any time based upon staff experience. It is meant to provide some helpful guidance to those facility licensees who are preparing to certify their plant-referenced simulators under Part 55, and who may have questions about the process.

- Before submitting an initial certification on NRC Form 474, complete (100%) performance testing in accordance with Section 5.4, "Simulator Testing," of ANSI/ANS 3.5, 1985 (the Standard) should be performed. This includes all tests that are required to meet the "Performance Criteria" of Section 4 of the Standard. This can be seen as equivalent to an Acceptance Test Procedure (ATP); and facility licensees may wish to utilize their ATP to satisfy this requirement. Please note that only submittal of the abstracts of performance tests are needed with Form 474 (see below). But the complete testing documentation should be available for NRC review.

- NRC Form 474 requires submittal of abstracts of performance tests. Submittal of the actual tests is not required. An abstract should be sufficient for an NRC reviewer to understand what was done, why and how it was done, what the results were, and what corrections are planned if there were problems with the test. A performance test abstract should include the following:

1. Date test conducted

2. Name and description of test (including relationship to Section 3.1.2, "Plant Malfunctions," of the Standard, if applicable).

3. Available Options (e.g., range of rates or severity of which the simulation facility is capable)

4. Tested options (e.g., what was actually tested for certification)

5. Initial conditions (for each option tested)

6. Final conditions/duration of test (for each option tested)

7. Description of baseline data used to determine fidelity to the reference plant.

8. Deficiencies found as a result of the test, corrective action planned and dates by which corrections will be made.

9. Exceptions taken to ANSI/ANS 3.5 as a result of the test, with justification.

If the baseline data used was the judgement of a panel of experts then documentation of their review, sufficient for a third party to evaluate the adequacy of the test(s) and results, should be included. This documentation may include such items as the makeup and qualifications of the panel and any differing professional opinions as to the outcome of the test(s).

- The annual performance testing regimen should begin with the date of the initial certification, and should culminate in a report to the NRC which is due every four years, on the anniversary date of the certification. There is no requirement for an annual report.

- Annual performance testing should include:

  - Appendix B, "Simulator Operability Tests," of the Standard, in full, every year.

  - The malfunctions shown in Section 3.1.2, "Plant Malfunctions," of the Standard, at a rate of approximately 25% per year, such that all of the malfunctions that were certified are tested in their entirety over the course of the four year cycle. The certification submittal should show which malfunction tests apply to each of the identified scenarios/events in Section 3.1.2.

  - Those tests identified in Appendix A, under "A3. Simulator Tests," of the Standard which are applicable to the simulation facility, and which are not duplicative of tests already identified in Appendix B or in Section 3.1.2 are to be done at the rate of approximately 25% per year. A breakdown of performance testing should be as close to 25% per year as possible. (Figure that 25% ± 5% is reasonable.) The facility licensee's judgement of the applicability of these tests should be made as part of the certification.

    For example, the following testing should be considered:

    a. Section A.3.1, "Computer Real Time Test"

b. Section A.3.2, "Steady State and Normal Operations Tests," to the extent that these tests do not duplicate those in Section B.1.1 (BWR) or B.2.1 (PWR), "Steady State Performance," and Section 5.4.2(2), "Simulator Operability Testing." Appendix B does not ask for testing simulator operation in accordance with plant procedures, whereas Appendix A (in Section A3.2(2)) does. Note that when testing simulator operation in accordance with plant procedures the NRC expects those procedures to be controlled copies. By this we mean up-to-date, unmarked copies of the same revision as actually being used in the control room. Allowances will be made for the fact that the Standard allows plant modifications to precede simulator modifications.

c. Section A.3.3, "Transient Tests," should be performed for transients which have occurred in the reference plant and for which data is available (Appendix B does not require such testing). The Standard, in Section 5, "Simulator Design Control," requires the incorporation of actual plant data within certain time limits. Performance testing of actual plant transients should comply with these requirements. For those transients which have not occurred in the reference plant and which are characterized by the Standard as "accidents or major occurrences," you need not repeat such testing if you have already addressed it in testing performed to satisfy Appendix B.

d. Section A.3.4, "Malfunction Tests." As the simulation facility may be capable of hundreds of malfunctions, not included in Section 3.1.2., "Plant

Malfunctions," prior to initial certification all certified malfunctions should be tested. It is not required to test them all as part of the annual performance testing. Rather, these tests should be performed in accordance with the schedule shown in Section 5.4, "Simulator Operability Testing," of the Standard.

Multiple Units

The question of multiple units is the last to be addressed with respect to certification. Regulatory Guide 1.149 discusses this issue and makes provision for a facility licensee to use a simulation facility for more than one plant. The guidance documentation for certification of multiple units is actually the same as for single units. That is, the facility licensee should include an analysis and summary of the differences between the simulation facility and each of the units for which it will be certified. Generally speaking, if a facility licensee meets the requirements for the operators to hold multiple licenses on the applicable units, then certification of one simulation facility for those units is anticipated to be acceptable.

## Approval

Application for approval of a simulation facility which does not meet the guidance of the Standard is the final aspect of the simulation facility evaluation program to be discussed. As of May 26, 1988, the cutoff date for this option, five (5) facility licensees submitted plans for application for approval. Since that time one plant has decided to shut down permanently and another has decided to purchase a plant-referenced simulator. The NRC continues to work with the remaining three (3) plants. The NRC reviewed the plans for all five applicants and sent letters of response providing additional guidance. Some guidance was previously provided in NUREG-1262, specifically, in response to questions 176, 177 and 178. In short, guidance for approval is similar to that for certification. A significant degree of fidelity is expected. Use of plant procedures is required. Finally, the evaluation and acceptance criteria are similar to those in ANSI/ANS-3.5-1985.

SUMMARY AND CONCLUSIONS

The Simulation Facility Evaluation Program is the NRC's program for the implementation of 10 CFR 55.45(b). Simulation facilities may be either certified by the facility licensee to meet the guidance of ANSI/ANS-3.5-1985 or approved by the NRC. For certification, while NRC review is not required, the Staff intend. o perform a desk-top audits of selected submittals to identify major problems and to conduct on-site inspections when required based either on major problems identified in the desk top review or on fidelity problems identified in examiner feedback. Regarding approval of approaches different from ANSI/ANS-3.5-1985, the NRC continues to work on a case-by-case basis with those ..w utilities which submitted plans in accordance with 10 CFR 55.45(b)(2)(i).

The intent of the regulation requiring a certified or an approved simulation facility was to allow license candidates to be evaluated on their performance, as well as their knowledge, in a setting which was as realistic as possible. In addition to the obvious benefits gained by such an improvement in the examination process, the facility licensee will also be allowed to omit certain details of an operator license applicant's qualifications when the utility has a certified or approved simulation facility and an accredited training program including a requalification program based upon a systems approach to training.

REFERENCES

1. Code of Federal Regulations, Title 10 Part 55 (10 CFR 55), "Operator's Licenses"

2. Regulatory Guide 1.149, Nuclear Power Plant Simulation Facilities for Use in Operator License Examinations

3. NUREG-1258, Evaluation Procedure for Simulation Facilities Certified Under 10 CFR 55

4. ANSI/ANS-3.5-1985, Nuclear Power Plant Simulators for Use in Operator Training

5. NUREG-1262, Answers to Questions at Public Meetings Regarding Implementation of Title 10, Code of Federal Regulations Part 55 on Operators' Licenses

6. Generic Letter No. 87-07, Information Transmittal of Final Rulemaking for Revisions to Operator Licensing - 10CFR55 and Conforming Amendments

7. Simulation Facility Inspection Report dated November 17, 1988, Docket No. 50-309, from P. M. Sears, Project Manager, Project Directorate I-3, Division of Reactor Projects I/II, Office of Nuclear Reactor Regulation to Mr. J. B. Randazza, President, Maine Yankee Atomic Power Company

8. Letter, K. E. Perkins, Jr., Chief Operator Licensing Branch, Division of Licensee Performance and Quality Evaluation, NRR to Mr. J. M. Black, Chairman, Utility Simulator Users Group, dated January 13, 1989.

TABLE 1 - SIMULATOR LIST - JANUARY 1989

| UNIT | SIMULATOR STATUS | 474 OR APPLICATION | GL 87-07 SUBMITTAL | DATE READY FOR TRAINING | SIMULATOR VENDOR | SIMULATOR LOCATION |
|---|---|---|---|---|---|---|
| ANO-1 | OP | | | 1986 | EAI | ON-SITE |
| ANO-2 | OP | 474 - 12/7/87 | | 1987 | GOULD | ON-SITE |
| BEAVER VALLEY 1 | OP | | | 1984 | W | ON-SITE |
| BEAVER VALLEY 2 | IFB | | | TBD | TBD | TBD |
| BELLEFONTE 1, 2 | OP | | | 1982 | SINGER | SEQUOYAH |
| BIG ROCK POINT | NON 3.5 | PLAN - 5/26/88 | 5/26/87 | NA | NA | NA |
| BRAIDWOOD 1, 2 (ML) | OP - *** | 474 - 10/7/88 | | 1983 | EAI | ON-SITE |
| BROWNS FERRY 1, 2, 3 (ML) | OP - **** | | | 1976 | SINGER | ON-SITE |
| BRUNSWICK 1, 2 (ML) | OP | | | 1983 | EAI | ON-SITE |
| BYRON 1, 2 (ML) | OP - * | 474 - 10/7/88 | | NA | NA | NA |
| CALLAWAY 1 | OP | 474 - 11/30/87 | | 1981 | W | ON-SITE |
| CALVERT CLIFFS 1, 2 (ML) | OP | | | 1986 | CE | ON-SITE |
| CATAWBA 1, 2 (ML) | OP | 474 - 8/1/88 | NR | 1/88 | W | ON-SITE |
| CLINTON 1 | OP | | | 1984 | SINGER | ON-SITE |
| COMMANCHE PEAK 1, 2 | OP | | | 1984 | SINGER | ON-SITE |
| COOK 1, 2 (ML) | OP | | | 5/88 | SINGER | ON-SITE |
| COOPER | UC | | 8/13/87 | EST-5/90 | SINGER | ON-SITE |
| CRYSTAL RIVER 3 | UC | | 3/17/88 | EST-8/89 | CAE | ON-SITE |
| DAVIS BESSE | UC | | 3/29/88 | EST-5/89 | CAE | ON-SITE |
| DIABLO CANYON 1, 2 (ML) | OP | | 4/28/88 | 1984 | W | ON-SITE |
| DRESDEN 2, 3 (ML) | OP | | | 1968 | GE | MORRIS, IL |
| DUANE ARNOLD | UC | | | EST -10/89 | SINGER | ON-SITE |
| FARLEY 1, 2 (ML) | OP | | | 1983 | W | ON-SITE |
| FERMI 2 | OP | | | 1984 | SINGER | ON-SITE |
| FITZPATRICK | OP | | | 7/88 | SINGER | ON-SITE |
| FORT CALHOUN 1 | UC | | | EST - 1989 | W | ON-SITE |
| FORT ST. VRAIN | NON 3.5 | PLAN - 5/24/88 | | NA | NA | NA |
| GINNA | OP | | | 1985 | [illegible] | ON-SITE |
| GRAND GULF 1 | OP | | | 1982 | SINGER | ON-SITE |
| HADDAM NECK (CONN YANKEE) | OP | | 2/9/88 | 1985 | SINGER | MILLSTONE |
| HATCH 1, 2 (ML) | OP | | | 1982 | SINGER | ON-SITE |
| HOPE CREEK 1 | OP | | | 1984 | SINGER | ON-SITE |
| INDIAN POINT 2 | OP - *** | | | 1973 | SINGER | ON-SITE |
| INDIAN POINT 3 | OP | | 12/30/88 | 1988 | W | ON-SITE |
| KEWAUNEE | OP | | | 1984 | SINGER | ON-SITE |
| LASALLE 1, 2 (ML) | OP - *** | | | 1983 | EAI | BRAIDWOOD |
| LIMERICK 1, 2 | OP | | | 1981 | SINGER | ON-SITE |
| MAINE YANKEE | OP | 474 - 8/17/87 + | 6/26/87 | 1984 | SINGER | ON-SITE |
| MCGUIRE 1, 2 (ML) | OP | | NR | 1988# | W# | ON-SITE |
| MILLSTONE 1 | OP | | 2/9/88 | 1986 | SINGER | ON-SITE |
| MILLSTONE 2 | OP | | 2/9/88 | 1985 | SINGER | ON-SITE |
| MILLSTONE 3 | OP | | | 1984 | SINGER | ON-SITE |
| MONTICELLO | OP | | | 1984 | SINGER | ON-SITE |
| NINE MILE POINT 1 | OP | | | 1984 | SINGER | ON-SITE |
| NINE MILE POINT 2 | OP | | | 1985 | SINGER | ON-SITE |
| NORTH ANNA 1, 2 (ML) | OP | 474 - 9/13/88 | | 1984 | SAI | ON-SITE |
| OCONEE 1, 2, 3 (ML) | OP - **** | | NR | 1983 | EAI | ON-SITE |

TABLE 1 - SIMULATOR LIST - JANUARY 1989

| UNIT | SIMULATOR STATUS | 474 OR APPLICATION | GL 87-07 SUBMITTAL | DATE READY FOR TRAINING | SIMULATOR VENDOR | SIMULATOR LOCATION |
|---|---|---|---|---|---|---|
| OYSTER CREEK | UC | | | EST-10/90 | W | ON-SITE |
| PALISADES | OP | | 5/26/87 | 1983 | SINGER | MIDLAND |
| PALO VERDE 1, 2, 3 (ML) | OP | | | 1980 | EAI | ON-SITE |
| PEACH BOTTOM 2, 3 (ML) | OP | | | 1987 | SINGER | SINGER |
| PERRY 1, 2 | OP | | | 1980 | SINGER | ON-SITE |
| PILGRIM 1 | OP | | | 1987 | CAE | ON-SITE |
| POINT BEACH 1, 2 (ML) | UC | | 6/10/87 | EST - 1990 | W | ON-SITE |
| PRAIRIE ISLAND 1, 2 (ML) | OP | | | 1984 | SINGER | ON-SITE |
| QUAD CITIES 1, 2 (ML) | UC | | | EST-7/90 | SINGER | ON-SITE |
| RANCHO SECO | UC | | | EST-11/89 | CAE | ON-SITE |
| RIVER BEND 1 | OP | | 5/10/88 | 1983 | SINGER | ON-SITE |
| ROBINSON 2 | OP | | | 1986 | [illegible] | ON-SITE |
| ST. LUCIE 1 (ML) | NON 3.5 | PLAN 5/24/88 | | NA | NA | NA |
| ST. LUCIE 2 (ML) | OP | | | 1987 | CAE | ON-SITE |
| SALEM 1, 2 (ML) | OP | | | 1983 | EAI | ON-SITE |
| SAN ONOFRE 1 | NON 3.5 | PLAN - 5/26/88 | | NA | NA | NA |
| SAN ONOFRE 2, 3 (ML) | OP | | | 1983 | SINGER | ON-SITE |
| SEABROOK 1, 2 | OP | | | 1980 | SINGER | ON-SITE |
| SEQUOYAH 1, 2 (ML) | OP - **** | | | 1977 | SINGER | ON-SITE |
| SHEARON HARRIS 1, 2 | OP | | 5/24/88 | 1986 | W | ON-SITE |
| SHOREHAM | OP | | | 1987 | SINGER | ON-SITE |
| SOUTH TEXAS 1, 2 | OP | | | 1985 | GOULD | ON-SITE |
| SUMMER 1 | OP | | | 1983 | W | ON-SITE |
| SURRY 1, 2 (ML) | OP | 474 - 11/23/88 | | 1978 | EAI | ON-SITE |
| SUSQUEHANA 1, 2 (ML) | OP | | | 1979 | SINGER | ON-SITE |
| THREE MILE ISLAND 1 | OP | | 5/19/88 | 1987 | SINGER | ON-SITE |
| TROJAN | UC | | | EST - 3/89 | W | ON-SITE |
| TURKEY POINT 3, 4 (ML) | OP | | | 1987 | CAE | ON-SITE |
| VERMONT YANKEE | OP | | 5/23/88 | 1986 | SINGER | ON-SITE |
| VOGTLE 1, 2 (ML) | OP | 474 - 10/25/88 | 11/16/88 | 1982 | SINGER | ON-SITE |
| WNP 2 | OP ** | | | 1983 | GOULD | ON-SITE |
| WNP 3 | UC | | | NA | GOULD | IN STORAGE |
| WATERFORD 3 | OP | | | 1987 | SINGER | ON-SITE |
| WATTS BAR 1, 2 (ML) | OP | | | 5/88 | SINGER | ON-SITE |
| WOLF CREEK | OP | 474 - 1/10/89 | 8/26/87 | 1983 | W | ON-SITE |
| YANKEE ROWE | IFB | PLAN - 5/26/88 | 7/23/87 | TBD | TBD | TBD |
| ZION 1, 2 (ML) | OP * | | | 1972 | W | ON-SITE |

(UNITS = 123) (OP = 67) (UC = 11) (IFB = 2) (NON 3.5 = 4)

TABLE 1 - SIMULATOR LIST - JANUARY 1989

| UNIT | OTHER SIMULATORS USED | NSSS TYPE | TURBINE/CONTROL TYPE |
|---|---|---|---|
| ANO-1 | X | B&W | W |
| ANO-2 | X | CE | GE |
| BEAVER VALLEY 1 | X | W - 3 LOOP | W |
| BEAVER VALLEY 2 | BEAVER VALLEY 1 | W - 3 LOOP | W |
| BELLEFONTE 1, 2 | X | B&W | BB |
| BIG ROCK POINT | GE - MORRIS, IL | GE | GE |
| BRAIDWOOD 1, 2 (ML) | X | W - 4 LOOP | W |
| BROWNS FERRY 1, 2, 3 (ML) | X | GE - MK I | GE |
| BRUNSWICK 1, 2 (ML) | X | GE - MK I(C) | GE |
| BYRON 1, 2 (ML) | BRAIDWOOD | W - 4 LOOP | W |
| CALLAWAY 1 | X | W - 4 LOOP | W |
| CALVERT CLIFFS 1, 2 (ML) | X | CE | GE/W |
| CATAWBA 1, 2 (ML) | X | W - 4 LOOP | GE |
| CLINTON 1 | X | GE | GE |
| COMMANCHE PEAK 1, 2 | X | W - 4 LOOP | AC |
| COOK 1, 2 (ML) | X | W - 4 LOOP | GE/BB |
| COOPER | GE - MORRIS, IL | GE - MK I | W |
| CRYSTAL RIVER 3 | B&W - LYNCHBURG, VA | B&W | W |
| DAVIS BESSE | B&W - LYNCHBURG, VA | B&W | GE |
| DIABLO CANYON 1, 2 (ML) | X | W/W - 4 LOOP | W |
| DRESDEN 2, 3 (ML) | X | GE - MK I | GE |
| DUANE ARNOLD | VERMONT YANKEE | GE - MK I | GE |
| FARLEY 1, 2 (ML) | X | W - 3 LOOP | W |
| FERMI 2 | X | GE - MK I | GE |
| FITZPATRICK | X | GE - MK I | GE |
| FORT CALHOUN 1 | CE - WINDSOR, CT | W | GE |
| FORT ST. VRAIN | NONE | GA | GE |
| GINNA | X | W - 2 LOOP | W |
| GRAND GULF 1 | X | GE - MK III | GE |
| HADDAM NECK (CONN YANKEE) | X | W - 4 LOOP | W |
| HATCH 1, 2 (ML) | X | GE - MK I | GE |
| HOPE CREEK 1 | X | GE - MK I | GE |
| INDIAN POINT 2 | X | W - 4 LOOP | W |
| INDIAN POINT 3 | X | W - 4 LOOP | W |
| KEWAUNEE | X | W - 2 LOOP | W |
| LASALLE 1, 2 (ML) | X | GE - MK II(C) | GE |
| LIMERICK 1, 2 | X | GE - MK II(C) | GE |
| MAINE YANKEE | X | CE | W |
| MCGUIRE 1, 2 (ML) | X | W - 4 LOOP | W |
| MILLSTONE 1 | X | GE - MK I | GE |
| MILLSTONE 2 | X | CE | GE |
| MILLSTONE 3 | X | W - 4 LOOP | GE |
| MONTICELLO | X | GE - MK I | GE |
| NINE MILE POINT 1 | X | GE - MK I | GE |
| NINE MILE POINT 2 | X | GE - MK II(C) | GE |
| NORTH ANNA 1, 2 (ML) | X | W - 3 LOOP | W |
| OCONEE 1, 2, 3 (ML) | X | B&W | GE |

TABLE 1 - SIMULATOR LIST - JANUARY 1989

| UNIT | OTHER SIMULATORS USED | NSSS TYPE | TURBINE/CONTROL TYPE |
|---|---|---|---|
| OYSTER CREEK | NINE MILE PT 1 - 3 | GE - MK I | GE |
| PALISADES | X | CE | W |
| PALO VERDE 1, 2, 3 (ML) | X | CE | GE |
| PEACH BOTTOM 2, 3 (ML) | X | GE - MK I | GE |
| PERRY 1, 2 | X | GE - MK III | GE |
| PILGRIM 1 | X | GE - MK I | GE |
| POINT BEACH 1, 2 (ML) | KEWAUNEE | W - 2 LOOP | W |
| PRAIRIE ISLAND 1, 2 (ML) | X | W - 2 LOOP | W |
| QUAD CITIES 1, 2 (ML) | GE - MORRIS, IL | GE - MK I | GE |
| RANCHO SECO | B&W - LYNCHBURG, VA | B&W | W |
| RIVER BEND 1 | X | GE | GE |
| ROBINSON 2 | X | W - 3 LOOP | W |
| ST. LUCIE 1 (ML) | ST. LUCIE 2 | CE | W |
| ST. LUCIE 2 (ML) | X | CE | W |
| SALEM 1, 2 (ML) | X | W - 4 LOOP | W |
| SAN ONOFRE 1 | W - ZION, IL | W - 3 LOOP | W |
| SAN ONOFRE 2, 3 (ML) | X | CE | GE |
| SEABROOK 1, 2 | X | W | GE |
| SEQUOYAH 1, 2 (ML) | X | W - 4 LOOP | W |
| SHEARON HARRIS 1, 2 | X | W | W |
| SHOREHAM | X | GE - MK II(C) | GE |
| SOUTH TEXAS 1, 2 | X | W - 4 LOOP | W |
| SUMMER 1 | X | W - 3 LOOP | GE |
| SURRY 1, 2 (ML) | X | W - 3 LOOP | W |
| SUSQUEHANA 1, 2 (ML) | X | GE - MK II(C) | GE |
| THREE MILE ISLAND 1 | X | B&W | GE |
| TROJAN | SNUPPS - PITTS., PA | W - 4 LOOP | GE |
| TURKEY POINT 3, 4 (ML) | X | W - 3 LOOP | W |
| VERMONT YANKEE | X | GE - MK I | GE |
| VOGTLE 1, 2 (ML) | X | W | GE |
| WNP 2 | X | GE - MK II(C) | W |
| WNP 3 | X | CE | W |
| WATERFORD 3 | X | CE | W |
| WATTS BAR 1, 2 (ML) | SEQUOYAH | W - 4 LOOP | W |
| WOLF CREEK | X | W | GE |
| YANKEE ROWE | SNUPPS - ZION, IL | W - 4 LOOP | W |
| ZION 1, 2 (ML) | X | W - 4 LOOP | W |

TABLE 1 - SIMULATOR LIST - JANUARY 1989

ABBREVIATIONS USED

| | |
|---|---|
| OP | - SIMULATOR OPERATIONAL |
| UC | - SIMULATOR UNDER CONSTRUCTION |
| NON 3.5 | - MAY NOT MEET ANS 3.5 DEFINITION OF FULL SCOPE SIMULATOR |
| IFB | - SIMULATOR INVITATION FOR BID ISSUED |
| W | - WESTINGHOUSE ELECTRIC COMPANY |
| GE | - GENERAL ELECTRIC COMPANY |
| B&W | - BABCOCK AND WILCOX COMPANY |
| BB | - BROWN BOVERI COMPANY |
| AC | - ALLIS CHALMERS COMPANY |
| GA | - GENERAL ATOMIC COMPANY |
| CE | - COMBUSTION ENGINEERING COMPANY |
| (ML) | - OPERATORS ARE ISSUED MULTIPLE LICENSES |
| RFT | - SIMULATOR ACCEPTED BY UTILITY AS "READY FOR TRAINING" |
| TBD | - TO BE DETERMINED |
| NR | - NOT RESPONSIVE |
| NA | - NOT APPLICABLE |
| * | - EXISTING SIMULATOR TO BE REPLACED - EST. 3/91 |
| ** | - EXISTING SIMULATOR TO BE REPLACED - DATE TBD |
| *** | - MAJOR SIMULATOR UPGRADE PLANNED - EST. 3/91 |
| **** | - MAJOR UPGRADE PLANNED - DATE TBD |
| + | - NRC SIMULATOR INSPECTION COMPLETED |
| # | - AFTER MAJOR UPGRADE OR REPLACEMENT |
| X | - USES OWN SIMULATOR |

NOTES

NOTE 1: Oconee Simulator being upgraded by Westinghouse.
Expected to be RFT 1/89

NOTE 2: Oyster Creek also uses a Basic Principles Trainer

NOTE 3: Peach Bottom simulator in operation at Singer.
Will be moved to site when building is ready.

NOTE 4: TMI also uses a Basic Principles Trainer.

TABLE 2 - CERTIFICATIONS, APPLICATIONS AND GL 87-07

| UNIT | 474 OR APPLICATION | GL 87-07 SUBMITTAL |
|---|---|---|
| ANO-2 | 474 - 12/7/87 | |
| BIG ROCK POINT | PLAN - 5/26/88 | '26/87 |
| BRAIDWOOD 1, 2 (ML) | 474 - 10/7/88 | |
| BYRON 1, 2 (ML) | 474 - 10/7/88 | |
| CALLAWAY 1 | 474 - 11/30/87 | |
| CATAWBA 1, 2 (ML) | 474 - 8/1/88 | NR |
| COOPER | | 8/13/87 |
| CRYSTAL RIVER 3 | | 3/17/88 |
| DAVIS BESSE | | 3/29/88 |
| DIABLO CANYON 1, 2 (ML) | | 4/28/88 |
| FORT ST. VRAIN | PLAN - 5/24/88 | |
| HADDAM NECK (CONN YANKEE) | | 2/9/88 |
| INDIAN POINT 3 | | 12/30/88 |
| MAINE YANKEE | 474 - 8/17/87 + | 6/26/87 |
| MCGUIRE 1, 2 (ML) | | NR |
| MILLSTONE 1 | | 2/9/88 |
| MILLSTONE 2 | | 2/9/88 |
| NORTH ANNA 1, 2 (ML) | 474 - 9/13/88 | |
| OCONEE 1, 2, 3 (ML) | | NR |
| PALISADES | | 5/26/87 |
| POINT BEACH 1, 2 (ML) | | 6/10/87 |
| RIVER BEND 1 | | 5/10/88 |
| ST. LUCIE 1 (ML) | PLAN 5/24/88 | |
| SAN ONOFRE 1 | PLAN - 5/26/88 | |
| SHEARON HARRIS 1, 2 | | 5/24/88 |
| SURRY 1, 2 (ML) | 474 - 11/23/88 | |
| THREE MILE ISLAND 1 | | 5/19/88 |
| VERMONT YANKEE | | 5/23/88 |
| VOGTLE 1, 2 (ML) | 474 - 10/25/88 | 11/16/88 |
| WOLF CREEK | 474 - 1/10/89 | 8/26/87 |
| YANKEE ROWE | PLAN - 5/26/88 | 7/23/87 |

SIMULATOR UPGRAADE AND CERTIFICATION - A SYSTEMATIC APPROACH

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PAPER WAS NOT RECEIVED AT TIME OF PUBLICATION

# THREE ALTERNATIVE SIMULATION SYSTEMS FOR TRAINING NUCLEAR POWER PLANT PERSONNEL

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S. D. Yeh

ABSTRACT

Many utilities are purchasing full scope control room simulators for training purposes. But, depending upon training requirements and finances, an alternative to a full scope control room simulator may be a viable option. Westinghouse has built and delivered two styles of alternative simulation systems. Both of these systems provide real-time, plant specific simulation, and the capacity to execute all plant general, emergency, and most off-normal procedures. This paper discusses the design of both of these systems, including the design of a hybrid simulator, presently under construction, which combines features from both of these designs. In addition, some of the training capabilities and limitations for each of these simulations systems is presented.

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## INTRODUCTION

Since the accident at TMI, the value of simulator training for power plant operators and staff has been recognized by the nuclear industry and is reflected in INPO and NRC guidelines and requirements for operator training and evaluation. As a result, many utilities have been purchasing "full scope simulators" as defined in ANS-3.5[4]. The cost for this investment (10 to 18 million USD at today's prices) can place a considerable burden on a utility. In addition, it essentially eliminates the possibility of providing a second plant specific simulator for applications outside of the site specific training department, or, for providing additional simulator time for multi-unit utilities where simulator time is in high demand.

In order to provide todays high fidelity nuclear power plant simulation at a more reasonable cost, Westinghouse has designed two alternative simulation systems, the Multi-Purpose Engineering and Training (MET) Simulator and the Westinghouse Compact Training (WCT) Simulator. Both of these systems provide real-time, high fidelity, plant specific simulation at a more reasonable cost. Their cost is minimized by replacing the control board replicas with a compact, sitdown control panel, and by carefully defining the scope of simulation based upon utility training objectives and simulator applications.

Westinghouse has built and delivered three MET simulators, one for Energia Nucleare E Delle Energie Alternative(ENEA) in Cassacia, Italy(June,1986), one for the Westinghouse International Division Headquarters in Brussels, Belgium, and one for the Westinghouse Instrumentation Technology and Training Center in Pittsburgh. A WCT simulator was built and delivered to Nordostschweizerische Kraftwerke(NOK) AG in Dottingen, Switzerland in April, 1987. The MET/ENEA simulator is a full scope simulator that was designed for engineering and training applications, and is operated through an interactive graphics system ("soft" controls). The WCT/NOK simulator is a limited scope simulator that was designed for operator training, and is operated through a miniature plant mimic panel ("hard" controls).

The purpose of this paper is three-fold. First, the design and construction of both the ENEA and NOK projects is discussed, including some advantages and limitations of each design as an alternative simulation package. Second, a WCT hybrid design is discussed which combines features from both designs, resulting in a compact simulator which may be operated via a combination of "hard" and "soft" controls. This design, which incorporates experience gained through the construction and operation of the ENEA and NOK simulators, is the proposed design for four WCT simulators being built for Kansai Electric Power Company of Japan. And last, a discussion of training capabilities and limitations for each of these simulation systems is presented. It is hoped that this presentation may be helpful to a utility in selecting an appropriate alternative simulation system which will enable them to meet their training objectives or provide high quality simulator performance for applications beyond training.

## MET SIMULATION SYSTEM

During the past ten years, the speed and accuracy of the available computer systems for use in real-time simulation has increased significantly. In conjunction with these improvements, it has been possible to improve the performance of real-time simulation to the degree required to support some aspects of engineering analysis and increase the depth and realism of transients that can be run for training exercises. It was during this time frame that the Multi-purpose Engineering and Training (MET) Simulator was conceived with both engineering and training applications in mind. This system was developed recognizing the limitations which a full scope training simulator with plant controls and indications spread over 75-100 feet of linear control board space places upon an engineer or operator. A large control board is not a convenient from of man-machine interface for detailed analysis and study of plant operations and transients. For this reason, the control panel replicas have been replaced with a convenient, compact, sitdown panel designed for operation by one or two individuals. All tasks normally performed at the control room consoles can be performed at this compact panel in a time frame matching operator performance in the control room.

The scope of simulation for each plant-specific MET simulator is selected by the utility. Partial or full scope simulation is available based upon utility requirements. If the simulator is initially designed as a partial scope simulator, its scope of simulation can be expanded incremently without hardware changes. Hence, it is possible to reduce the initial investment by starting with a partial scope simulator. Expansion to meet new training objectives or applications, can be accomplished as needed resources become available. If a MET simulator is purchased for a plant which already has an existing simulator, these models can be used in the MET system. Providing the necessary MET system hardware and I/O software may be all that is required to double an utility's available simulation time.

The compact panel consists of two n  cly identical operator stations (Figure 1). The basic design of each station typically consists of four CRTs, one or more touch screens, track balls, mice, or other cursor control devices one keyboard, one or more programmable key sets, and 72 hardwired alarm windows. This panel along with the associated I/O software provides the operator with all of the indications and controls which are normally available in the control room for the simulated systems. The exact hardware configuration for the operating stations is custom designed for each MET simulator.

Typically, the layout of control boards in an actual plant are oriented by system with limitations based upon available space or design criteria (such as Class 1E restrictions). The resulting control panel layout has only a limited functional organization. The MET panel has been designed to replace the control room consoles with a highly structured, functionally organized interactive graphics system. For discussion purposes, the interactive graphics system can be divided into three areas of interest: (1) plant/system status information; (2) plant controls; and (3) alarm status information.

For the MET simulator, the plant/system status information is presented via a functionally organized set of CRT displays. The display organization consists of three basic types of displays. System oriented displays present all the detailed information which is available on a plant system. Executive level displays provide a summary of major plant areas, such as NSSS or BOP main power train. The third class of displays fall into the category of functionally oriented displays. Each of these displays contains information from a variety of plant systems whose selection was made based upon a list of display tasks. These tasks may be sequential, e.g., for use during a reactor startup, or functionally oriented, e.g., for controlling reactor coolant system pressure (Figure 2). The application of a task analysis for each display is an invaluable aid in determining the information content of each CRT display. The task analysis provided guidance in selecting data for display content, and minimized excess data which prevented overcrowding of the CRT screen.

Plant control manipulations are accomplished through an interactive graphics system which employs various cursor control schemes to select and operate specific components. Two basic control schemes are simulated. For those plant controls which consist of a single pushbutton, a pushbutton mimic is located somewhere on the upper 40 lines of a CRT graphic display. Operation is accomplished by placing the cursor over the pushbutton and depressing an execute key or by direct contact through the touchscreen. For all other controls, the switch or component to be controlled is selected on the appropriate graphic and a control menu appears on the lower eight lines of the CRT screen. The graphic representation of every control mechanism is designed to reproduce the actual plant hardware as close as possible. For operators who prefer to maintain a tactile sense of feedback when manipulating controls, a set of six assignable pushbuttons operate in parallel with the control window located on the CRT. Although the physical fidelity of this control scheme is low, the functional fidelity of the control scheme is very high due to the one-to-one correspondance maintained between the plant control hardware and the CRT graphics design.

A typical plant has 800 to 1200 alarm windows. Obviously it is impossible to have this many dedicated alarm windows on a compact panel. Therefore, a CRT based alarm system was developed. The first CRT based alarm system, the one designed for the ENEA simulator, consisted of two dedicated alarm CRTs. One alarm CRT was for NSSS alarms and the other for BOP alarms. Each alarm screen was divided into two areas, one for critical alarms (alarms which require immediate operator action to prevent a trip) and one for non-critical alarms. When an alarm is received, a graphic duplication of the plant alarm window appears on the alarm screen. The alarm screen also displays the alarm response procedure number, the time of receipt, and an alarm suppression number. The alarm suppression number permits the operator to temporarily remove an alarm from the alarm system. This system provids two key elements necessary for operator training: (1) exact replica of actual control room alarm windows; and (2) the alarm response procedure number. The procedure number is necessary due to the loss of spatial orientation normally provided by the hardwired alarms in the control room. Hardwired alarm windows(144) have been added to the MET simulator design to augment the CRT based alarm system. This addition of hardwired alarm windows was based upon actual training experience on the ENEA simulator, and, confirmed through the operation of the WCT/NOK simulator. These hardwired alarm windows are selected based upon importance and frequency. This results in less crowding of the CRT-based system during severe transients.

A new software package, the Advanced Engineering Simulator Operations Package (AESOP), has been provided to aid engineers or operators in detailed transient studies. AESOP provides: (1) execution of pre-programmed operational sequences, such as recovery from safety injection, transfer to hot or cold leg recirculation, main feedwater pump startup, etc.; (2) on-line data collection and storage for later review; (3) on-line control of CRT trends, including variable selection, scaling, and update frequency; (4) data plotting on a color plotter; (5) on-line creation of new variables for monitoring; (6) access to simulated pump, valve, controller, and heat exchanger characteristics along with the capability of changing these characteristics; and (7) easy access to the entire status and control data base.

The ENEA simulator is a MET simulator which was provided with full scope simulation and a minimum control panel hardware configuration. Since ENEA uses the simulator primarily as an engineering tool, the portable instructor station which is usually provided with a MET system was eliminated. Normally each operator station is provided with four CRTs, one for alarm information and three for NSSS or BOP summary and system level displays. For the ENEA simulator, one graphic display at each control station was replaced with the instructor system and AESOP respectively. Control panel information can be accessed on the ENEA system through approximately 125 CRT displays. No hardwired alarm windows were provided. A more detailed description of the hardware configuration and applications of the ENEA simulator has been provided by Modonesi and Garrett[1].

## WCT SIMULATOR

The WCT simulation system is designed as a plant-specific, partial scope simulator. The scope of simulation is carefully selected based upon training objectives, while keeping in mind the space limitations of the compact control panel design. The WCT/NOK simulator is a partial scope simulator with approximately 27 of 55 plant systems modeled. In most cases, the models have the same detailed simulation that would be provided for a full scope control room simulator. All of the major NSSS and BOP systems are modeled, including the core, reactor coolant, chemical and volume control, process control and protection, residual heat removal, safety injection, main steam, main turbine, condensate and feedwater, switchyard, station electrical buses, etc. The extent of modeling can be selected such that all general, emergency, and most of the off-normal procedures can be executed.

The WCT/NOK simulator is operated from a compact, sitdown panel which is divided into three sections with each one having a small plant mimic panel (Figure 3). Most of the major plant controls and indications are located on the plant mimic sections. Four CRTs are located above the center section and provide access to in-plant computer displays, displays to augment the indications provided on the mimic panel, and provide alarm information. The left and right wings are provided with optional hardware to add two more CRTs.

The mimic hardware consists of miniature meters, LED digital displays, backlighted pushbuttons, multiposition switches, status lights, and alarm windows. Typically none of this hardware is identical to actual plant hardware. The mimic hardware is mounted on the panel using a tile and matrix system with individual connectors for each component. Using this system makes it quite easy to change component arrangement, add new components, or delete existing components. Mimic lines have been provided on the panel for the fluid and electrical systems. Valve, pump, fan, breaker controls, and meters are overlayed on this mimic. Most of the multiposition switches and controllers are located along the bottom row of the panels. Alarm windows (104 on the WCT/NOK simulator) are located along the top row and are distributed among the three panels.

The miniature plant mimic design was selected in order to maximize the indications and controls that can be placed on the panel. Even though miniaturizing these components reduces panel size, other space saving techniques were necessary to maximize the effectiveness of the panel area. Most multiposition switches for component control have been replaced by a single pushbutton. Some pushbuttons control more than one component, i.e. up to three pumps or up to eight valves. Redundant instruments are not displayed on the panel although this information is available on the CRT graphic display system. Some of the hardwired alarm windows replace up to four actual control room alarms.

The NOK simulator alarm system is similar to the latest MET simulator design. The alarm system is composed of 104 hardwired alarm windows and one CRT. The CRT screen is divided into two sections, one for NSSS and one for BOP alarms.

A more detailed discussion of the design, developement, and operation of the NOK simulator is provided by Lynch and Grimm[2].

HYBRID SYSTEM

The WCT/hybrid system has a combination of features from both the MET and WCT/NOK simulators. It can be initiall built as a full scope simulator or as a partial scope simulator which can be expanded incrementally to a full scope simulator at any time. Although this system takes features from both the MET and WCT/NOK simulators, it may not be the better choice for a specific application. It depends upon the application and training objectives of the utility. If a utility only needs a partial scope simulator, foresees no need for expansion, and desires the tactile sense of control provided by actual hardware, a WCT/NOK type simulation system may meet his needs. If the utility wishes to use the system for training on two different reference plants, the MET simulator design is more appropriate. The MET compact panel may be made completely independent of the plant simulation. On this type of system, by simply activating the appropriate plant simulation tasks, the system can be used for training on more than one type of plant. If the utility wishes to have the capabilty of expanding to a full scope system, desires the traditional feel of a hardwired control panel, and wants all plant controls available to the panel operator, the WCT/hybrid system is the appropriate selection.

The WCT/hybrid system has a small plant mimic panel containing most of the major plant indications and controls. In addition, it has one or two operating stations designed for soft controls. The soft control stations are used to manipulate all simulated controls which are located on the plant control room consoles, but do not appear on the simulated plant mimic section. Providing these soft control panels permits greater flexibilty in the layout and choice of controls located on the plant mimic. The indications and controls located on the WCT/NOK plant mimic included major controls or indications from all of the simulated systems. With a soft control panel, removing a control mechanism from the pla mimic does not mean removing it from the operator's reach. It will still be available through soft controls. Therefore, the indications and controls located on the plant mimic can be based upon both training and operational requirements. For example, in the case of training, changes in operating status of the component cooling water (CCW) and service water (SW) systems are infrequent, while changes in the status of the chemical and volume control system (letdown and charging) are done quite frequently. Therefore, more indications and controls from the CVCS system should be provided on the plant mimic while removing CCW and SW indications and controls. If any manipulation of the CCW and SW systems is necessary, the soft control stations are available for complete system operation. In the case of operational requirements, all protection system actuation pushbuttons, such as reactor or safety injection actuation, are placed on the mimic panel for rapid access.

An alarm system similar to the MET and WCT/NOK alarm systems consisting of hardwired alarm windows and a CRT based alarm system is provided. The CRT based alarm system consists of one or two screens, depending upon the scope of simulation. The CRT based system incorporates the improvements in the graphic representation of alarm information which was included in the NOK system based upon ENEA experience. This includes, among other items, the color coding of the alarms based upon importance.

The Kansai Electric Power Company Takahama 1/2, Takahama 3/4, Mihama 2,and Mihama 3 Compact Simulators are of the WCT/hybrid design type. There will be a plant mimic panel, along with four CRT's for status information and one for an interactive graphics system. The Takahama 1/2 and 3/4 simulators are designed to share the same operating control panel and instructor system. Minor differences between the two plants have been accommodate in the plant mimic panel. Controls are being added to the horizontal section of the control panels for the Takahama and Mihama Simulators. These controls, unlike the miniature control hardware, will be near replicas of the actual control room hardware. One of the key elements of this additional hardware is a replica of each plant's main turbine electrohydraulic control(EHC) panel insert. For the Takahama 1/2 and 3/4 Simulators, the EHC panel insert is interchangeble in order to assure accurate representation for the simulated plant. Based upon the utility's training objectives, this extra hardware and associated software is cost effective.

## SIMULATOR TRAINING

In order to fully evaluate the effectiveness of a potential simulator design for training, a list of goals and objectives for all anticipated training programs should be developed. This list would consist of rather broad training goals, such as, "develope the ability to function as a member of a control room team," down to and including rather specific training goals, such as "perform a reactor startup." A potential simulator design would then be judged based upon meeting the identified goals and objectives. This approach would be quite conclusive, but it would also be quite extensive when all personnel training programs, including new licensed operators, continuing licensed operators, non-licensed operators, plant management, maintenance personnel, engineers and technical staff, shift technical advisors, and instructors, are considered.

Rather than approach an evaluation of the MET or WCT simulators in this manner, a rough view of their capabilities and limitations can be accomplished by comparing some of their design features to those of a full scope control room replica simulator. The most obvious difference between a MET or WCT simulator and a full scope replica simulator is the control panel physical layout. Based upon the MET and WCT designs, there is no relation in their physical layout to the physical layout of the actual control room. Their application is limited for development of operator motor skills necessary to locate and manipulate control board instrumentation. The MET simulator minimizes this impact by maintaining a one-to-one correspondance between the control board instruments and the graphics. The WCT simulator simulator provides the trainee with the experience of operating a hardwired control panel, although not of the same physical layout as the actual control boards. Operator training would have to be supplemented with additional on-the-job training or plant walk-throughs in order to develope the necessary motor skills. For non-operator training, developement of the operator motor skills is probably unnecessary.

Most questions concerning the capabilities of the MET and WCT simulators pertain to very specific training objectives concerning drill capabilities. Simulator performance in this area is determined by the scope of simulation and mathematical model fidelity. As far as mathematical model fidelity is concerned, the same modeling techniques, and, in most cases, the same models that are provided on a full scope replica simulator are provided on the MET and WCT simulators. Therefore, the plant specific MET and WCT simulators offer the same model fidelity as a full scope replica simulator (Figure 4). The capabilities of a MET or WCT simulator are restricted only when the scope of simulation is less than full scope. A partial scope simulator will limit the number of available malfunctions and will restrict the number of detailed system operating procedures which can be executed. The WCT/NOK simulator was provided with 85 malfunctions, as opposed to 150-300 malfucntions for a full scope replica simulator. Despite the fact that it is a partial scope simulator, all NOK's general, emergency, and most off-normal procedures can be executed on their simulator. The trainees can gain the experience of performing such evolutions as a reactor startup, plant heatup or cooldown, respond to a steam generator tube rupture, station blackout, or inadvertant safety injection. The type of models excluded from the scope of simulation usually include plant auxiliary systems such as Turbine and Auxiliary Building HVAC, chilled water systems, service air system, hydrogen cooling system, radiological waste systems, etc. Few, if any, of these systems have any effect on plant safety or reactivity control.

Many of the broad goals associated with simulator training are independent of the exact physical layout of the simulator. Goals of this type include:

- o use of procedures and technical specifications
- o ability to apply theory to practical situations
- o ability to work as a team
- o ablitity to analyze information and diagnose problems
- o ability to respond to changing plant conditions

- ability to anticipate response rates of parameters being controlled

There are many additional goals of this type. Some of these goals can be achieved from training on any simulator, but many require plant specific simulation. The MET and WCT simulators provide both the necessary training environment and the plant specific simulation necessary to meet these broad training goals.

The compact panel designs enable operation of the MET and WCT simulators by a single individual as long as the scope of operation is within reason. This opens the entire area of individualized training programs. One-on-one training programs could be implemented to upgrade, maintain, or enhance individual skills or knowledge. Special graphics for enhancing training, such as axial plots of key core parameters and dynamic instrumentation and control block diagrams,etc., can and have been provided training. The WCT/NOK simulator is used significantly in this type of training as dicussed by Portman and Grimm[3].

## CONCLUSION

Three alternatives to a full scope control room simulator have been described. Each has its own advantages and limitations, but each one of them provides the necessary plant specific simulation to support the instruction of operators or other plant staff members in the control and operation of a plant. They differ from each other only in the scope of simulation and the style of real-time operating man-machine interface. The scope of simulation for the MET and WCT/hybrid systems is variable. They can be built as full or partial scope simulators. The WCT/NOK style simulator is limited to a partial scope system. All three simulation systems can be built for any selected reference plant. All three systems are designed to meet the performance criteria of ANS-3.5(1985). The MET and WCT/hybrid systems can also meet all the simulator capabilities of ANS-3.5[4], with the WCT/NOK style system limited only by its reduced scope of simulation. The MET system operating panel design is flexible and can be changed to meet specific utility requirements. It can be designed to be independent of the simulated reference plant, allowing operation of more than one reference plant simulation with the same hardware system. A WCT simulator retains a hardwired mimic panel which provides the traditional tactile feedback during control manipulation.

The choice of the appropriate system by a utility depends upon their anticipated application and training objectives. If their training objectives include training in normal, abnormal, and emergency operating procedures, but does not require detailed training on support systems such as fire protection, turbine or auxiliary building HVAC, boron recovery, waste processing, etc., a limited scope simulator may meet their requirements. No matter which simulator style is selected, the trainees will gain the experience and impact of operating a referenced plant simulator in real-time.

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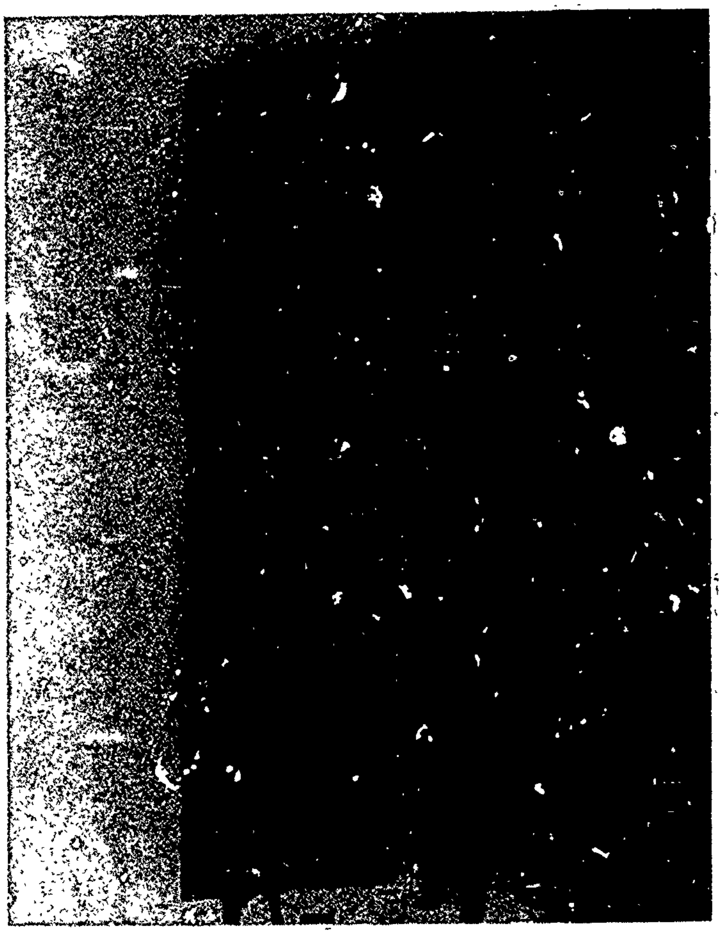
4. American Nuclear Society. 1985. Nuclear Power Plant Simulators for Use in Operator Training. ANSI/ANS-3.5-1985. American Nuclear Society, La Grange Park, Illinois.

## Figure List

### Caption



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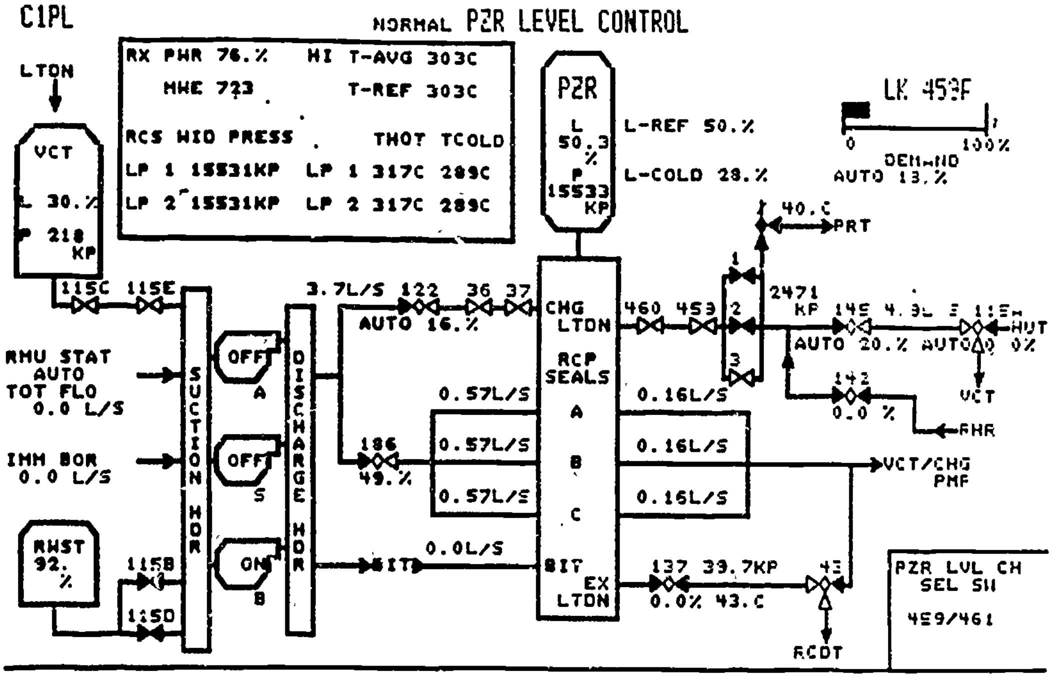
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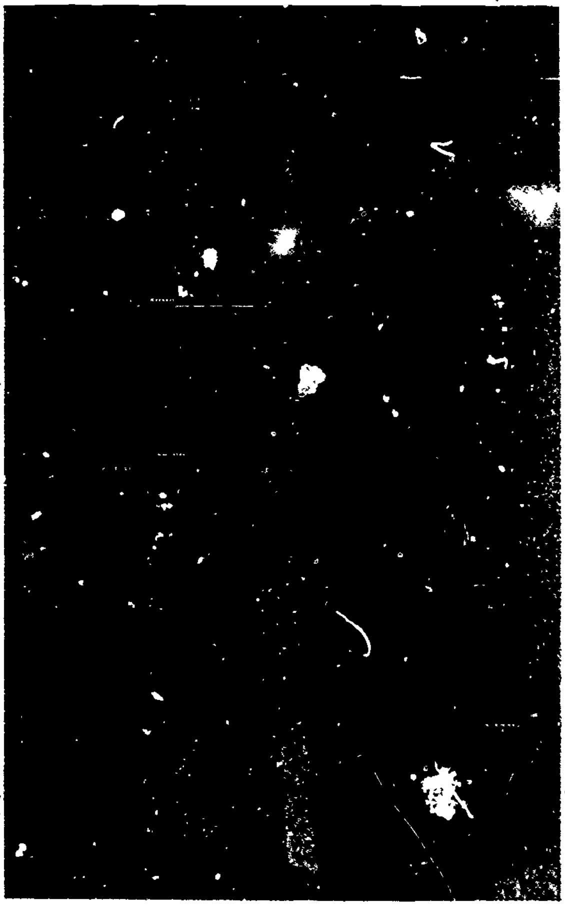

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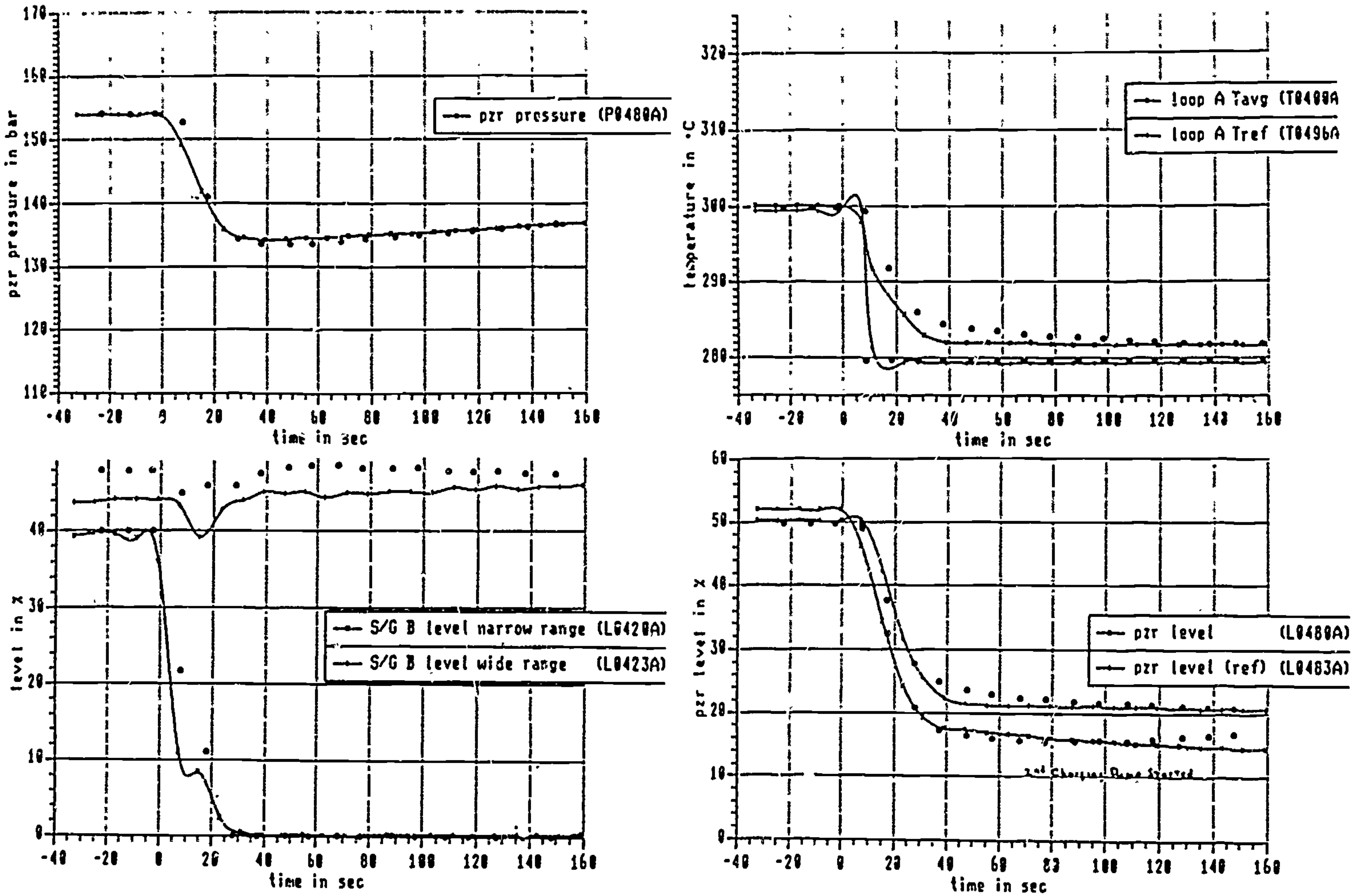
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pzr level (ref) (L0483A)
pzr level in %
time in sec

SIMULATOR INSTRUCTOR TRAINING - A CASE OF UTILITY TEAMWORK

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ABSTRACT

To address the complex challenge of simulator instructor training, the training managers in the Southeastern States Nuclear Training Association assigned staff personnel representing each utility to develop initial simulator instructor training materials. The goal was to develop and pilot a simulator instructor training workshop that would: 1) be used by INPO for its initial simulator instructor training; and 2) would be available to all nuclear utilities. The development of training materials on how to use each utility's site-specific simulator was to be the responsibility of each utility.

During the course of the year, beginning in March 1987, the team members worked through the process: table-top analysis of instructor skills; curriculum design of key lesson plans needed; the division of the topics for development among each group of participants; cross-company review of materials; editing; rewriting to establish continuity in approach; and finally, in August 1988, a pilot workshop. Nine utilities actively participated in the design and development of the materials.

In preparing the abstract, a two-fold topic emerges: 1) the dynamics of the project working group; and 2) the actual finished product - the materials themselves. Underlying the effort was the idea that the participants were working to focus on a very complex challenge, to meet a need for the industry at large, and to meet the need together. The project itself speaks to the expanding development of nuclear professionals. During the project, the representatives merged their talents to define and refine yet another dimension of professionalism in the nuclear power industry - the training of the beginning simulator instructor.

## INTRODUCTION

In February 1987, to address the complex challenge of simulator instructor training, the training managers in the Southeastern States Nuclear Training Association established a committee to develop a Simulator Instructor Training Program. Eventually they assigned more staff personnel to work with the committee and to develop initial simulator instructor training materials. The goal was to develop and pilot a simulator instructor training workshop that would:

1. be used by INPO for its' initial simulator instructor training; and

2. would be available to all nuclear utilities.

The development of training materials on how to use each utility's site-specific simulator was to be the responsibility of each utility.

## PARAMETERS

A few stipulations and parameters were set. The Simulator Instructor Training Program was:

1. to be a week long, 40 hour, training program;

2. to address the identified, simulator-specific instructional tasks;

3. to be designed for "new" simulator instructors, not seasoned veterans; and most challenging of all,

was not supposed to be simulator-dependent. The program was to be designed to be an intermediate step in the training of simulator instructors.

## A MANAGEMENT DIRECTIVE

In March 1987, the first planning meeting was hosted by Duke Power. Steve Frye, who is a long-time employee of Duke Power with a successful career as an SRO and an SRO instructor, was assigned the responsibility of being the chairman for the task team. Under Steve's direction, the task team first decided on and then completed the steps listed below.

- Table-top analysis of instructor skills
- Curriculum design of key lesson plans needed
- Division of the topics for development among each group of participants
- Cross-company review of materials
- Editing by developers
- Presentation to SSNTA managers
- Rewriting to establish continuity of approach
- Final presentation to SSNTA managers

- Pilot program
- Final editing
- Distribution to the industry

With these steps to complete and many hours of work to accomplish, it was time for the managers to settle on the personnel from their utilities who would be key players in the effort. Ultimately, nine utilities actively participated in the design and development of the training materials.

## PARTICIPANTS IN THE PROCESS

All told, there were 13 active licensed or "has held" NRC SRO licensed individuals who currently work in simulator training and two instructional technologists involved in the project. The project lasted from March 1987 through the final editing which took place in December 1988.

Nine utilities took active roles in preparing materials, in reviewing materials, and in providing feedback on suggestions for changing materials. The committee members are listed below. The committee members who have simulator instructor/supervisor experience, nuclear operations experience, or NRC SRO certification are indicated by an asterisk (*).

| | |
|---|---|
| * Chris McLean | Alabama Power Company |
| James W. Hunt | Carolina Power & Light |
| * William B. Geise | Carolina Power & Light |
| * Steve Frye, Chairman | Duke Power |
| Alice Ipock (editor) | Duke Power |

| | |
|---|---|
| * Ken Carnley | Duke Power |
| * Donald Smith | Florida Power Corporation |
| Jack Springer | Florida Power Corporation |
| * Mark Shepherd | Florida Power & Light |
| Ed Allan | Florida Power & Light |
| Ann G. Tench | Georgia Power |
| * Dana A. Williams | Georgia Power |
| Steve Allison | Georgia Power |
| * Drew Bottemiller | SERI (Grand Gulf) |
| * Randy Ruff | South Carolina Electric & Gas |
| * Nathaniel Smith (editor) | South Carolina Electric & Gas |
| * Clyde T. ("CT") Benton | TVA |
| * Clyde O. Brewer | TVA |
| Mark Walters | TVA |
| Tom Cowell | TVA |
| * Donald Fellows | Virginia Power |
| * Larry Gardner | Virginia Power |
| Alice Swander (lead editor) | Virginia Power |

## TEAMWORK FROM THE BEGINNING

The most interesting thing about the entire project was the team work and the willingness to share materials that we had with each other, to strive for the end product that, in our minds, would be a help to the entire industry. Everyone knows the regulations we are under and everyone knows the standards that we, in the nuclear power industry, must meet. We also remember not so long ago when a real cooperative venture between a number of utilities would not have been possible. However, this group worked well and started from a basis of trust and comradery to tackle the project and to take one more step in meeting the needs of training in our challenging industry.

The steps have been mentioned earlier. At this point, it is appropriate to delineate what actually happened in each phase of the project and thereby reflect the teamwork that existed.

## TABLE-TOP ANALYSIS OF INSTRUCTOR SKILLS

On March 19, 1987, approximately 9 committee members met in the Duke Power Corporate offices in Charlotte, North Carolina. The meeting had several goals to achieve: to decide on the course or direction of the project, and to conduct a table-top analysis. To conduct the table-top analysis of which instructional skills needed the committee's attention, we reviewed the study done by Dr. Jan Reitmeyer, former Curriculum Development Supervisor for Pennsylvania Power and Light Company. Dr. Reitmeyer had completed a study, IDENTIFICATION AND VERIFICATION OF COMPETENCIES CONSIDERED ESSENTIAL TO THE SUCCESS OF NUCLEAR SIMULATOR INSTRUCTORS. The committee reviewed the identified competencies in Dr. Reitmeyer's study which covered all skill areas of simulator instructors. From this review, the committee selected tasks to be covered in the Simulator Instructor Training Program. A complete list of Dr. Reitmeyer's identified tasks and the ones selected by the committee can be found in Attachment A.

In the deselection of tasks, several issues were considered. The tasks that were deselected were either considered site-specific, were considered entry level instructor skills and, therefore, prerequisite, or were viewed as not falling within the scope of the generic Simulator Instructor Training Program.

We decided that "new" simulator instructors would be expected to have completed their respective utility's basic instructor training program before attending the simulator training program and would, therefore, be familiar with educational terminology as well as with basic lesson plan development and basic presentation skills.

At the completion of the day, the committee had conducted a table-top job analysis to verify tasks to be trained to in the program and had developed a tentative list of topics that would eventually become the curriculum design for the program.

## CURRICULUM DESIGN OF KEY LESSON PLANS NEEDED

On July 10, 1987, a meeting was chaired by Steve Frye and all utilities were represented with more personnel. The managers had decided who most of their project personnel would be. Based on the work done in March, the meeting opened with a serious discussion of which topics should be developed into lesson plans. Next came the work on the sequence of the lesson plans. This was not very difficult and the group settled on the following sequence:

1. The Role of the Simulator Instructor
2. Cognitive Behavior Applications in Simulator Training
3. Oral Questioning Techniques in Simulator Training
4. An Introduction of Some Techniques of Using the Simulator to Enhance Adult Learning
5. Developing and Using an Effective Scenario/Exercise Guide
6. Developing Effective Observation Skills
7. Evaluating Training Performance in the Simulator
8. Conducting a Critique

9. Evaluating Simulator Instructor Effectiveness (this was added by a training manager and subsequently deleted after the pilot)

## DIVISION OF THE TOPICS AND CROSS-COMPANY REVIEW

Division of labor was of paramount concern to all of the committee members because, like everyone in nuclear, "We are really busy!" A matrix was developed on the board that came to represent our interaction away from the meetings that enables us to complete the task at hand.

Steve did a masterful job of ensuring that all interested parties shared the work load. Once that was accomplished and each utility had a lesson plan to develop or was the co-lead in the development of a lesson plan, Steve moved us into the cross-company review phase. Each utility volunteered to act as an initial reviewer of the materials developed by another company. This worked quite well, even resulting in several utilities enabling their representatives to meet for more in-depth review and team development sessions.

Mr. Frye was a fine task-master who did an excellent job of making certain that we had materials ready for presentation to the managers by January 1988. He was also busy developing one of e lesson plans.

## EDITING BY DEVELOPERS

After the developers had received their final cross-company review, they had the responsibility for refining their lesson plan and preparing it for presentation to the SSNTA managers in January 1988.

## PRESENTATION TO SSNTA MANAGERS

The big day arrived and representatives from the utilities met to present the lesson plans to the SSNTA managers in January 1988. One factor deserves comment about the entire process and the overall support of the managers. Although few utility representatives could attend all meetings, the managers ensured that several did and thereby fostered continuity throughout the project from meeting to meeting. Also, the managers had several personnel working on the project together. In Virginia Power, for example, I was the lead on the project but the SMEs, Larry Gardner and Donald Fellows, assisted by Mike Neal who is a training specialist, wrote our lesson plan. My function was to edit the lesson plan and prepare it for final submittal.

Significant work was contributed to this effort by the training specialists and instructors who prepared materials and who presented these materials to the Southeastern States Nuclear Training Association managers on January 4-5, 1988.

Presenters from the utilities were:

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|---|---|
| Alice Ipock | Duke Power |
| * Steve Frye | Duke Power |
| * Donald Smith | Florida Power Corporation |
| * Dana W[illegible]iams | Georgia Power |

| | |
|---|---|
| * Drew Bottemiller | SERI (Grand Gulf) |
| * Randy Ruff | South Carolina Electric & Gas |
| Tom Cowell | TVA |
| * Larry Gardner | Virginia Power |

After the presentation, the managers decided that one more major step was needed to establish continuity among the lesson plans regarding writing and presentation styles. To provide continuity in approach, an editing committee was selected: Nathaniel Smith, Alice Ipock, and myself. I was assigned the responsibility for the final overall editing and continuity of the training materials.

## REWRITING TO ESTABLISH CONTINUITY

To complete the major portion of the editing/rewriting phase, Alice Ipock, Nathaniel Smith, and I met in Richmond, Virginia, from February 2-4, 1988, to review all of the training materials and to edit the materials as needed to ensure uniformity. A significant contribution was made by Yvonne Logan, of my staff, who assumed the responsibility for all of the organization and word processing for the edited materials. She was supported by Charlene Baker of the graphics section.

In the editing process, the editors became immersed in this project very quickly. The process involved:

- a disciplined review of all lesson plans as submitted so that each editor would know essentially what was addressed specifically in each lesson plan;

- a brainstorming session to define the scope of the work for what needed to be done in the three days; and

- a division of work so that each editor was responsible for editing and expanding specific lesson plans.

In some instances, development work was involved to tie the lesson plans together. The disciplined review was very beneficial because it provided a continuity of the entire instructor guide and how each part that was edited would reinforce previous lessons. The disciplined review was a verbal review of major content addressed in each lesson plan, not a laborious sentence by sentence review. Restructuring and reorganizing took place during this activity. Once the review was completed and each editor knew the scope of work, lessons were divided among the editors and they began their work independently.

Finally, once the editors had finished significant portions of their respective responsibilities, the entire program was discussed, walked-through, and essentially "acted out" to see how the parts fit. When the editors determined that their collective job was done, Alice Ipock and Nathaniel Smith returned to their utilities. I undertook the final task of making sure everything read correctly, was clear, and that transitions phased one lesson plan into the next. Yvonne and Charlene did the word processing and the graphics.

## PRESENTATION OF FINISHED PRODUCT TO SSNTA MANAGERS

Before the "OK" was given for the pilot presentation, the training managers received an overview of the final product. On March 18, 1988, Alice Ipock and I made the presentation to the training managers at their meeting in Florida. This presentation was conducted nearly 12 months to the day from the first committee meeting held in 1987.

Each training manager as well as Walter Popp, representing INPO, received a complete package of the training materials including a Cross-Referenced Task List (Attachment B) and copies of the two example videotapes.

## PILOT PROGRAM

In August, 1988, a pilot program was conducted. Don Smith, Drew Bottemiller, and Nathaniel Smith conducted the training. The pilot was successful and the curriculum design up-held. Approximately 20 simulator instructors participated in the pilot; there were six observers representing INPO, the NRC Office of Operator Licensing, and several Northern utilities. Several recommendations and comments to clarify the role of the course in the industry as perceived by the developers, editors, and pilot instructors warrant repetition.

1. The participants are expected to have basic instructional skills training and classroom materials development and presentation experience prior to participating in the workshop.

2. The workshop is designed for the conference room training environment, with 8-12 participants.

3. Each utility is expected to adapt selected learning activities to the simulator if one is available.

4. The course is designed for a "new" simulator instructor, not an experienced simulator instructor. (Portions of the material can certainly be adapted as continuing training overviews. Experienced simulator instructors should make the

site-specific videotapes crucial to the instruction, and thereby provide examples of sound instruction as well as reinforce their own skills.)

After the pilot, a final editing prior to distribution was necessary.

## FINAL EDITING

With the completion of the pilot and based on instructor, participant, and INPO representative recommendations, Yvonne Logan and I, assisted by Barbara Dunlap and Charlene Baker, completed the final reorganization of the lesson plans and the final editing in December 1988.

The final list and sequence of lesson plans that constitute the simulator instructor training program is presented below.

<u>Simulator Instructor Training Program</u>

Preface

Program Introduction

1. The Role of the Simulator Instructor
2. Cognitive Behavior Applications in Simulator Training
3. An Introduction to Some Techniques of Using the Simulator to Enhance Adult Learning
4. Oral Questioning Techniques in Simulator Training
5. Developing and Using an Effective Scenario/Exercise Guide
6. Developing Effective Observation Skills
7. Evaluating Trainee Performance in the Simulator
8. Conducting a Critique

Summary and Participant Critiques

## DISTRIBUTION TO THE INDUSTRY

In December, 1988, all managers in the Southeastern States Nuclear Training Association were sent copies of the completed instructor guide. Each chairman of the other regional training associations were sent copies of the instructor guide for distribution among members of their region as they saw fit.

## SUMMARY

The project was enormous and undertaken by all participants on behalf of their specific training needs and their perceived training needs of the industry at large. It has never been intended that these instructional materials be considered the definitive statement on initial simulator instructor training. The materials have been developed, piloted, and edited to provide the industry with what is hoped will become valuable guidelines and adaptable instructional materials for improving simulator instructor training.

It is incumbent upon each utility to provide the most instructionally sound videotapes possible to augment this training. It is fully expected that the materials will be enhanced by each utility to meet site-specific needs. It is hoped, though, that short-cuts will not be taken in the presentations and that these materials will provide the basis for the development and implementation of even more effective and more refined simulator instructor training throughout the industry.

## CONCLUSIONS

The workshop addresses professionalism and the significance of the simulator instructor to nuclear power plant operations. A handout that I wrote and included in a lesson plan on oral questioning accompanies this report as Attachment C. Repeatedly throughout the training materials, the points of professionalism, scope of responsibility of the simulator instructor, and the role in reinforcing operator or license candidate knowledge of systems, integrated plant operations, board manipulations, articulation during walk-throughs, and applicable procedures were reiterated.

In preparing the paper, a two-fold topic emerged: 1) the dynamics of the project working group; and 2) the actual finished product - the materials themselves. The materials have been developed. The need has been met. Underlying the effort though was the idea that the participants were working:

- to focus on a very complex challenge;
- to meet a need of the industry at large; and
- to meet the need together.

The project itself speaks to the expanding development of nuclear professionals. Additionally, the tangible results of the project speak to:

- the willingness of the participants to share time and talents openly with one another;

- the desire of the training managers to allocate personnel time and resources to the project; and demonstrates

- the need for utilities to work even more closely together to solve their problems in the training areas.

During the project, the representatives merged their talents to define and refine yet another dimension of professionalism in the nuclear power industry - the training of the beginning simulator instructor.

## THE FUTURE

What does the future hold for simulator instructor training? What now becomes acceptable as continuing training? That depends on many factors. Larry Gardner suggested the following for continuing training:

> "A continuing training program is needed. This is necessary to ensure proficiency is maintained consistent with the latest INPO guides and industry practices. This program could simply consist of annually attending a seminar and visiting another power station's simulator to observe and to compare techniques."

The perception of the committee members, of which Larry was one, was that simulator instructors are a small and rather elite group in the nuclear power industry. The idea of an annual seminar with presentations on "state of the art" topics and innovations received overwhelming support from the participants. Not everyone could attend every year; not everyone could present papers; but representatives from the utilities could attend and share the presentations with colleagues.

It would be much less than fair not to acknowledge that there is undoubtedly teamwork throughout the nuclear power industry. In this one example, it was my experience to be able to participate in all but one meeting, to meet with colleagues, to struggle together with the challenge, and to watch all of us enhance our individual talents based on our interaction with each other. The success of the project rests solely with the commitment of each member from the chairman of the project, Steve Frye, to each of us who took a part. The Simulator Instructor Training Program was a fine example of utility teamwork that continues today.

# PANEL DISCUSSION

## A NEW PERFORMANCE-BASED EXAM PROGRAM FOR LICENSED REACTOR OPERATIONS

Ralph A. Cooley, NRC
R. J. Mette, SCE
Tom TIpton, NUMARC

# A NEW PERFORMANCE-BASED EXAMINATION PROGRAM FOR LICENSED REACTOR OPERATORS

R. A. Cooley S. Guenther

ABSTRACT

Nuclear power plant operators licensed by the U. S. Nuclear Regulatory Commission (NRC) are required to participate in continuing ("requalification") training programs sponsored by their facility licensees. The NRC has developed a new performance-based examination methodology to evaluate the proficiency and currency of power plant operators and the effectiveness of the facilities' programs. This examination methodology includes an operating test and a written examination, each involving two parts.

The operating test allows the examiner to observe the operators' actions during simulated accident scenarios and during a plant walk-through. The simulation facility demonstration is designed primarily to evaluate the performance of the combined control room crew, while the plant walk-through evaluates individual operators' abilities to correctly perform tasks (Job Performance Measures (JPMs)) that are important to safety.

The two-part written examination is conducted in a static simulator and in a classroom. Both parts are administered in an open reference format in which the operators have available to them the same reference material that they would normally have available in the control room for use in operating the plant. This allows the operators to display their ability to monitor, predict and analyze operational data and to follow procedures for accidents that may exceed the design basis of the plant.

The facility being evaluated provides proposed materials for the examination development which includes simulator scenarios, JPMs and written exam questions developed by the facility in accordance with its systematic, performance-based training program and two senior reactor operators to provide the NRC with facility specific technical assistance in the preparation of the examination. The operating tests are administered by the facility evaluators

with NRC examiners evaluating and asking follow-up questions. The written examination is proctored by the NRC. The operating tests and the written examinations are parallel graded by the NRC and the facility. Any significant differences in the grading are used in the evaluation of the facility's requalification program.

This new examination program provides a more realistic operational setting than ever before. Trials of the program were highly successful and full-scale implementation is currently underway.

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## INTRODUCTION

Operators licensed by the United States Nuclear Regulatory Commission (NRC) to operate nuclear power plants are required to participate in continuing ("requalification") training programs. As part of these requalification programs, operators must successfully complete annual operating and biennial written examinations administered by their facility licensees. Additionally, NRC rules require that at some time during the term of each operators' six year license, he or she must pass a comprehensive written examination and an operating test administered by the NRC.

## EARLY EFFORTS

The NRC's early efforts in conducting requalification examinations employed the same methods and techniques used for initial operator licensing examinations. Over a period of time, it became evident that the programs which had been implemented to enhance reactor safety were not providing adequate assurance to the NRC that they were fulfilling that goal. The early efforts were very similar to an initial license exam in order to renew his or her license for another two years. The requalification training programs were evaluated by examiners when they visited a site to administer license exams. This evaluation was principally a paper review of the training material and reviews of the quizzes and exams used by the facility to determine the level of the material taught and the difficulty of the evaluations performed by the facility. The feeling that there was a lack of assurance provided by these processes led the NRC to consider and evaluate a number of different requalification examination approaches, with a range of successes and has resulted in the development of the process being presented here.

## NEW METHODS

Since that time, the NRC has developed and tested a new methodology for assessing the effectiveness of facility requalification training programs and the proficiency of their operators, maintaining the goal of enhancing plant safety. The new requalification methodology utilizes existing industry training program standards to develop and administer the examinations. By administering requalification examinations that are consistent with existing facility-developed continuing training programs, the NRC reduced the impact on the facilities and their operators while improving the reliability, validity and credibility of our program assessments. No longer are we criticized for disrupting the facilities' systematic approach to training in order for them to conduct training on what they expect the NRC to ask.

## SYSTEMATIC APPROACH TO TRAINING

To be compatible with our new assessment methodology, the facility's requalification program under evaluation had to be both systematically developed and performance-based.

The content of the facility's continuing training program was derived from an analysis of the performance requirements of the operators' job. That is, a job/task analysis (JTA) was performed to determine the frequency, difficulty and importance of various tasks performed by licensed personnel. The JTA identified the knowledge, skills and abilities (KSAs) required to perform the operators' job. The training staff utilized the JTA and appropriate management feedback on operator performance in developing the continuing training program. The topics selected for continuing training emphasized infrequently performed, job-related tasks and associated KSAs important to reactor safety, new or modified equipment and procedures and safety significant nuclear industry events.

## OPERATING TEST

Each NRC requalification examination under the new methodology included an operating test and a written examination, each of which was comprised of two distinct parts. The first part of the operating test was conducted in a simulation facility, which allowed the examiners to observe selected control room crews during simulated transient and accident scenarios. The focus during this portion of the examination was on the crew rather than the individual, with emphasis on the evaluation of time critical and team dependent behavior. Each scenario was developed to facilitate evaluation of all crew members at their appropriate license levels by exercising their abilities in the use of emergency operating procedures, the emergency response plan, and the facility's technical specifications. The scenarios were verified against the facility's requalification program learning objectives prior to administration and were reviewed to ensure all required tasks met minimum importance rating criteria as identified in the NRC's generic knowledge and abilities catalogs or the equivalent plant-specific documents. The NRC examiners and facility representatives worked in concert to identify "critical tasks" that were crucial to plant safety in each scenario. The success of a crew or individual to correctly perform these "critical tasks" established a basis for a satisfactory evaluation on this portion of the examination.

WALK-THROUGH

During the plant walk-through, individual operators were evaluated on their ability to correctly perform plant tasks that are important to safety. The emphasis of this mode of testing was to ensure that the operators have maintained their understanding of, and proficiency in performing selected system tasks. The facility trainers, in concert with the NRC, identified a number of plant systems which play an important role in protecting the public health and safety. Systems which were covered during the requalification cycle, new or recently modified systems, probabilistically-identified risk dominant systems and components, and systems which were the subject of recent licensee event reports or NRC generic communications were emphasized in the selection process. The facility's JTA and learning objectives and the NRC's knowledge and abilities catalog were then reviewed to identify salient tasks for each of the selected systems. Each of the identified tasks was then developed into a Job Performance Measure (JPM) which was used in evaluating the operators' adherence to specific performance elements and standards. The initial conditions, initiating cues, references, performance elements, knowledge areas, output statements and critical steps were defined for each JPM to facilitate evaluation of the operators' abilities and underlying knowledge.

Each operator's walk-through evaluation tested his or her ability to perform a selection of ten JPMs covering activities both in the control room and at other locations throughout the plant. Some "common" JPMs were administered to each operator being examined in an effort to assess the requalification program's effectiveness in addition to the individual operator's proficiency. Each walk-through examination was reviewed and approved by the NRC prior to its administration. NRC examiners monitored the examination process, asked questions of the operators as necessary to ensure adequate system knowledge and JPM coverage, and made independent assessments of the operators' performance and the evaluator's examination.

## WRITTEN EXAM

A two-part, open reference written examination was administered to assess the operators' knowledge of plant systems, procedures, and operating limits. The "plant operations" section was administered on a static, or "frozen", simulation facility and was designed to evaluate the operators' knowledge of plant systems, integrated plant operations and instruments and controls. This section was also used to evaluate the operators' ability to diagnose postulated events and to recognize Technical Specification Limiting Conditions for Operation. During this portion of the examination the simulation facility was "frozen" with the reactor either at power, but with some equipment in an abnormal status, or shutdown as a result of a major transient. The operators then used the simulator and any other material normally available to them in the control room as reference tools in answering written examination questions. A minimum of two different "frozen" conditions were evaluated. One of these involved a major transient with an engineered safety features actuation system initiation

The "procedures" section of the written examination was also in an open reference format but was administered in a classroom setting. It was designed to evaluate the operators' ability to analyze a given set of conditions and determine the proper procedural steps and administrative practices. The operators were given access to the same abnormal, emergency, and administrative procedures that would be available to them in dealing with similar real world situations in the control room. Normal procedures were de-emphasized in the requalification examination administered by the NRC.

## QUESTION BANK

The written examination sections were constructed primarily from proposed items provided in a question bank by the facility. The NRC reviewed and modified the proposed items as necessary to ensure accuracy, clarity, importance to safety, and appropriateness for an open reference format. Each item was tied to the facility's JTA and satisfied the minimum importance rating requirement in the NRC's knowledge and abilities catalog or an equivalent plant-specific document. Both the facility and the NRC developed a plan for drawing from the bank of approved items in constructing an examination. These test specifications were used to determine the percentage of the examination to be derived from various topic areas. The NRC examiner had the opportunity to choose substitute NRC-developed questions to round out the questions drawn from the question bank, as a check on examination security, or to cover a topical area not addressed by the facility. (In fact, in the prototype program, the NRC participated actively with the facilities in the development of their examination question banks.) NRC examiners constructed the final examination using their plan and the facility's best estimate of the time required to respond to each test item to ensure that a competent operator is able to complete the examination within the allotted time. Prior to its administration and with proper security, the completed examination was subjected to a final review by the facility's training and operations representatives to ensure clarity, technical accuracy and operational and safety significance.

## NRC-LICENSEE COOPERATION

The implementation of the new requalification methodology involved a significant cooperative effort between the NRC examiners and the facility's training and operations staff. The NRC and the facility licensees worked together in developing, administering and grading the examinations. The written examination items, the walk-through JPMs and the simulator scenarios were co-developed and agreed to by both parties prior to administration. To the extent practical, objective criteria were developed for evaluating the results of the operating test. Individual and crew performance during the operating examination were monitored by NRC and facility examiners, with both parties developing independent pass/fail decisions. The NRC has the responsibility for and makes the final determination on pass/fail with respect to the individual candidates and the overall program. Similarly, examiners from both the NRC and the facility utilized a pre-approved answer key to independently grade each operator's written examination. All differences in opinion between the NRC and the licensee regarding an operator's passing or failing any portion of the examination were evaluated and resolved. The licensee's ability to satisfactorily evaluate the proficiency of its operators was the NRC's primary criterion for evaluating the adequacy of its requalification training program. Although the NRC and the facility licensee shared responsibility for constructing, administering, and grading the examination, the NRC retained final authority for the results.

## SUMMARY

Whereas the NRC's initial efforts to evaluate facility requalification training programs were based solely on individual operator performance, the new methodology assessed both operator proficiency and program effectiveness. It was founded on performance-based, systematic approach to training techniques which minimized impact on the operators and the facilities, while improving the overall assessment reliability through the use of passive evaluation techniques and objective grading criteria. Since it was based on industry-developed job task analyses and tested the operators in their work-related environment, the new process resulted in a more realistic and operationally oriented assessment than ever before. This, coupled with the facility and NRC shared construction, administration and grading of the exams, has effectively de-fused the criticism regarding the credibility of NRC administered exams and examiners.

The new methodology has been very favorably received by both the nuclear power utilities and their operators. By implementing a performance-based and systematically-derived evaluation methodology, the NRC has provided added impetus to the utilities to adopt compatible training principles. The Nuclear Management and Resources Council (NUMARC), the Institute of Nuclear Power Operations (INPO) and the regional utility training associations have sponsored a series of workshops to assist the utilities in making the transition to the new program.

Trials of the new examination program have been highly successful. Each of the five pilot examinations administered between December 1987 and June 1988 provided valuable insights which were fed back into the program during subsequent examinations. Facility and individual operator performances on the pilot examinations were, for the most part, satisfactory. The individual pass/fail decisions made by the facilities' and the NRC's examiners were highly consistent.

# INDUSTRY ACTIVITIES ON OPERATOR REQUALIFICATION

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(NUMARC)

## ABSTRACT

The NRC has developed a new performance-based exam program for operator requalification exams. NUMARC has worked very closely with the NRC, INPO, and the Regional Training Associations during the pilot phase of its development. Guidelines were developed and discussed at four co-sponsored workshops. Additionally, NUMARC sponsored a one-day industry meeting to discuss how utilities can organizationally plan methods of sharing work products to develop the operator requalification examination materials. NUMARC's Operator Issues Working Group, chaired by Don Schnell, Senior Vice President, Union Electric, has been directly involved in all phases of this issue. The revised requalification program was fully implemented in October 1988. NUMARC will continue to work closely with the NRC to facilitate a smooth transition into the revised process.

## INDUSTRY ACTIVITIES ON OPERATOR REQUALIFICATION

The process of licensing and requalification of operators has received intense scrutiny by both industry and the NRC. Over the past several years, a major concern developed because of the apparent lack of focus between the direction taken by industry in the continuing training and requalification of operators within accredited programs and the direction taken by the NRC in their requirements for operator requalification.

The NRC made revisions to 10CFR55 that became effective in May 1987. As you know, the Commission staff response to the requirements of the new Part 55 was to develop a plan to administer NRC-developed requalification examinations on a random basis to operators with only two weeks advance notice. This plan for requalification testing created major problems among licensed operators all over the country and inspired the formation of the NUMARC Working Group on Operator Issues in December 1987. Don Schnell, Senior Vice President at Union Electric Company, is chairman of this group.

In response to the overwhelmingly negative reception the new process received, the NRC convened a public meeting in September 1987 to discuss the issue. Prior to the meeting NUMARC called together a group of involved industry people to try to understand the major problems and to prepare for the upcoming meeting. NUMARC asked its members to participate in this meeting and several operators, trainers, and management personnel from utilities voiced their concerns on the direction being taken. The concerns expressed were not limited to the impact on people and training programs; the issue of basic plant safety was involved -- raised by the potential loss of large number of experienced operators. Based on its internal review and the September public meeting, the NRC was receptive to the concerns expressed and immediately suspended all requalification testing pending a reevaluation of the process.

Then in November 1987, the NRC arranged another public meeting and presented a completely revamped requalification examination process. This new process was designed to address the valid concerns of the industry while fulfilling the NRC's obligations under Part 55. The process consists of three major elements:

- An operating test administered on a simulator;
- Performance of tasks during a plant walk-through, with well-defined Job Performance Measures (JPMs); and
- A two-part written examination consisting of open-reference questions.

The emphasis within all elements of the new examination process is to assess whether operators possess the knowledge and capabilities necessary to perform their jobs. To ensure that the examinations are performance-based, operationally oriented, and valid, the NRC uses utility-supplied simulator scenarios, JPMs, and open-reference written questions to construct the exams. To accomplish this, the utility assigns an operations department SRO and a training department license trainer, who is an SRO or is certified, to work with the NRC exam team several weeks in advance to assist in examination construction and validation.

The Commission implemented this new process on a pilot basis at H. B. Robinson in Region II, Fort Calhoun in Region IV, San Onofre in Region V, Perry in Region III, and Salem in Region I. All pilots were completed in 1988. The utilities involved in the pilots are unanimous in their view that the new exam format is a significant improvement over previous requalification processes. Summarizing their comments:

- o Utility personnel considered the exam to be operationally-oriented and compatible with INPO-accredited training programs;

- o The involvement of utility personnel with the NRC in preparing the examination addressed past concerns about the validity of exam questions, simulator scenarios, and JPMs; and

- o The format of the examination, which also evaluates team skills, enhanced the operational relevance of the process.

Several opportunities for improvement noted during administration of the pilots have been worked on by both the industry and the NRC. The major issues have been the scope of plant walk-through tasks and the availability of suitable Job Performance Measures, the development of open-reference questions, the reduction of the length of utility-developed simulator scenarios to fit the exam format, and the development of more explicit simulator evaluation criteria.

The NRC issued an updated version of its document entitled "Requirements and Procedures for Requalification Examinati ," which is formatted as a draft Examiner Standard. This document has been revised based on the learning experience from the pilot exams.

The NRC fully implemented this new requalification program evaluation process in October 1988. Over the last several months of 1988, NUMARC worked with utility representatives and the NRC to help industry meet this schedule. As illustrated by the pilot plant experience, several key activities must be completed by a utility in preparation for this new process. These activities include:

- o Developing a bank of open-reference questions;
- o Developing suitable simulator scenarios;
- o Identifying operator tasks within "safety significant" systems; and
- o Developing Job Performance Measures that can be readily used for the walk-through examination.

I must emphasize that, based on the pilots, considerable front end preparation work is required of each utility to be ready for the exam. For example, we have found that during the pilot phase it took four to six man-hours to develop and validate each open-reference question. NUMARC assisted in this effort in several ways. Specialized task groups of the NUMARC Working Group made up of people from member companies, with the help of INPO, developed guidance for constructing open-reference questions, simulator scenarios, and Job Performance Measures.

Four regional industry workshops co-sponsored by NUMARC, INPO and the applicable utility regional training association were held in July 1988 in Atlanta, New York, Denver and Chicago. There were 372 attendees including 262 utility representatives and 58 NRC representatives. These workshops included breakout sessions during which the industry guidelines were discussed and questions answered by the utility and the NRC representatives. Proceedings of the workshops were prepared by NUMARC and distributed to the workshop participants.

NUMARC sponsored a one-day industry meeting in Atlanta, Georgia on November 10, 1988 on sharing operator requalification examination materials. The purpose of the meeting was to share information on the question bank development initiative by the Southeastern States Nuclear Training Association (SESNTA) and to provide a forum for other utilities to organizationally plan methods for sharing their work using, for example, the SESNTA methodology or other approaches to reduce the impact on each.

The objective of the SESNTA activity is to provide a cost-effective method for sharing operator requalification test materials so that the resource requirements at each nuclear site in Region II can be reduced while increasing the rate of test material production. Their intentions were to have 700 open-reference written examination questions, 77 Job Performance measures, and 15 simulator scenarios completed by January 1989. These generic test items forms a resource base from which each utility may draw on when writing plant-specific test items.

To conclude, these changes in the operator requalification process are encouraging. The NRC has shown its willingness to listen to valid concerns of licensed operators. They have moved quickly to modify the way that requalification evaluations are conducted in order to address these concerns while fulfilling their regulatory responsibilities. NUMARC will continue to work closely with the NRC to facilitate a smooth transition to this new process and to ensure that industry expertise and comments are factored into its development and application. We all want a fair, effective, and realistic requalification examination process.

# TEAM SKILLS TRAINING: THE CRITICAL NEXT STEP AT GPU NUCLEAR

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## ABSTRACT

Numerous reports and articles have been written recently on the importance of team skills training for nuclear reactor operators. But little has appeared on the practical application of this theoretical guidance. The Training and Education at GPU Nuclear (GPUN) has initiated a high level of activity and commitment to team skills training.

In 1987, GPUN undertook a significant initiative in its licensed operator training programs to design and develop initial and requalification team skills training. Prior to that time, human interaction skills training (communication, stress management, supervisory skills, etc.) focused more on the individual rather than a group.

Today, GPU Nuclear conducts team training at both its Three Mile Island (TMI), PA and Oyster Creek (OC), NJ generating stations. Videotaped feedback is used extensively to critique and reinforce targeted behaviors. In fact, the TMI simulator trainer has a built-in, four camera system specifically designed for team training. Evaluations conducted on this training indicated these newly acquired skills are being carried over to the work environment. Team training is now an important and on-going part of GPUN operator training.

# INTRODUCTION

Historically, licensed operator training in the nuclear power industry has focused on the technical aspects of control room operations. Training programs for reactor operators (RO's) and senior reactor operators (SRO's) are designed to include many months of training on the technical requirements of the job. Periodic requalification training is conducted to review and/or update those skills. With the advent of training on plant-referenced simulators, the focus, initially, remained highly technical. Simulator training programs have stressed following procedures to avoid and mitigate potential problems.

There is no doubt that the technical aspects of reactor operation are of vital importance. The nuclear power industry could not exist without this training. GPU Nuclear believes, however, that there is another consideration to safe and reliable reactor operation that also deserves attention, that is, the ability of a group of individuals to function effectively as a team.

Systematic training in team skills for RO's and SRO's bridges the gap between technical knowledge and on-the-job performance of licensed operator skills. In response to guidance from the NRC, NUMARC, and INPO, GPU Nuclear assembled a team to design, implement, and evaluate team training. The group applied GPUN's Training Systems Development (TSD) process as they wrestled with such questions as: What tasks require team skills? How much of the training should be generic? How much plant specific? Who should provide the training? In what settings? How should we evaluate its effectiveness?

## The Analysis Phase

Believing that team skills training are an important part of operator training, GPUN management formed a Diagnostic and Team Skills (DATS) Project Team to conduct a job analysis. The team consisted of individuals from plant operations, operator training, corporate training, and management training. The results of the job analysis overwhelmingly showed that close to two-thirds of the tasks would involve some sort of teamwork or diagnostic skill application.

At this point, the DATS Team decided to limit their continuing effort to only team skills training. Originally, the group thought that diagnostic skills could also be included in the training package. But due to time and other resource constraints, the diagnostic skills training would need to come later.

With a clear mandate of the job analysis conducted by subject-matter experts, as well as management support and initiative, the project was ready to move into the next phase.

## The Design and Development Phases

The main thrust of this phase was the development of objectives and lesson plans that would enable the training to take place. At this point some very important decisions had to be made. How much of the training would take place in the classroom? How much would take place in the simulator? Should we videotape the operators in the simulator and then let them critique themselves? Should a professional consultant conduct the critiques or should GPUN trainers do that? How will we know that the training has been successful? What performance indicators should we evaluate to determine effectiveness?

Finally the most important decision still needed to be made. What should be the framework of the training, and what exactly did we hope to accomplish within that framework -the overall design of the training and the objectives? We decided to review the guidance found in two documents: NUREG/CR 4258, An Approach to Team Skills Training of Nuclear Power Plant Control Room Crews and the INPO draft TQ-503, Guideline for Teamwork and Diagnostic Skill Development.

Thus, the training would be divided into three broad categories: generic team skills, operational team skills, and team skills application. The first two parts of the training would take place in the classroom setting. The application portion would take place in the simulator. Then the operators would have the opportunity to critique themselves immediately following the taping. In this way, positive behaviors could be reinforced and improvements could be suggested while the experience was very fresh in the minds of the operators.

Next came the difficult chore of writing the objectives. Much of the time spent by the DATS Team was concentrated on discussing the wording, number, validity, etc. of the objectives. Finally, the following broad objectives were accepted by all parties for the Generic Team Skills:

1. In a control room environment communicate required information to all team members as per AP 1029. (Administrative Procedure 1029 is entitled, "Conduct of Operations" and is the document that drives much of the activity in the TMI Unit 1 control room. The purpose of the procedure is to "establish guidelines and requirements for the safe, formal and professional conduct of operations in the plant." It also "insures attentiveness to assigned responsibilities and... clearly establishes the authority and responsibility of Licensed Operators on duty to shutdown the plant when conditi warrant.) The DATS Team believed that the criteria to evaluate the effectiveness of the generic team skills training should be firmly rooted in AP 1029.
2. In a control room environment, provide performance feedback when required per AP 1029.
3. In a control room environment, pursue and validate alternatives, concerns and questions per AP 1029.
4. In a control room environment mitigate the effects of stress on individual performance during normal and off normal conditions as per AP 1029.

5. In a control room environment, resolve conflicts per AP 1029.
6. In a control room environment, SS/SF/CRO effectively leads the team as per AP 1029

The operational team skills objectives also reflected the guidance found in the NUREG and AP 1029. They mirrored and expanded upon the generic team skills, facilitating the transition from the classroom "theoretical" information to actual implementation in the control room. The nine (9) skills we agreed on are as follows:

1. Request, receive, acknowledge and provide information to or from other team members.
2. Interpret and evaluate information from other team member or plant instrumentation.
3. Assign specific tasks and direction to the team or team members both inside and outside the Control Room.
4. Evaluate the effectiveness of the actions taken by the team or team members.
5. Coordinate the activities of the team both inside and outside the Control Room.
6. Recognize and diagnose the causes of off-normal events.
7. Evaluate options to arrive at a best alternative for action.
8. Develop appropriate courses of action for the team.
9. Establish a pace of activities which satisfies operational needs yet does not promote a loss of coordination or control.

Finally, as part of the design and development phase of the project, we decided to use the services of a professional consultant to conduct videotape critiques. The individual chosen had done this type of training before and would have much credibility and experience to relate. To further support the training effort, a $35,000 audio/video taping system was purchased and installed permanently in key locations throughout the simulator.

In addition, we decided to conduct an in-house pilot course evaluation. Later, on-going videotaping in licensed operator requalification (LOR) training programs would provide deeper insight into the worth of the intervention by measuring learning and behavior changes. A major story in the company newspaper at TMI provided a rare opportunity to measure results, the highest level of evaluation, and often the most difficult to measure.

## The Implementation Phase

The teamwork training for the instructors was implemented first at TMI during August 1987, and then later that year for the operators. To equip the instructors with the facilitation skills they would need, the Senn-Delaney Leadership and Team Building staff conducted a three-day, facilitator course. The staff and Mr. Doug Harrington, the private consultant, observed the pilot teamwork training conducted for instructors. Their comments helped to fine tune the course for presentation to the crews.

Approximately six (6) hours were spent on the classroom portion of the generic team skills training. Lectures, discussions, and small group exercises were conducted to review and reinforce skills that many of the operators already possessed. Many of the operators were surprised that they already possessed some of these skills. The training also introduced other skills that were relatively new to the operator culture. Feedback during various evaluations indicated a need to revise the training in order to mitigate the cultural shock.

The operational team skills were the heart of the classroom training and provided a bridge from the generic to the on-the-job application portion of the training. Operators viewed the film "Why Planes Crash" and discussed implications for the operation of a nuclear power plant. They also viewed videotapes of themselves taken earlier in the training cycle. They analyzed their behaviors in the context of the operational team skills learning objectives. Operators were shown examples of positive team skills behavior and other behaviors where improvement could be made. Needless to say, the discussions were lively and provided much grist for thought!

Next, the operators were filmed once again in the simulator and encouraged to critique their performance. This time, they had had the opportunity to view former behaviors, hear and discuss suggestions for improvement, and choose to change or reinforce their own behaviors. Once again the discussions were spirited to say the least!

Finally, in this phase, comments were collected on trainee reaction forms, instructor reaction forms, and course evaluator forms. This data was used to prepare the Team Skills Pilot Course Evaluation. Comments were collated and a report submitted to operations and the operator training managemen. Appropriate changes were made to the course before the next offering.

Based on the initial experience at TMI, Oyster Creek operator training management decided to use even more of the skills of Mr. Harrington. In their first time offering, he conducted all of the classroom training as well as the critique of the videotaping in the simulator. Also, a "Teamwork and Diagnostics" module was added to the initial classroom training using case studies to predict plant behavior and mitigate the consequences. TMI operator training now uses Doug for some of its requal training programs.

## The Evaluation Phase

As mentioned previously, the initial evaluation was an in-house pilot course evaluation which collected and reported reactions to the training activity. Reactions ran the gamut from "information of questionable value" to "very good course; needs to continue throughout the year. Nevertheless, positive comments exceeded the negative by a ratio of approximately three to one.

Officially, the course evaluation identified five (5) internal good practices and six (6) suggested revisions, based on all the input from instructors, operators, and the course evaluator. Appropriate changes were made to the training, pending further input from evaluations conducted on-the-job. These observations would deal with <u>actual behavior changes</u> in the control room.

Unfortunately, despite all of the effort, little objective behavior modification occurred in the operator crew cultures. Reality hit hard early in 1988 when an INPO Evaluation and Assistance Team observed 24 hours of crew performance on the simulator and found the control room operators had selected communications and team skills deficiencies. This finding resulted in a redesign of the team skills training course.

The revised communications and team skills training has recently been implemented for all crews. The significant difference is in the details provided to each team member on their individual role and responsibilities within the team.

The old course focused on the "soft" skills and allowed each crew to develop its own culture. We have abandoned this approach and replaced it with a system that much more rigidly defines who says what and when. It clearly establishes the times and lines of communication within the control room team. It also sets plant policy on silencing many simultaneous alarms to reduce the noise and stress level within the control room.

To enhance the instruction, Training produced a demonstration videotape to show the crews model communications during a casualty situation. The Plant Operations Director, TMI-1, played the role of the Shift Foreman on the tape to ensure that all control room operators could perform according to the TMI-1 Management Standard. In addition, Senior TMI-1 Management and a representative from the newly-formed Human Performance Evaluation System (HPES) group attended the training on the new communications guidelines.

We are now starting to see changes in control room behavior. The January 1989 annual simulator examinations revealed that much of the crew behavior has been effected. The general consensus is now that plant management is actively supporting and modeling team behaviors for the control room operators. Those behaviors are being reinforced in the team skills concepts.

As a follow-up based on feedback from the course observers, these new communications guidelines are also being delivered to non-licensed operators. In this way, communications and teamwork on the larger operator team will improve as well. TMI-1 is installing a modification to the control room alarm system to help reduce stress levels during a off normal activity when many simultaneous alarms degrade crew performance.

Team skills training for initial reactor operator candidates will also adopt the new guidelines. We plan to use Mr. Harrington to conduct a generic team skills course. Training will then complete the program by delivering the specific communications guidelines. We believe this approach to be the best of both worlds.

## SUMMARY

Much activity has occurred at GPUN over the past two years on the development and implementation of team and diagnostic skills training. A key factor in the learning curve was the involvement of plant management in the development and delivery of team skills training. Use of an outside consultant with much experience and credibility throughout the industry in this topic has proven beneficial. The next steps will include non-licensed operators in the training of team skills and indoctrination on the new communication guidelines and policies will bring significant changes in the "larger" control room operator team culture.

Where do we go from here? Plans are continuing to train even more personnel corporate-wide in the Senn-Delaney Leadership and Teamwork Skills. This strategy will enhance the effectiveness of the training being conducted exclusively for control room operating teams. Incorporating certain aspects as necessary of the new program on "Control Room Resource Management" developed by the Institute for Nuclear Power Operations (INPO) into our already existing program will further enhance its credibility and effectiveness. As time progresses, and the culture changes even more, other members of the plant team--maintenance, rad con, environmental protection, communications, etc. --will participate directly with control room teams in such training.

In the final analysis, everyone benefits from working together as a team. Remember the article in the company newspaper? It seems that a sharp-eyed reactor operator trainee took the initiative to ask about and discuss some strange indications he observed on the control room panel. As it turned out, after troubleshooting and visual inspection by operators, I & C technicians, and various management personnel, a valve was not open as far as it should have been.

Air pressure was dangerously low because the valve was slowly closing. The problem could have resulted in leakage and most likely a plant shutdown within a half hour. Because of the efforts, especially in team communications, the problem was corrected within 24 hours. One control room operator was quoted as saying, "It was a good catch. Things didn't look right... and all the experience he's gained with his crew on the Simulator during the year helped him recognize that something was wrong." Senior management added, "This is a good example of catching a relatively small problem early, thereby preventing a potentially larger problem from developing."

# LESSONS LEARNED FROM THREE YEARS OF OPERATOR TEAM SKILLS TRAINING

Douglas K. Harrington

There is an old saying in education that states, "If the learner hasn't learned, the teacher hasn't taught." A modern addition to that saying might go something like this: "If the teacher hasn't learned something along the way, the teacher hasn't been paying attention."

Three years ago this "teacher" became involved in an interesting and challenging project with a nuclear utility to develop a training program with the goal of improving the team skills of control room operators. After many hours of research, including interviews and observations of operators in their control room and in the control room simulator, a training program was developed. Now, three years and over three hundred operators later, it is time for the "teacher" to reflect on what has been learned from the experiences with these unique men and women who operate in a very complex and fascinating environment, the nuclear power plant control room.

## THE LEARNING PROCESS

It has become increasingly clear that team skills training is not just a training program, but rather an on-going learning process through which nuclear operators become increasingly aware of their behavior in a team and how that behavior either contributes to or detracts from the effectiveness of the team. As the operators continue in that process, they choose to make changes in their behavior that enhance their value to the team. This awareness does not always come easily, and it does not come from the trainer. The awareness comes as a result of the operators observing their own performance on videotape and from experiencing feedback from fellow team members, from knowledgeable facilitators, and from themselves.

Behavior change starts with an experience, not a lecture. Few of us learned the behaviors necessary for driving by sitting through a class on how to relate to a car. We learned by experiencing what it was like to get behind the wheel and adjusting our driving styles through feedback from someone sitting in the right seat and from things we observed ourselves. This principle became quite clear during the pilot program for the initial attempt at a team skills training program that began in January 1986 at a nuclear plant in the southeast. The students were prospective reactor operators and senior reactor operators in a license preparation class. The teachers were consultants, including myself, who had developed the program and had written the lesson plans.

Phase one of the training program included a videotaping session in the simulator with the class divided into teams of four operators. Following the taping, we, the consultants, watched the tape, without the operators present, and attempted to pick out "good" and "bad" team behaviors of each operator. A few days later, after writing the critiques, we gave the individual operators feedback on their strengths and weaknesses which they would be able to develop or change in the upcoming team skills training program. The fact the operators were less than enthusiastic about the feedback they had just received about their performance did not stifle our optimism.

We were, however, somewhat surprised at the lack of interest from the students during the four-day classroom portion of the training, but rather elated from the positive response to day five which included the simulator practice sessions with videotape replay and group feedback. One major clue to the problems with the training came from the student responses on the course evaluation form: "Shorten the classroom time and give us more simulator time."

Assuming we had simply picked a negative group for the first class, we made only minor modifications to the lesson plans and pressed on with the program. Again we experienced similar responses from the students with more of the same feedback: "less classroom and more simulator."

After three very similar experiences with more of the same feedback, we decided to make some changes. Simulator time was increased to give the operators more practice and feedback every day. Lectures were reduced, with classroom time being devoted to small group discussions in which the teams evaluated their performance from the previous day and discussed plans for improving their performance in the next simulator exercise. In addition, the phase one written report and feedback was replaced with immediate feedback for the operators by having the teams sit down with us and review their videotape following the simulator exercise. Teams were given a handout describing the team behaviors to watch for as they evaluated their videotaped performance. Our role was that of facilitator rather than evaluator as the operators critiqued their own performance.

Following these changes to the program, operator acceptance of the team skills concept improved measurably. Team members worked together enthusiastically providing honest feedback to each other and putting forth concerted efforts to improve areas of team skills in which they perceived themselves weak.

Lessons learned?

- Trust the team members to give each other the necessary feedback.
- Provide operators with the opportunities to get that feedback through numerous videotaped simulator practice sessions.

INFLUENCE OF THE SHIFT SUPERVISOR

While the primary purpose of team skills training was to increase the crew members' awareness of their individual behavior and the changes needed to improve their effectiveness as a team member, as the training moved from the license preparation classes to the requalification training of control room crews, an even greater influence on the team performance of crews became evident. After working with and observing the operating crews in six different nuclear plants, the influence of the shift supervisor's leadership style began to stand out as a significant contributing factor to the crew's performance as a team. Some styles seemed to promote and reinforce effective team behavior, while others created crews in which there was little or no team interaction.

No one will deny the need for confident and decisive leadership in the control room of a nuclear plant. In fact, the Nuclear Regulatory Commission, in evaluating the effectiveness of SRO's and control room supervisors, has, in the past, looked favorably on the strong, controlling "John Wayne" style of leader. This describes the leader who is willing to take charge, make decisions, and tell the rest of the crew what to do, when to do it, and how to do it whenever a problem arises in the control room. While this style of leadership may have been thought effective in the past, it has become very ineffective in today's modern nuclear power plant control room with its well trained and highly qualified operators.

Even though the over-controlling style of leader is ineffective in today's team oriented control room, the style seems to dominate many control room crews we have observed over the past three years. One of the reasons for this may be that the more controlling style has been reinforced over the years by the management of nuclear power plants as well as by the NRC. RO's, aspiring to become SRO's and supervisors, have as their role models those strong leaders who are admired and rewarded for their take-charge style. Thus, the controlling style is perpetuated as new supervisors and SRO's are promoted.

What is the problem with having the controlling leader in charge of the control room crew? One of the negative aspects observed in crews dominated by these leaders is the obvious lack of crew input during problem diagnosis. Most of the communication taking place within the crew is one-way from the supervisor to the operators. If information is communicated from the operators it is usually in response to a question from the supervisor. If doubts exist about the appropriateness of the supervisor's directions, those doubts may not be communicated. Assumptions are left unchecked because of the faith placed in the supervisor to know everything, or because of the reluctance of the operators to question the crew leader. Crew members become passive and wait to be told what to do, or they become totally supportive of the supervisor as a way of maintaining good relationships.

Lessons learned?

o Shift supervisors play a key role in whether or not individual crew members use effective team skills.

- If the shift supervisor's style of leadership does not permit crew member input or questions, it doesn't matter how much you lecture about the value of good team skills, they are not likely to become a reality in that crew.
- Shift supervisors must always take part with their crews in team skills training and feedback sessions following simulator exercises. At one plant, a shift supervisor chose to go on vacation during his crew's two-day team skills training session.
- Needless to say, shift supervisors must be open to feedback from their crew members. In some of the most successful crew feedback sessions conducted during the team skills training, the shift supervisor took the lead in seeking input from the crew members - not only on how the crew could improve its teamwork, but on how he could improve as well.

## WHAT IS A TEAM?

One of the first inaccurate assumptions we may make in preparing to teach a class on team skills is that everyone has the same definition of the term "team." I was often told by crews during the introductions that they were not sure why they were in this class because they had all been together for several years and got along just fine. Everyone does their job and they never have any problems in their crew. All too often these crews demonstrated the least amount of teamwork when performing in the simulator exercises.

As an example, a shift supervisor made the statement that his crew had worked together for a number of years and he was very pleased with their teamwork. Later that day in the simulator it was obvious he was correct. During the exercise, as the emergency scenario progressed, the supervisor became very busy trying to keep track of what was going on and what everyone was doing. He was moving about rapidly waving his hands and arms while barking out orders to his crew members. Little or no input was every received by the supervisor, only one-way communication from him to his crew. However, as that supervisor was defining teamwork, his crew was doing just fine.

Lessons learned?

- Begin any program on team skills with a clear understanding of what is meant by "team."
- Help crews understand that teamwork goes well beyond getting along with each other.
- It is not how well the crew can avoid conflict, but rather how constructively conflict is managed, and even encouraged, to find the best solution to the problem at hand, to produce better team

performance, and to help attain a higher level of individual fulfillment.

THE CULTURE OF THE CONTROL ROOM CREW

A crew, remaining as an intact team for several years, develops its own culture - ways of behaving or ways of doing things - that may or may not reflect the culture of the overall plant, and that possesses inherent strengths and weaknesses. As new members join the crew, they soon adjust and reflect the culture of that crew. Crew members, spending long hours together in the control room, develop a strong bond that carries over even into their private lives. It is not uncommon to hear operators talk about hunting or fishing during off hours with others from their own crew.

While distinct crew cultures are inevitable, in reality they can either support or hinder overall plant performance in subtle, powerful ways. When shift supervisors disagree with management about how things are done at the plant, they may share those feelings with their crew, thus directly inducing negative attitudes toward the plant and its management. These attitudes are soon reflected in the performance of the crews. Crews, in an adversarial relationship with the larger plant team, tend to lose trust in management and not feel a part of that larger team.

While no clear evidence is available on the impact of these divergent cultures on the performance of control room crews, the lessons learned open up possibilities for future studies into the impact of cultural differences on the behavior and performance of the crews, and the implications this may have for future team skills training. While the initial emphasis of team skills training has been placed at the control room crew level, the power of senior management's example suggests that team skills training start with plant or even corporate management and continue throughout the site. In an actual emergency situation, it becomes imperative for the entire plant to be working together and communicating as an effective team.

Team skills is currently in its infancy with many and varied possibilities for the future. While not fully supported today by the entire nuclear industry, the concept is beginning to gain wider recognition as a viable method for improving the performance of control room crews. However, for team skills to have its greatest impact in terms of plant reliability and safety, it must receive support and reinforcement from all levels of management. When the entire plant is operating as a team, everyone wins.

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# EFFECTIVE SIMULATOR TRAINING FOR BWR OPERATING CREWS IN JAPAN

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## ABSTRACT

The BWR Operator Training Center (BTC), established in 1971, has 2 full-scope simulators. (The third simulator is under construction and scheduled to go into use in October 1989.) These simulators are used to train all operators of BWR utilities in Japan.

A high level of ability by shift crews as well as individuals is required in order to maintain the safe and reliable operation of a nuclear power plant. The team training for each shift crew, called "Family Training", is conducted to upgrade team performance using the simulator. All operating crew members take part in Family Training which is a 1 day course, and each crew is trained 2 or 3 days a year.

In this training, the shift supervisor submits a training plan based on the tasks laid out for his crew members, and the BTC instructors' training technology contributes to the simulator exercises.

Consequently, the training needs of the operating crew and BTC training know-how are fruitfully combined to achieve the most effective result. It is a good feature that BTC can conduct team training for each utility using effective methods, which are acquired and accumulated by BTC from many years of experience.

## INTRODUCTION

As of March 1988, there are a total of 36 commercially operating nuclear power plants in Japan (BWR 19, PWR 16 and GCR 1). These power plants continue to operate in a stable and safe manner at continual high power levels as a result of thorough investigation of past events and subsequent modifications including a higher level of quality assurance.

In order to ensure safety and reliability of the plant, it is realized that the roles of the operators are important, hence, their continual training is absolutely necessary. The BWR Operator Training Center Corporation commonly referred to as BTC was established in 1971 with the objective of training such operators for all BWR utilities and has been in service since 1974. Currently, BTC possesses 2 full scope simulators. A third unit under construction is scheduled to start training operations in October of this year.

In Japan, we implement a 5 shift-system for operating 1 or 2 units from one main control room. Each shift crew consists of:

Shift Supervisor

Assistant Shift Supervisor

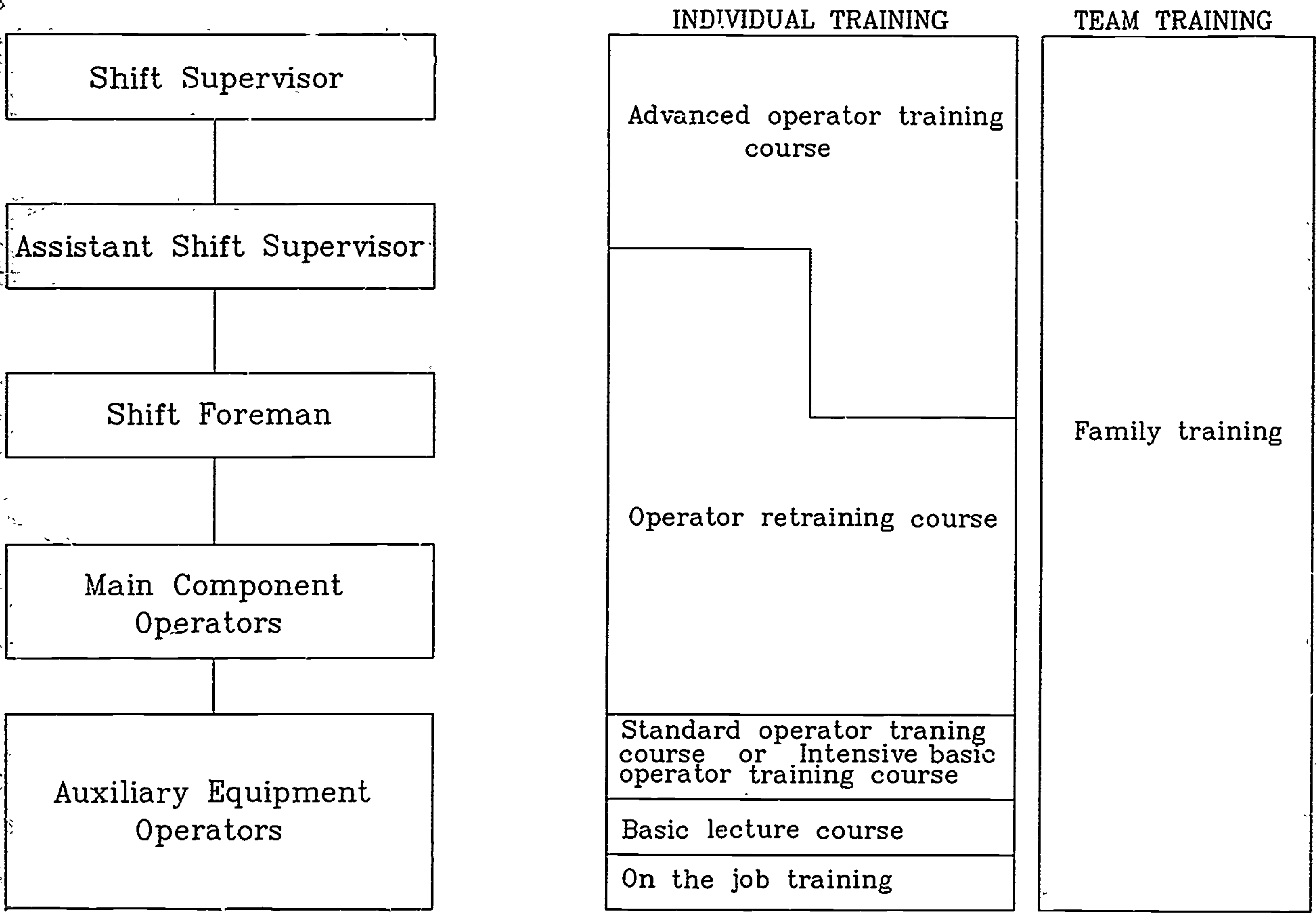
Shift Foreman

Main Component Operators

Auxiliary Equipment Operators

BTC offers 5 training courses (Fig. 1) based on respective operator level and experience.

FIGURE 1. COMPOSITION OF OPERATING CREWS AND APPLICABLE TRAINING COURSES



In training courses directed at individuals, 4 trainees from each electric power company make up a team and undergo both classroom and simulator training. This training style is beneficial to trainees who possess specialized knowledge of their individual companies by stimulating mutually intense study and offering the opportunity to exchange their individual plant operating experiences.

In addition to individual training, BTC offers crew training in order to improve performance as an operating crew. This is called "Family Training".

At BTC, Family Training for each crew is conducted 2 or 3 days a year either on a single day basis throughout the year or on subsequent days. Since the start of Family Training in 1976 and up to March 1989, BTC has provided training for a total of more than 1,200 teams (1 team equals 1 day of crew training).

This report presents our efforts to produce effective "Family Training" and its contribution to improving team performance.

## TRAINING FOR IMPROVING TEAM PERFORMANCE OF OPERATING CREWS

Operators undertake various training in order to fulfill their job responsibilities. Training options include those in which the operators can improve his own ability on an individual basis, such as learning the various systems and performing plant walk-throughs, as well as BTC simulator training. Other types of training include training in which the entire crew members participate so that their team performance can be improved. Table 1 illustrates an example of team based training.

TABLE 1. TRAINING CONDUCTED WITHIN THE BWR OPERATING CREWS

| TOPIC \ LOCATION | TRAINING WITHIN THE PLANT | BTC FAMILY TRAINING |
|---|---|---|
| Control Operation | Learn the Safety Regulation of their plant. | Confirm items to be obeyed during operation through use of the simulator. |
| Normal Operation | (a) On the job training<br>(b) Study procedure manuals | (a) Master the procedures by using the simulator<br>(b) Confirm coordination as a team |
| Abnormal Operation | (a) Study procedure manuals<br>(b) Review plant incident cases<br>(c) Training by panel mock-ups | (a) Master the procedures by using the simulator<br>(b) Experience examples of plant incidents<br>(c) Improve team performance |
| Emergency Situation (Response) | (a) Fire fighting drills<br>(b) Training for plant emergencies[a] | Confirm communication setup for emergency situations while using the simulator. |

[a] This training includes all plant personnel

The team based training can be divided into 2 vast scopes. One is training within the home power station, and the other is Family Training at BTC. The former consist of: the mutual study among operators regarding the Safety Regulations of their plants, the study of Procedures for Abnormal Conditions and the review of Examples of Accidents. Also as countermeasures for emergency conditions, there are fire fighting drills and accident state reaction training, which includes participation by all power station personnel.

BTC Family Training, which utilizes the simulator, is found to be most effective in improving the overall performance of the crew by employing the fruits of training conducted at their home power station. This simulator training is directed towards maintaining and improving both operational skill for normal startup/shutdown and response capabilities for abnormal conditions.

## OUTLINE OF FAMILY TRAINING

The objective of Family Training can be divided into 2 scopes. The first being maintaining and improving the skill of the individuals who compose the crew; in order to display better team performance, it is necessary for each and every one of the team members to maintain and improve his own skill according to his level and his responsibility. The emphasis of this scope is on transmitting the experiences and skills of the more senior operators onto other operators; especially, to learn the experiences of actual plants for prevention of error recurrence.

The second objective is improvement of the overall performance as a team. Included in this scope are the following:

(a) Improvement of skill in coordinated maneuvers among operators

(b) Improvement of skill with regards to interaction, direction and communication among all crew members.

(c) Re-confirming the scope of work of individual operators

An example of (a) would be the coordination between the reactor operators and the turbine/generator operators. When an operator is about to begin an operation, he should grasp the plant condition in a broad sense and must also understand the significance of his maneuvers. Therefore, in order to comprehend the condition of the plant correctly, and recognize what is most important under the circumstances, it is essential that the operators perform the operation by mutually communicating in a timely manner.

Simply put (b) means transmittal of effective information within the entire crew; for instance, the reporting of conditions from the operators to the shift supervisor and vice-versa. The shift supervisor must obtain abundant information from the operators, determine the direction of the maneuvers and give commands to the operators. This is most important, as a team, when taking correct action against abnormal conditions and for maintaining plant safety. Also, by transmitting information in a proper manner, potential errors can be prevented by mutual coverage.

In (c) each operator must recognize his own responsibilities as a crew member within the total team. By exercising practical operational training with the simulator, each operator recognizes what actions are required of him and which information he should exchange in order to contribute to the crew team performance.

Once items (a), (b), and (c) are achieved, mutual support is created among operators and a team is built which is capable of demonstrating maximum performance.

With this scope under consideration, the shift supervisor of each crew drafts a Family Training plan for his crew aimed at their specific needs. Based on this plan, the training contents are discussed with the BTC instructors prior to implementation of Family Training. BTC instructors assigned to each session will offer comments and advice, about the teams performance, based on their training experiences and viewpoints common to all utilities. As described above, by applying BTC training expertise to each crews training needs, BTC Family Training can produce excellent results.

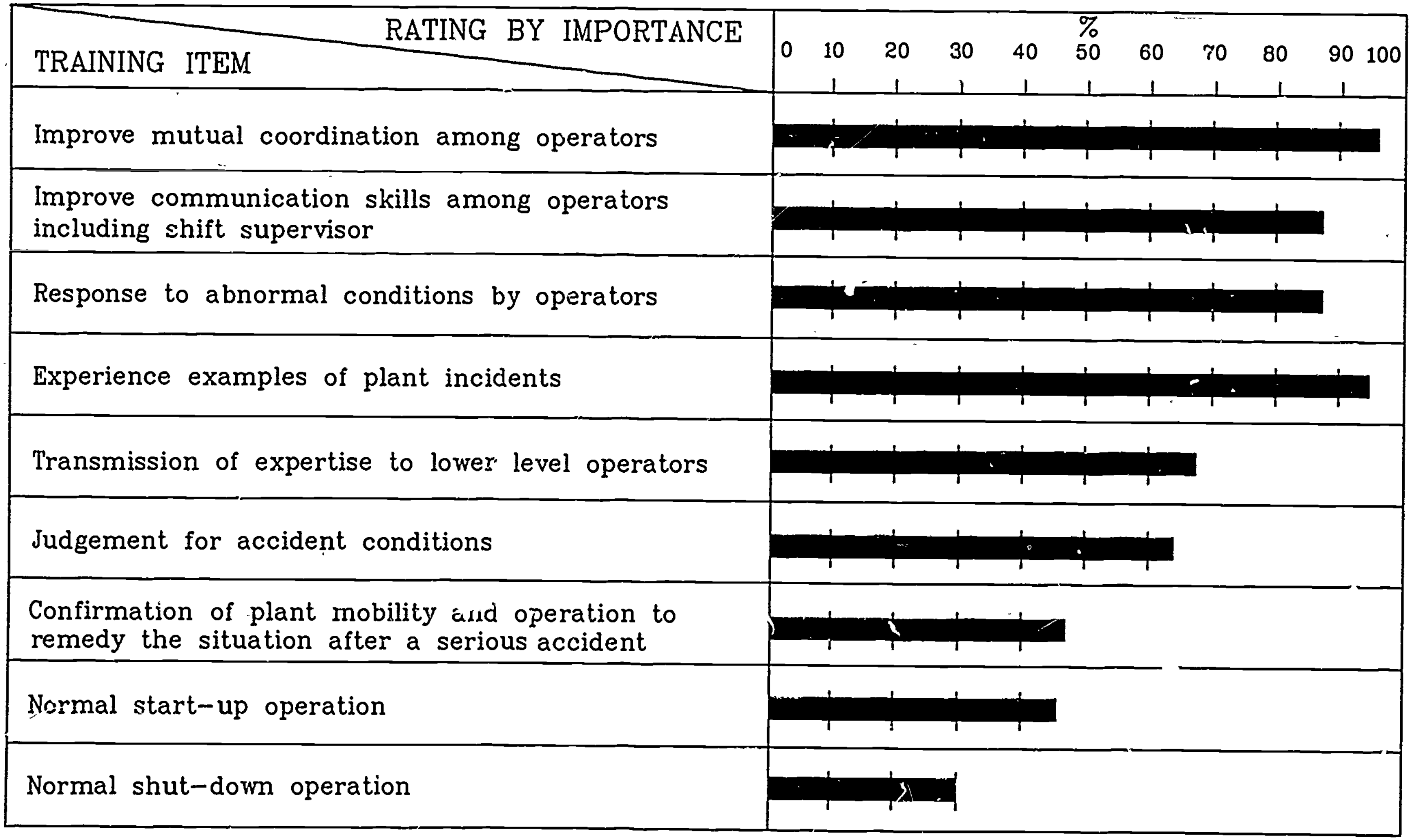
## CONTENTS OF FAMILY TRAINING

### Expectations of Family Training

In order to discover what crews desire from Family Training, BTC conducted a questionnaire survey of all BWR utilities. The results are shown in Fig.2. From this it is possible to learn what the respective crews gave importance to when undertaking Family Training. The three items selected as most important are:

(a) Improvement in capability for coordinated action as a team (especially for operation under abnormal conditions).

FIGURE 2. HIGH PRIORITY OBJECTIVES FOR FAMILY TRAINING



(b) Re-enactment by the simulator, of problems and incidents that have occurred in actual plants (prevention of recurrences).

(c) Transfer of skill from experienced senior operators to other operators (especially items pertaining to the actual plant).

## Training Procedure

The training plan for Family Training is drafted by the shift supervisor of each crew several weeks prior to its implementation. Then, it is forwarded to BTC. An example of a training program is shown in Fig. 3. The BTC instructor makes preparations based on the program received. Finally, on the day that Family Training is conducted, the shift supervisor and the instructors confer to finalize the training program. Then, the training is launched.

For normal operation training, from the standpoint of rearing, operator candidates in most cases perform each operation, with the senior personnel observing their actions and offering advice in accompaniment. In this manner their skills are passed onto the operator candidates.

For training of responses against abnormal conditions, the trainees act out, as in an actual plant, the role of the shift supervisor, shift foreman, reactor operator, turbine/generator operator and auxiliary equipment operator. Additionally, the role of the local area operator is assigned to one of the members and the communication with the local area, via paging, is also included in the practices. In some cases, these positions are acted out by operators in such posts at actual plants, and other cases not. By such assignment the trainee is able to expand his

FIGURE 3. EXAMPLE OF A FAMILY TRAINING PROGRAM

| TIME | TRAINING ITEMS (EXAMPLES) |
| --- | --- |
| 08:00 | Normal start-up operation<br>(1) Reactor criticality<br>(2) Sub-critical and re-criticality for D/W inspection<br>(3) Turbine start-up and generator synchronization<br>(4) Reactor feedwater pump switchover<br>Note: Training should be aimed mainly at operator candidates |
| 10:00 | Basic recovery of plant trip<br>(1) Reactor scram } --- Open MSIV<br>(2) Turbine trip }<br>(3) Reactor scram } --- Close MSIV<br>(4) Turbine trip } |
| 12:00 | Lunch and recess |
| 13:00<br>17:00 | Response for abnormal conditions<br>(1) Loss of off-site power<br>(2) Multiple malfunctions<br>* Earthquake occurrence - -> scram + inner D/W leakage<br>* Loss of all feedwater + immobility of HPCI/RCIC<br>* Reactor scram + immobility of 86G<br>* T/G trip + immobility of 1 RPS CH + stuck relief valve<br>(3) Training of response to abnormal conditions which simulate the event in the actual plant<br>(4) Training of judgement of plant conditions |

own capability and, moreover, can comprehend the viewpoints of the personnel he is communicating with. He consequently becomes capable of transmitting information with the understanding of his teammates situation.

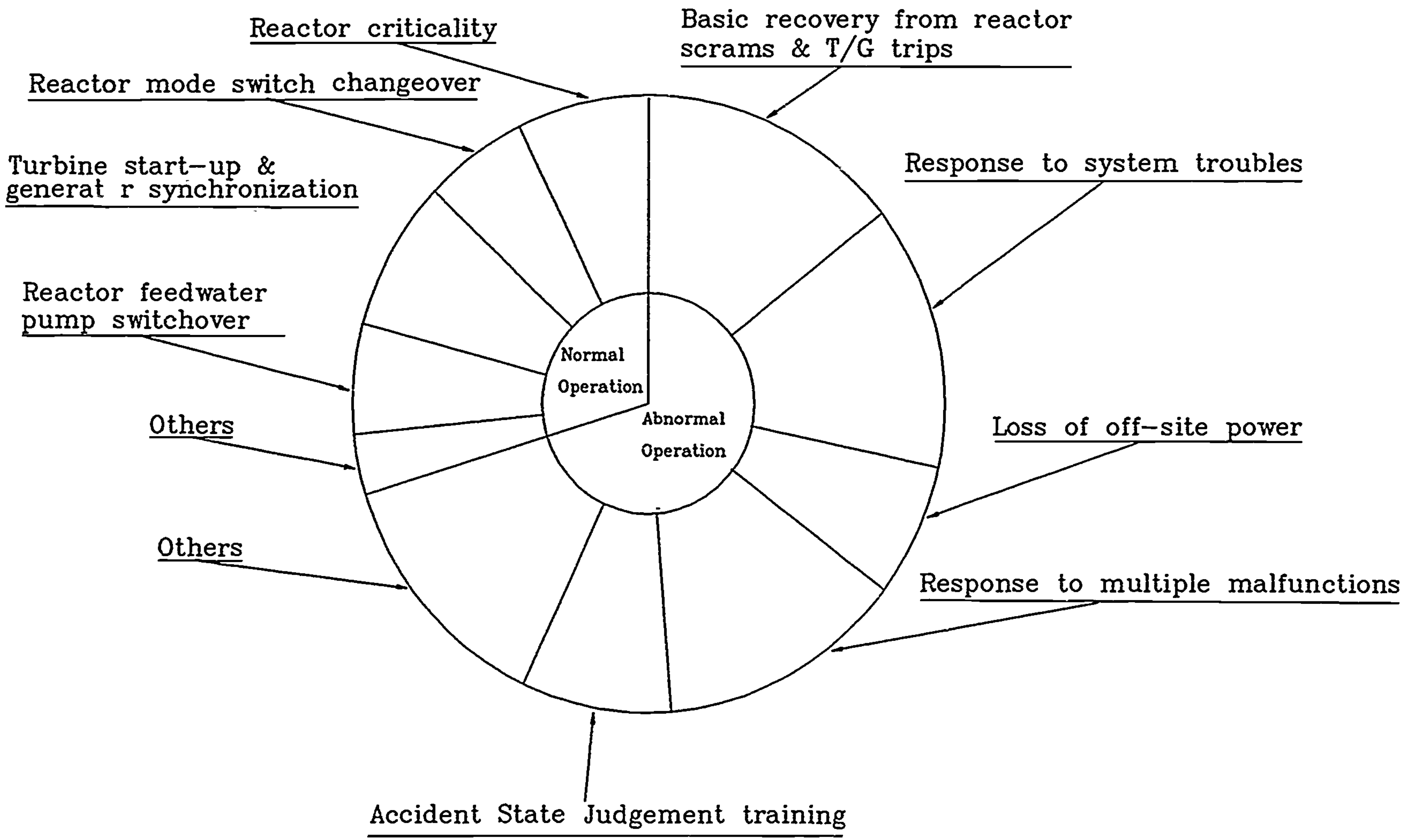
Upon completion of each training exercise with the simulator, review meetings are always held. In these meetings, along with self reflection on the actions taken by each operator, guidance is offered from the shift supervisor and discussions are held mutually among operators. In this manner their comprehension of the exercise is expanded and their communication during operational actions is confirmed. This also strengthens their capability for teamwork. Furthermore, supplementary advice from the BTC instructors, who are trained for proficient observation from an objective standpoint, enhances further training performance.

There are some cases in which training exercises are recorded on video tape. These tapes are utilized as material for the training review meeting. They provide many points to be reflected on as the operators can observe their own exercises objectively. Also, they are useful for crew review after returning to the plant. Repeated observation of these tapes will maintain and improve each operators skills after Family Training.

## Training Items

In order to grasp the trend of training items that were applied to Family Training, an analysis was made of the training contents for approximately 250 teams of Family Training that were conducted during the period, April 1987 to September 1988. The results are shown in Fig. 4. This indicates that in Family Training, importance is placed on responses for abnormal conditions, so, it is found that 70%

# FIGURE 4. ITEMS ACCOMPLISHED BY FAMILY TRAINING

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of the entire time is spent on such training. (The remainder is training for normal operation.)

With concern to the training items, it was found:

-For normal operation, training was conducted centering on maneuvers of main items required during plant start-up operation, such as reactor criticality, turbine and generator start-up, generator synchronization and feedwater pump switchover.

-For response to abnormal conditions, training included reactor scram/turbine trip, single system failure, loss of off-site power and multiple malfunctions, etc.

Training of basic skills for coping with the initial stages of reactor scram and turbine trip are conducted from the standpoint of rearing operator candidates, as well as for refreshing operators of the main control room.

Training for responses to loss of off-site power and to multiple malfunctions are frequently performed. Because the plant information accompanying these events is abundant and the phenomena is very complex, information must be accurately screened and plant situations must be correctly judged. Consequently, these events are effective for training regarding inter-crew communications, coordinations and command order, and for nurturing the ability of grasping situations broadly.

Additionally, for upgrading the ability of plant diagnosis, Accident State Judgement Training is conducted. This is performed by freezing the simulator in mid-operation while responding to the accident. Trainees check the entire plant condition, make a judgement and then determine the direction of necessary operations to be followed.

For training reflecting actual plant events, scenarios have been created by using as reference the cases of such events that have occurred in Japan and overseas. In more recent cases, there are such occurrences as,the frequency deviation at the off-site power source and increasing neutron flux oscillations.

Because Family Training is conducted with the various crews periodically, all BWR operators have the opportunity, as a crew, to experience recent occurrences in actual plants within a minimal time period after such occurrences.

## THE ROLE OF THE BTC INSTRUCTOR

In Family Training, the instructors produce effective training scenarios, check trainees actions during training and offer advice on the technical aspects and the correct behavior for team functioning.

The BTC instructors having had experiences with training of operators of all BWR utilities, can produce training scenarios that reflect current training contents of all these utilities and, moreover, can incorporate the training methods used by them. Thus, the better training practices implemented by BTC provide deep dimension to training contents.

With regards to the instructors advice, importance is placed on the following items:

(a) Basic skill of operation

(b) Ability for diagnosing abnormal conditions

(c) Determining priorities

(d) Teamwork

## CONCLUSION

Thus far we have described Family Training at BTC.

Family Training has performed a great role in maintaining and improving the maneuverability of the various crew members and their team operation capabilities as a crew. The characteristics of Family Training can be summarized as follows:

(a) Reflect the training needs of actual plant crews based on their own requirements.

(b) Enable training in a timely manner, which conforms with actual plant events.

(c) Provide appropriate advice from instructors based on viewpoints common to all BWR utilities.

In order to develop Family Training further, the items to be pursued in the future by BTC are as follows:

(a) Development of more effective scenarios for team training.

(b) Development of an evaluation method for team performance.

(c) Upgrading of the instructors guidance method.

(d) Introduction of more realistic simulations to increase their effectiveness.

(e) Improving of training methods taking into account the possibility of human error factors existing in a team.

# THE FRUSTRATION, THE CHALLENGE AND THE VICTORY OF TEAM BUILDING

Michael B. Brown

ABSTRACT

Traditionally, Team Training has been an exercise in Team Talking. We work in an industry that has never really been known for its team efforts. The Nuclear Regulatory Commission talks about the individual and that person's individual responsibility. Licensing exams evaluate the individual and on a shift basis and not as a member of a larger team. Approximately 80% of the staff functions outside of the Control Room. Our astronauts can only get into space if the team as a whole functions well. It should be noted that those teams train together in mock launches and simulated flight. In our industry, we believe that if the Control Room trains as a team, somehow the remaining 80% of the staff will function as a precision clock. We have failed. The time is now to champion a new approach to Team Building based on innovation and creativity.

Tom Peters in his book "A Passion for Excellence," points out that in order for a new product or concept to succeed it is essential that there be a product champion. He describes this enlightened individual as "a monomaniac with a mission." Reflecting on our industry, I would have to say that when we looked at team building the product champion, or "monomaniac," has been none other than our own Ed Carroll.

While serving in his capacity as the Vice President of Training for United Airlines, Ed saw the measurable benefit of team training in the cockpit. Later on while Ed was serving as President of the National Nuclear Accrediting Board, he personally brought the message home to our industry. The concept was to say the least, challenging and thought provoking. While we all believed in what he was saying, we just were not certain on how to deliver the gospel.

As in all good stories, we needed a knight to come to the rescue, so, enter Ken Strahm. On February 10, 1988, he issued TQ-503 Developing Teamwork and Diagnostic Skill Development. Unfortunately, that document as with United Airlines training was too narrow in scope and thus fatally flawed when applied to our industry.

Early on in his crusade, I had the opportunity of interviewing Ed Carroll for several hours on the subject. I asked, "How did you integrate the cockpit crews with the stewardesses, jet mechanics, the instrument technicians, or the Aeroframe mechanics?" He pondered a while an replied, "those people are not part of the flight crew."

"They are not at 40,000 feet where those crucial decisions are made." Maybe he is right, and then a- in reflecting on this past year's litany of aviation crashes, i. may appear to some that we still have a problem: Of particular concern was the Aloha Airlines skin peel-back incident (which resulted from unidentified fatigue cracks), Midland Airlines shutdown of the wrong engine (due to improper cockpit indication), and Piedmont Airlines physical loss of its engine while taking off from Chicago's O'haire Airport (resulting from a failure of the support mounts). These incidents beg the question, "Does the team extend beyond the cockpit?"

We need to examine our own industry and build on United's experience, not emulate them. While the flight crews may define their world as the cockpit, TQ 503 is significantly deficient when the only team it addresses is the Control Room Team. We do not enjoy the luxury of a solo flight. A major portion of the historical challenges to our safety systems were not initiated by the Control Room Operator but by the maintenance and technical staff. Unlike the cockpit crew, while our operators are at the controls, they must contend with maintenance personnel in the bowels of the unit, instrument technicians manipulating the patient's brain signals, while the chemists are altering the chemistry of the patient's circulatory system.

So you now ask, what is the answer? That brings us to the heart and soul of the issue before us.

William Arthur Ward stated "The mediocre teacher tells, the good teacher explains, the superior teacher demonstrates, the great teacher inspires." Now ask yourself what has your training programs or organization done to inspire team building beyond the control room. How have you worked to overcome the perception of arrogance of our operational staff, the indifference of your maintenance personnel and the isolated status of your training organizations?

The solution lies not in some prescriptive TQ or maintenance rule, but through a commitment to restructuring the most fundamental elements of your training programs. If we are to preach the gospel, we cannot emulate Jimmy and Tammy Baker, we need to lead by setting the example ourselves. The training organization needs to inspire the masses by itself becoming the product champion of team building.

You need to ask yourself but a few questions which may help you assess your organization's health, those are:

1) How many hours do the technicians/electricians spend on the simulator a year training?

2) How many hours a year do the technicians and operators train together on new backfits?

3) Do you integrate all technical disciplines into your E Plan Drill whereby these individuals must perform analytical and maintenance tasks during the evolution?

4) To what degree does your operations training staff train the technicians and maintenance personnel, and vice versa does the technical staff train the operating crews?

5) Are your technical trainers qualified to operate the simulators and use them as part of their technical training programs?

While each of our organizations are different. The secret to inspiring teamwork exists within your organization. The vehicle to ext. ct the specific solution for you is Creativity and Innovation.

Teambuilding is a never ending evolution. It is a frame of mind found deep in the roots of your organization. It will not happen unless you establish an environment that encourages teambuilding. It is not a subject one can lecture on and expect to see results. The team starts in the training organization. You need to establish teambuilding as a priority. You need to recognize instructors who take the initiative and who are creative enough to champion a new approach to teambuilding. Innovation will not happen in a restricted environment. You need to foster the spirit. Management needs to speak out and champion innovation itself. When your staff knows it's a priority with management, ~~they will make it their priority. You~~ need to encourage as many champions as you possibly can, and then some. With that behind you, you now have to accept failure as a price of doing business. Thomas Alvin Edison and Werner Von Braun both failed their way to success. Your staff will not venture out into uncharted water unless you send them a clear message that "Failure is Acceptable."

Your core message each day should be, if you have not had at least ten failures today, then you are just not trying hard enough. They need to commit themselves to the concept that their survival in our industry is tied to the effectiveness of your team relationship. The Control Room and the plant staff operate together and as such must train together. Mutual respect is only built through understanding of each others job functions, expertise, and perspective.

Over the years, we have defaulted to luck and osmosis our destiny. Hoping that physical proximity would in itself promote cooperation and teamwork. We need to manage this process, and there is no better place than the classroom.

The future is ours. You can make the difference. You need to set the stage, you need to promote product champions. Ask your staff these critical questions. "What have you done creative today?", "What have you done to promote teamwork?" For those that pick up and run with the torch, you need to recognize their accomplishment. To this end, we have built a Hall of Innovators to recognize the accomplishments and contributions of our talented staff. Trainers have egos and you can do much to establish a win-win environment by feeding these egos. Teambuilding is more than an exercise or a TQ. It is a spirit and to win that spirit you need to inspire the masses.

I would like to review some of the products that creativity and innovation have fostered for us.

1. We instituted integrated Technical Training modules which span multiple disciplines. We enrolled Health Physics Technicians, Safety Engineers, Mechanical Engineers, Quality Assurance Technicians and Mechanics into a reactor coolant pump seal replacement training programs. As part of our effort, we debriefed the students daily. This facilitated gathering feedback from the individual's professional perspective. The net result on this one unit was 72 procedure changes and the manufacturing of about ten jigs, speeding up the overall process. We have duplicated this type of training in the I&C, electrical and other mechanical programs. The real product was mutual respect, and a fundamental understanding of each other's role.

2. We have trained I&C personnel on the principals associated with teambuilding and then assigned training staff in to the line departments to evaluate their day to day team relationships.

3. We have integrated I&C technicians on the simulators. Our instrument failure analysis course is totally focused on the technicians relationship to the operator during a wide spectrum of instrument failures. We have since enlarged the scope of this effort to integrate electricians on the Simulators.

4. We are in the throes of developing an integrated Emergency Plan Training Program that will actively integrate all personnel into the training evolution. Various instrument, mechanical, electrical and chemistry failures will be actually instituted while the training evolution will be running on real time in the simulator. This will require all parties involved to analyze their respective failures while interfacing with the Control Room (simulator).

5. We have established an internship program whereby the training staff is assigned to a line organization for six months serving as first line supervisors while the respective supervision is assigned to the Training Department. The first secret to successful teams is mutual respect. Internships are a vehicle to developing that respect.

6. We are expanding that internship to cross cover the traditional training barriers. Whereby technical instructors will be required to train as simulator instructors while these operator counterparts will function as lab instructors.

7. We have instituted Quality Circles as a means of promoting mutual respect, integrated team problem solving, and providing the staff a means of contributing to their well-being.

8. We have formed a joint task force to analyze training effectiveness. This comprehensive study will look at such difficult issues as comprehension, retention, job structure and requal as a measure of learning. Forming this integrated team are training department personnel, various graduate schools of adult education and the plant staff.

9. We have developed an Assessment Center to evaluate the meas' ble knowledge and proficiency of the instructional staff. This assessment module amongst many of the elements, evaluates the instructor in a team setting and his/her relationship to the team during problem solving.

10. Within the training organization, we have joined across disciplines t- train plant staff on future design changes. These integrated efforts help to focus on both the operational and technical aspect of a pending design change.

The profits derived as you can see were in fact significant. The risk was minimal. The obvious now lies before us all. To function as a team, you need to train as a team. If a training organization is to teach the spirit, it must be a part of the spirit. The opposition to change is great. We all work in a very conservative industry, creativity and innovation are looked on with suspicion. The Protectionist and the Traditionalist will line up at your door to tell you why you are wrong.

It takes courage to change direction. It takes indulgences to tolerate the failures, and it takes perseverance to win at Team Building.

# DEVELOPING A SYSTEMATIC APPROACH TO TEAM TRAINING FOR EMERGENCY RESPONSE PERSONNEL

Y.E. Derrer

## ABSTRACT

Preparing a group of station employees with diverse expertise and backgrounds to work together as a team during an emergency is a challenge. One that is best addressed by a systematic approach to team training. To provide more effective training the Washington Public Power Supply System's Technical Training Department conducted a job and task analysis. Based on the results the Supply System redeveloped initial training, using a center based concept. This system provided a method to train individuals from different disiplines as a team. To avoid simple repetition of initial concepts and to culture the team approach, a center based continuing training program was developed which focused on the previous year's major exercise scenario. This system allowed all center members the opportunity to interact with each other as a team, learn from any deficiencies identified during the previous year and provide input to enhance center operations. This systematic approach has been accepted by the participants with a positive attitude, has led to closer teamwork and has reduced the number of deficiency findings.

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## INTRODUCTION

As human beings we do many things in groups. We grow up, play, learn, live and work as groups, but seldom do these groups become teams. Even more seldom are they trained as teams.

The concept of team training has been successfully applied in the nuclear industry for several years, but has been limited in most facilities to operational teams. Expanding this team concept to the emergency response organization enhances the utilities ability to effectively respond to emergency situations.

Emergency teams can be likened to community teams that form seasonally to participate in baseball, soccer and other sports. They are composed of individuals with diverse backgrounds and areas of expertise, people who many not normally work together, but who must be molded into a capable team swiftly and effectively. To develop a group into a workable team requires a common goal understood by all members. A team training program can be used to effectively pull members together to work toward that goal.

## TRADITIONAL TRAINING CONCEPT

Training was initially developed and presented using traditional methods which brought all emergency personnel together for overviews and specific skills training regardless of the emergency center to which they were assigned. Each years refresher consisted of repeating the same material. This provided the training but did not foster or encourage team building and became repetitious for center personnel.

To reevaluate the training, and to bring the program into line with other training programs a systematic approach to training was implemented. Job/task analysis was performed for all emergency positions. The results of the analyses were used to design a program for both initial and continuing training. The program was developed based on the team training concept, specific to meet the needs of each emergency center.

## CURRENT TRAINING PROGRAM

The training is divided into initial and continuing training for each center and each program is developed and implemented in a different manner. The remaining sections of this paper will discuss these programs, their implementation, advantages and disadvantages.

### Initial Training

When the task analysis was complete, the information was used to develop center-based training using a phase concept. In center-based training, all individuals assigned to a specific center are scheduled into one class which is divided into phases. The phases move from generic to specific information and from simple to complex skills. Upon completion of each phase the trainees are required to pass a written exam and demonstrate any performance based actions required for their position. When the exam is completed, those whose emergency positions require the next phase remain.

<u>Example</u> In the Technical Support Center and in all other centers, phase one consists of an overview of the entire emergency organization and specific center operations. The organization overview includes:

- o 10 and 50 mile exposure pathways
- o Overall organization and jurisdictions
- o Emergency classifications and notifications
- o Measures used to ensure employee safety
- o Drills and exercise participation
- o Procedures and documentation requirements

The specific center operations includes:

- o Center location and layout
- o When, where and how to report
- o Primary center functions and responsibilities

- Communciations system and their use
- Specific procedure reviews

Phase two of the Technical Support Center is required by center personnel who are assigned to make Protective Action Recommendations and phase three provides training in Offsite Dose Assessment and computer manipulations. An individual must successfully complete all phases required for their assigned position before being considered a qualified member of the team.

<u>Advantages</u> This system allows for scheduling individuals to receive all required training in one session rather than having to return several times. It also provides a continuous flow from general to specific training and when initially presented, allows for interaction among center personnel.

<u>Disadvantages</u> The primary disadvantage of the system is that, once the initial training is completed for each center, future classes contain only one or two individuals as they are added to the emergency organization. This limits the team training concept. Because of this limitation continuing training is totally based on the team concept using this initial training as a knowledge base.

## Refresher Training

To avoid simple repetition of initial training and to culture the team approach, continuing training is based on the previous years major exercise scenario.

All objectives identified for initial training are cross referenced to the refresher training to assure the program fulfills all requirements.

Each student is given a self evaluation exam booklet at the beginning of class and answers questions pertaining to his or her actions at specific points in the scenario.

The instructor reads the first section of the scenario (normally broken down into Unusual Event, Alert, Site Area and General Emergency) and then allows time for students to answer questions in their self evaluation exams. The correct answers are reviewed and discussed.

The instructor then covers critical points used by controllers and evaluators to assess center and personnel activities at that point in the exercise. If center or personnel activities during the major exercise resulted in deficiency findings; the issue, findings and corrective actions are reviewed.

As each section is reviewed, the instructor discusses any industry events that have occurred since the previous years training that apply to the specific center or scenario.

The process is repeated until all sections of the scenario have been covered.

If an individual's emergency position required performance actions such as computer or equipment manipulations in the initial training, those individuals are required to remain after others have left to demonstrate these performance based actions.

The NRC/FEMA evaluation is reviewed with emphasis on findings for the specific center and input is solicited from participants for improvements to center activities or procedures. All suggestions are documented and forwarded to the manager of Emergency Preparedness for review.

<u>Advantages</u> Reviewing all center actions and functions using this method of training reinforces each individuals awareness of how he or she fits into the center, how the center works as a team and how the team fits into the overall picture. It also demonstrates how center actions are interrelated to each other and how the diverse expertise and abilities of the staff achieve the team goals and objectives.

<u>Disadvantages</u> This method requires that the refresher training for each center be redeveloped each year.

## SUMMARY AND CONCLUSIONS

Fostering a team spirit among center personnel leads to more effective decision making and communications and reduces the number of incidents of staff members operating as individuals.

Overcoming motives to resist team work requires that each individual understand the necessity of working as a team and how his or her participation is essential to the center's success.

By coupling this team training program with the team experience received by the individuals during drills and exercises, motives for not working as a team such as self interest, competition, different styles or opinions and interpretation of the individuals role are minimized.

This systematic approach to emergency team training has been effective in reducing the number of deficiency findings based on staff actions and has been received by personnel with a very positive response. The opportunity to interact and provide suggestions for center or procedure improvements has given participants a feeling of ownership for center activities and team success.

# TEAM MAINTENANCE AS A RESULT OF TEAM TRAINING

S. K. Stone
D. R. Lavender
P. C. McAnulty

WHAT DOES IT TAKE TO MAKE A SUCCESSFUL TEAM? According to Henry Ford, "Coming together is a beginning; keeping together is progress, working together is success."

Nuclear station maintenance crews have long confronted complex jobs and adverse conditions. Crews often consist of diverse station and vendor personnel who may never have worked together as a team. They are given highly technical tasks that are further complicated by radiological controls, interfacing station groups, and shift turnovers. These complications, combined with the requirements of high quality and job execution standards, tend to result in extended down-time, increased radiation exposures and considerable stress on maintenance crews. A task involving these complications is the replacement of reactor coolant pump (RCP) seals.

When operating properly, reactor coolant pump seals sufficiently control radioactive coolant leakage from the pump. But when the seals fail, maintenance personnel must repair and replace them in a minimum amount of time while maintaining radiation exposures ALARA. Due to a documented incident of reactor coolant pump seal failure, the Institute of Nuclear Power Operations (INPO) recommended in SOER 82-5:

> "Plant personnel should be trained and qualified for RCP seal maintenance to ensure quality work and minimize radiation exposure per ALARA program requirements (consider using seal mock-ups, vendor training or job performance aids to improve expertise)"

In implementing the INPO recommendation, Duke designed a RCP seal training course as an individual performance-based program that emphasized specific knowledges and skills identified by task analysis. During the initial implementation of this training, job performance suffered from poor team interaction. These performance weaknesses occurred because maintenance crew make-up was formed from different groups, each having its own leadership and maintenance methods. This mixture of personnel provided the potential for non-productive time and decreased quality due to lack of cooperation and conflicts arising from:

- ♦ Inefficient team leadership
- ♦ Differences in station procedures
- ♦ Communication problems
- ♦ Differences in documentation and Health Physics requirements
- ♦ Inexperienced workers

Consequently, our RCP seal training has evolved into a team training program. The focus of this program is team maintenance and team cooperation through the accomplishment of the following objectives:

- ♦ Establish working relationships among team members prior to the job.
- ♦ Identify leadership capabilities within the maintenance crew and develop them in a controlled laboratory setting.
- ♦ Address inter-group conflicts over methods and procedures in the classroom instead of at the nuclear station.
- ♦ Identify the responsibilities of interfacing groups. (Operations, Quality Assurance, Health Physics, Instrument & Electrical)

Duke Power's RCP seal maintenance training program uses a combination of classroom discussion and laboratory exercises that involve hands-on maintenance on a full scale mock-up. It is designed to elicit trainee involvement and enhance team building through mutual interaction. A class consists of a six-person maintenance team with two observer positions available for Quality Assurance and Health Physics personnel.

During the classroom phase we review seal construction, operation, and analyze job responsibilities of various station groups. By using an interactive training method, we not only elicit, but require, the involvement of each team member in the training process. Through the use of slides and a training manual, the instructor initiates group discussion to define responsibilities of interfacing groups, component part identification, procedural steps for component disassembly, inspection, and assembly. During these discussions, trainees identify personnel safety concerns and radiological hazards.

In the laboratory exercise the class uses a full scale mock-up to perform seal maintenance involving disassembly, inspection, assembly, and motor alignment. The instructors use the station's maintenance procedure which further allows for procedure validation and prepares the team for the upcoming station outage. Team members rotate through the various job positions during the exercise to ensure they have a full understanding of all aspects of the job, such as:

- Procedure documentation
- Component part removal/installation
- Component part labeling, cleaning, and storage
- Special RCP tooling
- Tool control

## Advantages of Reactor Coolant Pump Seal Team Training

- Improves job performance and reduces time required to execute seal replacement.

  The team is better prepared and more familiar with plant specific maintenance methods. Team training identifies strengths and improves weaknesses in team members' overall knowledge and skills of the job. The team has a better understanding of seal parts and operation which prepares them in staging each step of the job. The training also improves awareness of personnel safety and radiological hazards.

- Improves maintenance team cooperation and minimizes inter-personal conflicts.

  Reactor coolant pump seals maintenance team training establishes working relationships among the maintenance technicians prior to the job. The team identifies leadership capabilities within the maintenance crew and enhances those abilities on specific assignments. Each trainee can address inter-group differences of maintenance methods and procedures.

- Improves interfacing group relationships and defines responsibilities.

  Team training assists the members in understanding specific station group procedures and responsibilities such as Health Physics considerations, Quality Assurance sign-offs and Operations system preparations. When Health Physics and Quality Assurance personnel are included in the training, they elevate the maintenance technician's understanding of their coverage and are able to improve their own knowledge of the RCP seal work.

♦ Improves communication and minimizes non-productive time during shift turnovers.

By training the teams prior to the actual plant job, the technicians have the same level of knowledge on component identification and procedure steps. This knowledge will enhance communications during shift turnovers and will allow for better job preparation.

♦ Validates procedures.

The reactor coolant pump seal mock-up is being used to validate work procedures, ensure procedure step sequence and develop a generic procedure for all of Duke Power's facilities. The training identifies technical procedural deficiencies and allows technical support personnel to upgrade the procedures prior to the outage.

♦ Identifies special tooling.

Mock-up training identifies the need for special lifting equipment and other tooling to perform the job. The tool list is verified to include only the tools needed for the job. In the controlled training laboratory our engineers and technicians test new ideas, new tooling and other modifications prior to the job.

Team training as demonstrated by our reactor coolant pump seals maintenance course is beneficial to our stations both in plant operations and component maintenance. Because of the many advantages of team training, Duke Power anticipates that time spent in training will greatly maximize job performance and improve team effectiveness. It appears that team training will reduce outage time and radiation exposure levels. Above all, the most important result of team training is the teamwork involved in team maintenance.

To expect each individual to become knowledgeable and proficient in all elements of a major task is an admirable goal, but not always an achievable one. To best utilize the different knowledges and skills of individuals in a group to accomplish a major task is an achievable goal, but requires teamwork. Incorporation of the team training concept in the area of nuclear station maintenance can provide us with the winning edge.

# RELATING QUALITY AT WORK TO QUALITY AT HOME

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## ABSTRACT

INPO 87-004 details specific topics to be covered in General Employee Training. At Boston Edison, these topics were combined with Company commitments and policies, and a belief that by relating the importance of quality concerns to each worker's daily lives, the application of Quality Assurance and Quality Control practices at Pilgrim Station could be enhanced. It was decided that if a commitment to quality was to be instilled in each worker, a high quality General Employee Training program should set the example. This commitment to quality was implemented using a fast paced, multi-image technique with a high quality visual and audio presentation format. The program was designed so that a minimum of changes would be needed over its life. The program's success has been proven since its installation in 1986. During updates to the Pilgrim General Employee Training Program since that time, no programming changes have been needed in the Quality Assurance module.

## INTRODUCTION

Pilgrim Station began implementation of a totally revised General Employee Training (GET) Program in 1984. The new GET Program was to incorporate the requirements of INPO 82-004, *Guidelines for General Employee Training*[1] in addition to the objectives detailed in the then current approved GET Program. A training facility for GET was constructed in a building adjacent to the plant site, decisions were made on media for instructor support, and program materials were completely revised.

In addition to the requirements of INPO 82-004 (This has since been updated with the release of INPO 87-004.), Boston Edison had committed to train all new workers on the Company's legal commitment to Quality Assurance, and the meaning of each Quality Assurance (QA) criterion listed in 10CFR50 Appendix B.[2]

To teach about Quality Assurance, it was clear that we first had to teach about quality. In fact, we had to teach what quality really is. It was also clear that, as instructors, and as representatives of management, we had to jump right in and provide a program that demonstrated QUALITY to all the workers coming to the site. We had to show them that we could do a quality job, that we cared about their training, that we cared about their performance, and therefore that they should also care.

This led us to review media support that would provide a high quality impression to the trainees and have a lasting impact on them. We chose Multi-Image. This medium uses six slide projectors in our implementation. It provides a large, bright, high resolution image, and operates with a high fidelity stereo sound system. The system has operated for almost three years without a failure and with a minimum of maintenance requirements. A detailed description of the Multi-Image system and its advantages was presented in a paper at the Seventh Training Symposium in Orlando, Florida.[3] The media program has proven effective in capturing and holding the attention of the trainees.

## QUALITY - DO WE KNOW WHAT IT IS?

All of us strive for quality in our lives. But if we would take a poll on the street, or even within the nuclear training community, asking people what quality or quality of life is, we would certainly get many different answers.

Quality to most people generally means something that is good, or expensive, or long lasting, or durable. Quality of life is almost always in the eye of the beholder. It might be a good marriage, good friends, having a large home or a fast car. It might be taking a lot of vacations, having an enjoyable job, or being able to separate one's work from one's home life.

In reality, we all take measures to assure success in our aspirations and to assure we can maintain them once they are achieved. That is, we all try to assure our personal definition of quality of life will be achieved and maintained. We also take measures to assure that once we obtain something of quality, it will maintain its high quality. We periodically wax our cars, we maintain the plumbing in our homes, we cut our grass, we clean our golf clubs. We also do such things as *practice* our golf game, or, as I am doing right now, we *use* our typing skills. The list goes on and on.

What we don't do is overtly recognize that we follow a specific *process* to assure our subconscious definition of quality. For instance, if we are going to purchase a new car, we first do a little research. We read advertisements and product reviews. We go to a dealer for a test drive and some hands-on feel. We write up specifications with the salesperson to place an order. When the car comes in, we compare the deliverable with the specifications, take it for a test drive, and make sure we have all the documentation. We commit to a maintenance program. All this is a process, a determination of requirements and assurance that those requirements are met.

Once we recognize that quality is "conformance to requirements" as expressed by Philip Crosby in his book *Quality is Free*,[4] we can get a handle on quality, demonstrate to workers that they are commited to it in their personal lives, teach workers that the plant Quality Assurance Program is only an extension of their personal commitments, and then persuade them to be active and willing participants in the plant Quality Assurance Program.

## QUALITY AND SAFETY

One component of a quality life is the absence of life threatening conditions. We usually plan our lives to avoid them.

I have a friend who usually took good care of his car. Recently, he was having trouble with his automatic transmission. It wouldn't always engage until after the car warmed up. One particularly cold morning, after pulling out of his driveway, the transmission just would not engage. He gave the car a little more gas, let up on the peddle, and tried again. He did this several times. Finally, during one of the high engine RPM moments, the transmission took hold and sent him straight into a fire plug in the neighbor's front yard. Fortunately, no personal injury resulted from this. But the car was damaged, the fire plug was displaced about 20 feet, and his ego was sorely damaged. And to add insult to injury, the police cited and fined him for failure to control his vehicle. A check of the transmission determined the fluid was low. How easy it would have been to prevent all this agony.

Most of us will have flown to the Training Symposium. We've all read how safe flying is. But I'll bet several of us will avoid flights on one financially troubled airline that services the Knoxville airport. Why are we confident about the safety of the other airlines? Why are we confident the pilots will do their highest quality job for us? Would we feel as secure if the plane was flown by automatic pilot from a ground station?

We are particularly concerned about the safety of our children. TVA uses an excellent example of a complex playground apparatus being built by a group of adults. To assure the children's safety, the ORGANIZATION building the apparatus assures that materials are properly PROCURED, that only QUALIFIED workers participate, and that the DESIGN is followed. INSPECTIONS are made to assure construction is performed properly. CORRECTIVE ACTION is taken if needed, and RECORDS are kept of the entire process.[5]

Assurance of safety is a legal requirement in the design and operation of a nuclear power plant. Part of safety assurance is accomplished through a Quality Assurance Program. The Quality Assurance Program to be followed at all nuclear plants is designed around the requirements of 10CFR50, Appendix B *Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants.* At Pilgrim Station, these criteria are implemented through the Boston Edison Quality Assurance Manual.

My friend's accident with his car resulted because of a breakdown in his personal commitment to maintain the quality of his transportation through a preventive maintenance program. Simply checking his engine fluids when he filled his gas tank would have prevented the accident. A similar breakdown in the quality assurance program at Pilgrim Station could result in an analogous (and perhaps more consequential) failure, possible injury, a notifiable violation, and possibly a fine. Avoiding all these is important to us, but most important is the safety of our personnel and the general public.

## MODULE OUTLINE

The primary objective of the Pilgrim Program Quality Assurance module is to involve the workers in the plant QA Program by relating the similarity of their everyday personal quality concerns to those implemented at the plant. This is begun by showing several examples of quality checks made at home, and of quality related activities performed at home. The program opens by presenting *Quality in the News* to quickly review several examples.

Then, the official Pilgrim Station definition of Quality Assurance is presented:

> All planned and systematic actions necessary to provide adequate confidence that an item will perform satisfactorily in service.

This is followed with explanations of the expected important results of an effective program, including:

1. Ensuring protection of the public (including those who work at the plant,
2. Ensuring compliance with requirements - from the NRC, Department of Transportation, Occupational Safety and Health Administration, the EPA, the State of Massachusetts (I'm sure you've heard of our governor), and, of course, Boston Edison, and
3. Ensuring efficient, reliable, operation of the plant.

The program then returns to examples from home. It's possible to come up with a host of examples, but time permits using only a few being presented. Our choice was to relate one that details our personal commitment to quality assurance as a process, and another that most, if not all of us, completely ignores, or possibly have never thought of.

The first example takes the viewer through the life cycle of an automobile purchase. It discusses the review of sales literature as we concern ourselves with the DESIGN of the potential purchase. Then the test drive and our concern for PERFORMANCE, and our inspection of the dealer's SERVICE department. These are all activities related to the PROCUREMENT process. Next, the module gives examples of the ADMINISTRATION and DOCUMENTATION phases of the purchase. The example continues with our activities related to INSPECTION and TESTING of the car when it arrives, and VERIFICATION that it is indeed the car we specified. We discuss the periodic checks done to check the OPERATING STATUS, and the CORRECTIVE ACTION we take when necessary. The example concludes by relating the INSPECTION, CONFIRMATION, and RECORD KEEPING we do of repairs that are made. These are related to the QUALITY CONTROL aspects of Quality Assurance.

The second example is a plumbing example, of an isolation valve present in everyone's home. Isolation valves also are present in all nuclear power plants, and require maintenance checks, as we all know. But the quarter-inch line isolation valve leading to our toilet flush box is usually ignored until it is needed. Then, it is usually found to be too corroded to be useful, and the whole household is inconvenienced while repairs are made. The analogous consequences in the plant of not following the required QA Program may be a shutdown and loss of revenue.

The module next relates this comparison to the primary difference between the home and workplace - that at Pilgrim Station, QA is the law, and it is implemented through the Boston Edison Quality Assurance Manual. This implementation is reviewed through a logical sequential discussion of the 18 Criteria from 10CFR50 Appendix B. The emphasis throughout this discussion is on the importance of safety and the required adherence to procedures.

Finally, the program closes with a return to the opening theme of *Quality in the News*, and a tie in the Pilgrim General Employee Training theme - **DO IT RIGHT!**

## CONCLUSION

The Pilgrim Station Quality Assurance module receives considerable praise from plant management, and we believe it to be effective in promoting an increased awareness for a commitment to quality performance at the plant. We believe that by showing workers how they are involved in quality assurance every day, we have made them better participants in the Pilgrim Station Quality Assurance Program.

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# CHANGING ORGANIZATIONAL CULTURES - CREATING QUALITY ACHIEVERS THROUGH TRAINING AND TEAMWORK

William C. Widen: Westinghouse Electric Corporation
and
Thomas H. Cowell: Tennessee Valley Authority

## MAN-MACHINE INTERFACE: THE GROWING BATTLE OF AUTOMATION COMPLACENCY

One of the fundamental truths is that "things become more complex over time". For example, cars are more complex; income tax laws are more complex; even a contemporary refrigerator has more gadgets and features installed than the common man can use - or, perhaps, afford. In older, less complicated times we didn't worry about the concept of man-machine interface, because our machines were simpler, less sophisticated tools. But today we have far more complex machines; and we even have a complex term, ergonomics, which is the science of how man interfaces with technology. Nonetheless, a thorough analysis of this interface seems to lead us to our second fundamental truth: that the <u>man</u> is still the most important factor in the man-machine equation. Consider the following:

- China Airlines flight Dynasty 006 perilously tumbled six miles before the crew was able to regain control of the airplane. After climbing to cruising altitude, the crew set the airplane on automatic pilot and essentially removed themselves mentally and emotionally from their principal job of piloting the plane. As one of the plane's outboard engines failed, the crew was unable to respond quickly enough to avoid the harrowing six mile tumble. Although no one was seriously injured, the 747 jet sustained substantial structural twisting and warpage. It is truly fortunate that such planes are "overdesigned" for typical flight duties.

- A Union Carbide pesticide manufacturing plant near Bhopal, India continued its day to day production even though 3 of 5 safety systems were non-operable. The operators were well aware of increasing pressure in their methyl isocyanate tank and even documented eye and nose irritation. However, they assumed that this pressure build up had been initiated by the previous shift and that they would be informed where to pipe the gas as their crew continued its shift. Unfortunately, the gas erupted from the tank and killed approximately 2,600 people in the Bhopal area.

- Electrical engineers at the Chernobyl 4 reactor in the Soviet Ukraine conducted a rotational inertia test to determine the relative time span of emergency coast down power availability from the plant's turbine momentum. Although the test was designed to be conducted at approximately 20% power, the engineers, through a series of maneuvers, found themselves at 6% power and decided to proceed with the test; placing reactor control in a extremely unstable position. In addition, several automatic safety systems were blocked out to conduct the test. The resulting explosion and fire killed 31 people and injured nearly 200 in the worst nuclear power disaster to date. Ironically, Chernobyl 4 had the best performance record of any plant in the Soviet Union.

- The government of Bangladesh invested substantial resources to update and automate its rail system. Approximately one week after the new automated signaling system became operational, Bangladesh registered the worst rail disaster in its history, killing approximately 110 people and injuring over 1,000. It appears that the railroad engineers did not fully understand the automated signaling devices and were placing full and unquestioned faith in the fact that the automated devices would operate their locomotives safely for them.

The common thread intertwined through all of these incidents is that the operator, the man, is still the most crucial component of the man-machine team. Machines, indeed, have made our lives easier and saved us from tedious work. However, man can tend to place too much faith in the machine. The new challenge of man-machine interface is evolving into man's battle to fight the effects of automation complacency; that is, the vigilance required to check and monitor the machine's operation.

Nuclear power plants represent a complex, intricate, high-tech assemblage of systems and machinery. Hence, the issue of man-machine interface and the study of ergonomics are key parameters for nuclear plant operation. But, through all this high-tech dialogue, it still appears that the operator remains the principal ingredient for safety and efficiency. Indeed, people represent the ultimate lines of defense. For these reasons, the <u>culture</u> at the plant: the professional demeanor and conduct of the operating crews, represents the most important factor for overall plant safety and availability. The balance of this paper will address how the Tennessee Valley Authority's Office of Nuclear Power set the stage for and implemented a comprehensive program to improve the overall conduct of operations and organizational culture at its three nuclear power plants.

CREATING QUALITY ACHIEVERS: A COMPLEX ISSUE OF CHANGING ORGANIZATIONAL CULTURES

An organization's culture is composed of a set of shared understandings which members of the organization have in common. These understandings consist of shared values, shared beliefs, shared attitudes and shared behavior norms. An organization's culture can be inferred from the sayings, feelings, and actions of its members. There are three elements involved in changing an organization:

- Its technology -- building a better machine.
- Its structure -- developing and writing better policies and procedures.
- Its people -- the most important factor in the man-machine interface and those who truly define an organization's culture.

In the past, most industries that attempted to solve problems focussed upon changes in technology or structure; seldom addressing the people issue. The people issue(s) was seen as having unpredictable outcomes, and managers often feel uncomfortable when dealing with the feelings and values of others.

The bottom line for many companies was that tremendous amounts of money and resources were quickly spent on the problem by hiring more people and buying more equipment; but the problem still remains unsolved. This has led to a long range focus on solving organizational problems by "fixing the people" or changing the culture.

To change a culture is to change the shared understandings - the beliefs, the values and the attitudes of the members. To effectively make this change, the people must "buy in" to the redefined set of values and beliefs that the organization establishes <u>before</u> their behavior will change. They must be educated as to why the change is needed; how the new values are better than the existing values and beliefs; and, how these changes will impact the individual. Only then will the behavioral change and the new behaviors be used in daily work-life. The re-education process is never-ending since organizations must constantly change to meet competitive demands and changing markets.

Following the lengthy shutdown at TVA's nuclear plants, the Office of Nuclear Power was challenged to change the culture of its nuclear plants. This was a very complex issue involving three different plant sites with three different plant cultures, all of which were experiencing deep-rooted morale problems that permeated the entire organization. During shutdown, all of TVA's nuclear plants were undergoing various changes or some stage of completion; including, design studies, engineering modifications, and procedural revisions (two of the three elements needed to change an organization's culture). The machine and documentation components of the ergonomic equation seemed immense at first glance, making the culture (employee' behaviors and attitudes) dwarfed and insignificant by comparison; but in reality--the most important. That is to say, the operating crews were inundated by new systems, new procedures, new working relationships, and new reporting requirements to a point where they began to question "What is my role?"; "What am I responsible for?"; "Am I really in charge of the Plant?"; etc. Another concern, and perhaps an even more significant one, was that the plants were experiencing low morale and an attitude of complacency stemming from increased bureaucracy and accountability changes. Simply put, many people (operations personnel and others) were saying: "Anything I do doesn't matter"; "I can't really change anything"; "I do not control anything--others control everything for me". Naturally, the Office of Nuclear Power needed to restore a sense of faith and the ability of the individual to make a difference. Low morale and complacency cannot be allowed to exist within the nuclear industry.

The clear cut goal of TVA's Office of Nuclear Power was to erode this culture of low morale and complacency and replace it with a culture valuing professionalism, ownership, and responsibility. In order to achieve this, both attitudinal and behavioral issues had to be addressed. It is both attitudes and behavior that govern a plant's culture; hence, any modification of the culture had to incorporate both attitudinal changes and behavioral changes as dual goals.

What is a professional attitude and what is professional behavior? In a study deemed "Professionalization", Vollmer and Mills judged nuclear industry workers as professionals for the following reasons:

- implementation of highly specialized technology supported by a body of theory;
- a technology and career supported by the association of colleagues;
- a status supported by community recognition; and
- responsibility for the health and safety of the public.

Clearly, nuclear workers in general, and control room operators in particular, are professionals fulfilling professional responsibilities. But just how do we measure the degree of this professionalism? One way to measure it is the overall excellence expressed for their conduct of operations. That is to say, a culture that reflects a professional attitude and accompanying professional behavior will engender excellence in their daily conduct of operations. Consider the following examples:

- On June 9, 1985 the David Besse Plant encountered seven (7) malfunctions in seven (7) minutes, cutting off main and auxiliary feedwater. Without heat transfer from the primary to the secondary, reactor pressure and temperature increased. In variance to procedure (but not in violation of it), the assistant shift supervisor ran into the plant and placed the motor driven startup feedwater pump into service. He accomplished this typical 20 minute job in 4 minutes. He then proceeded to another location in the plant and assisted the equipment operators in resetting the tripped throttle valves in order to restore the #1 and #2 auxiliary feedwater pumps to service. This display of human knowledge, competence, and teamwork demonstrates professional behavior at its best.

- The Nuclear Regulatory Commission culminated a period of extensive evaluation at Peach Bottom by imposing civil penalties against 33 individuals for inattentiveness. The 33 Peach Bottom personnel were fined between $500 to $1,000 each, and all penalties were paid by the individuals. In this case, it appears that an unprofessional attitude permeated contagiously throughout the plant.

TVA's Office of Nuclear Power needed to imbue a new, redefined professional attitude and behavior at its three nuclear sites. Reactor restart plans needed to focus not only on engineering modifications and procedural upgrades but upon a specifically engineered plant culture which reflected a strong sense of professionalism and plant ownership. Specifically, individuals had to be acclimated to rapid organizational changes and professional behavior modification. Skills and knowledge that were adequate in the early 1980's were no longer adequate today. Similarly, an attitude of non-responsibility (that does not infer irresponsible) had to be replaced with an attitude of responsibility and plant ownership. In order for the restart effort to reach its goal, each TVA employee (maintenance, chemistry, as well as operations) had to feel a sense of personal responsibility and plant ownership. In addition, these same attitudes had to be reflective in the conduct of operations of the plant's employees. These goals are being achieved through a variety of integrated programs in training, teamwork and professional communications.

## CREATING ORGANIZATIONAL CHANGE THROUGH TRAINING & TEAMWORK

### Management Commitment

Cultural change at TVA began with upper management's total commitment to professionalism and safety. The Office of Nuclear Power was restructured and organized to provide direction and support to the operating plants. Goals and objectives were clearly communicated to all working levels of the nuclear organization as well as support. Work-place meetings and discussions were held in open forums with upper level management available for open dialogue through questions and answers. Periodic newsletters clearly delineated each plant's progress toward restart goals. Personnel at all levels got involved in increased communications and culture change efforts. Site managers were established to orchestrate the interface between departments at site locations. The training department was upgraded to division status so that it might play a more important and central role in providing all personnel the requisite skills and knowledge for restart. Finally, and perhaps most importantly, an overall philosophy permeated all nuclear operations focussing upon professionalism and doing things right the first time every time. Attention to detail, conscientiousness, and diligence in daily conduct of operations came to the forefront of everyone's mind. It was apparent to all by word and deed that management was committed to professional behavior and attitudes within the day to day conduct of TVA's nuclear operations.

ENHANCING PROFESSIONALISM THROUGH TRAINING: THE CONDUCT OF OPERATIONS PROGRAM

As a second step, TVA's Office of Nuclear Power chose to initiate the concepts of professionalism and plant ownership through the Conduct of Operations course developed by Westinghouse Electric Corporation. This one day seminar was delivered to each operating crew (management, SRO's, RO's and AUO's) at the Sequoyah, Browns Ferry, and Watts Bar plants. The goal of the course was to increase employee awareness for conducting station operations in an attentive, diligent, and conscientious manner. Specific emphasis was placed upon each individual's methods and demeanor as principal factors leading to safe and efficient operations.

The course relied upon a combination of lecture, class participation, and video tape to focus awareness upon good conduct of operations. Case studies of operating incidents from a variety of industries were relayed throughout the day. Students derive that accidents can and have occurred due to unprofessional behavior and attitudes. Conversely, a professional attitude and behavior often does serve as the final barrier and defense of adverse consequences in operations. As the case studies unfold, each crew is challenged to delineate its own criteria and standards of professional behavior. In addition, station management played an integral role in the program by introducing the course and concluding the course with questions, answers, and open discussion and a first draft proposal for a formal conduct of operations policy. Several important concepts that were developed through the course are as follows:

- First impressions may not be accurate or fair, but we all are subjected to them. Consider the following:

- Coffee stains on the flip down trays of an airplane lead us to believe that the airline does not perform its engine maintenance properly.
- The professional advise of a doctor dressed in a business suit is taken much more seriously and prescriptively than the advice of a doctor dressed in blue jeans and tennis shoes. The patients know that both doctors are technically competent, but they listen with greater conviction to a doctor who looks like a doctor.
- Nuclear power has a long lasting first impression to the public. After all, it was introduced at Hiroshima.
- We in nuclear power will be judged by others (the NRC, INPO, our peers, the public) and their first impressions of our professionalism. These first impressions may not be right, may not be accurate; but nonetheless, we will be judged. Fortunately, our behavior and our attitude can control that first impression.

* Within the hi-tech, complex world of man-machine interface, it's still the man that makes the difference. Regardless of industry or technology, people are the common thread that leads to either operational excellence or tragedy.

  - United flight 123 crashed outside of Portland, OR killing 8 people. As the captain circled the airplane for 1 hour preparing for a possible emergency landing, he did not hear his co-pilot tell him (3 times) that the plane was running out of fuel.
  - Three Conrail locomotives collided with an Amtrak passenger train outside of Baltimore, MD killing 16 people and injuring 198. Why wouldn't the nation's rail ~~system have the technology to prevent such an accident?~~ When one considers that the Conrail engineer: proceeded through two working stop signals; operated a locomotive with a safety light missing; operated a locomotive with an audible emergency horn willfully disabled; manually overrode the dead man switch; and smoked marijuana - it becomes difficult to fault the rail system's safety technology.
  - The Herald of Free Enterprise set sail across the English Channel with its bow doors open. In addition, it was improperly ballasted, had no instrumentation to indicate the position of its bow doors or the degree of ballast, and had adopted a communications system of only negative reporting (i.e.; communications were implemented only to report a known fault). The unfortunate result was the death of 198 passengers.

Ironically, in tragedy after tragedy in our hi-tech world, the success or failure of good operations falls clearly to the professional demeanor and conduct of the operator.

- Although the aforementioned case studies were indeed sobering and gruesome, they were a constant reminder that it is the man who is, and always will be, the principle component of the man-machine system and any adverse consequences that may result. Although we design, construct, and follow procedures to prevent adverse conditions at power plants, we know that initiating events still happen and occasionally slide through the holes of our protective mechanisms (see figure 1). We also know that the most dynamic and responsive barrier is the man, who is comprised of a complexity of human skills and attributes as depicted by Figure 2.

  Just as attitude, job knowledge, attention to detail, diligence, conscientiousness, communications, and verification represent the principal attributes of the man, they also represent the key dimensions of professionalism. When all of these skills and attributes are at their best, the man, or the team of men, become an impenetrable barrier against adverse consequences.

FIGURE 1

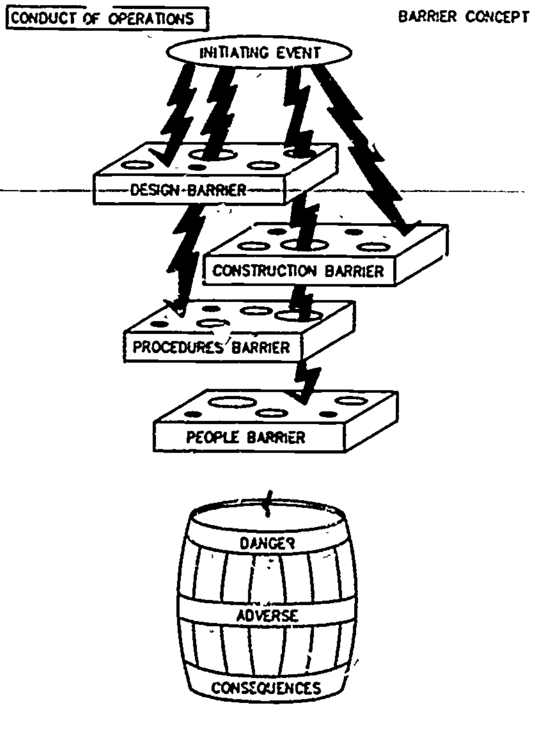
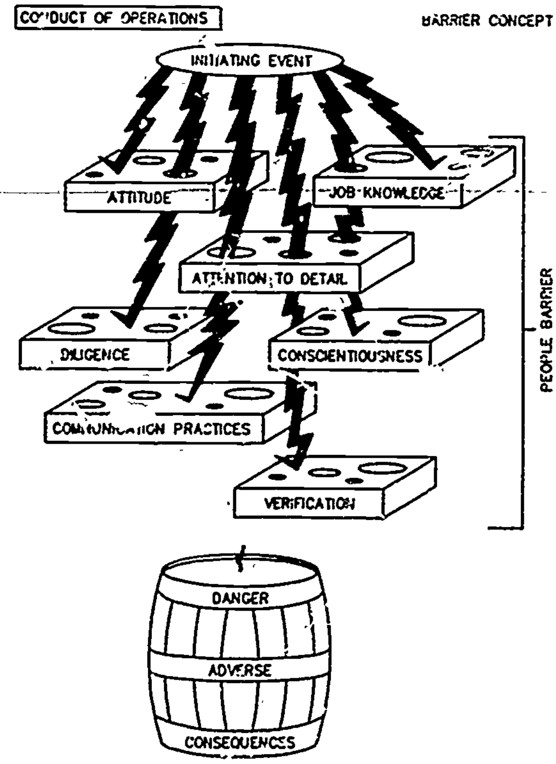



FIGURE 2



- The course was concluded with an open discussion and dialogue between the operating crew and station management. At this time all parties express and defend their standards of professionalism and openly discuss the environment and culture needed to achieve these standards. A first draft of the conduct of operations policy was distributed for review, comments, and future revision with inputs from all operational levels.

The Conduct of Operations program represented a strong catalyst for implementing cultural change at TVA. However, we as trainers realize that few if any one day programs can engender behavioral changes. At best, such a program can start to challenge attitudes and values, thus providing a preliminary foundation for behavioral change. A brief synopsis of specific follow-on actions taken by TVA is as follows:

- The primary thrust of the TVA's Nuclear Training Division was to train all operations personnel in teamwork and team building skills. This endeavor involved teaching the operators several approaches or paradigms to teamwork, and then putting these concepts into practice through role playing and simulation. A good amount of this training was conducted using the simulator, challenging the operating crews to implement the concepts in real world situations with those same persons that one works with everyday. Throughout this training, emphasis was placed on communications, and a number of videotaped scenarios were utilized to contrast good versus poor teamwork and communications in the control room.

- As plant start up approached, the Conduct of Operations seminar challenged operating crews to delineate their standards for professionalism and good Conduct of Operations. Upon this foundation, TVA structured group discussions to involve most operations personnel in the development of a formal Conduct of Operations policy. Simply put, this endeavor represented the grass roots effort to obtain input from all operational personnel regarding their standards and criteria for Conduct of Operations at their plant. The resultant policies depicted the inputs and standards of operating personnel at all levels, specifically tailored for each plant. Naturally, the operating crews sense great pride and ownership in "their" policies and living up to the standards they helped established.

- As operating crews completed training in teamwork, communications, and professionalism, the Division of Nuclear Training expanded this training into the plant to include those individuals who interface with operators.

Again, these support personnel were allowed to delineate their standards for professionalism and were allowed to apply concepts for improved communications and teamwork through role play situations.

- As this training was concluded, the Training Division faced the broader challenge of keeping the concepts and practices current in people's minds. That is, conducting training is far easier than changing a culture. One way in which TVA kept these concepts in the forefront of everyone's thinking was to capture the essence of the training on 3"x5" pocket cards. In particular, a 3"x5" laminated card was given to each employee participating in team work and communications training. The cards fit into an individual's shirt pocket. One side of the card describes appropriate communications techniques (see figure 3), while the reverse side of the card reminds people of key points in reporting abnormal conditions (see figure 4). At a glance, plant personnel can review the essence of the concepts for successful communications.

- In their best selling parable, The One Minute Manager, Blanchard and Johnson highlighted the importance of "catching people do' ı things right." The entire focus of: 1) the development of the Operation's Professional Code; 2) the teamwork and communications seminars; and 3) the video taped scenarios was to involve people in "doing things right." Changing a culture is hard, becaus_ we are all entrenched in our old and comfortable behaviors and attitudes. However, as people provided new concepts and guided opportunities to apply those concepts, the new behavior can . ome more comfortable and more fulfilling than the old behavior. In this case, TVA controlled the environment to involve people in doing things right. Slowly but steadily the plant cultures are changing to reflect the newfound ownerships in professionalism - an attitude and accompanying behavior leading towar_ overall excellence in Conduct of Operations.

## LESSONS LEARNED

Changing an organizational culture to create quality achievers is neither an expedient nor an easy task. Nonetheless, it is achievable and extremely fulfilling. As you consider undertaking this process, the following lessons learned at TVA may aid in guiding your endeavor.

1) A work-place culture is based on both attitude and behavior. In order to achieve quality through training, both issues must be integral parts of the training process.

2) The change process begins by challenging people's attitudes at the deep or visceral level. The Conduct of Operations seminar was an effective tool at forcing people to ask themselves, as individuals and as work teams, 'What do I believe? What are my (our) standards for professionalism and good conduct of operations? What do I need in my environment to help me attain those standards for excellence in conduct of day to day operations?"

3) When you involve employees in the process of delineating their standards for professional behavior, they tend to adopt more stringent professional standards and seem more committed to the standards than if they were told what standards to follow. Naturally, there is strong ownership for the standards accompanied by strong desire to achieve the standards.

4) Regardless of how powerful an eight hour seminar may be at the emotional level, it will not in and of itself change behavior. Any behavioral change that results must draw upon and practice the standards of professionalism defined by the employees. Key elements to achieving actual behavioral changes are:
   - a public, unwavering management commitment to enhanced professionalism and cultural change; and
   - integrated, follow-on training that focusses upon teamwork, communications, and professionalism and that involves people in doing things right.

5) Management communication regarding cultural change must be public and consistent. At TVA, the Office of Nuclear Power provided:
   - publicly displayed goals;
   - open forums for questions and answers;
   - direct interface and dialogue at all Conduct of Operations seminars;
   - periodic news bulletins reflecting management philosophy and tracking the status of restart objectives; and
   - a restructured management organization sculptured to achieve restart criteria in a professional and expedient manner.

6) Ongoing training at TVA is reinforcing the concepts and techniques of teamwork, communications, and professionalism. Training scenarios and environments have been structured to <u>involve</u> people in doing things right. The operating crews as well as those who interface with the operating crews receive ongoing training in these areas.

The essence of good communications is being kept at the forefront of people's minds by providing them with 3"x5" cards depicting proper communications techniques and techniques for reporting abnormal conditions.

7) In our modern fast paced, hi-tech work environment we must remember that it is the operator - the man - who is the most crucial component in the man-machine team. Although we do our absolute best to design and implement a series of sophisticated barriers to tragedy, we all know that it is and will always be man's role to serve as the final barrier. Professionalism and excellence in conduct of operations are the key ingredients in fortifying the human barrier.

Remember these key points when communicating items of a directive nature:

**FACE TO FACE COMMUNICATIONS: be sure to use:**

1. A component identifier
2. State the action to be taken or status to be checked
3. Get acknowledgement (close the loop) before taking action

**TELEPHONE/RADIO OR REMOTE COMMUNICATIONS should be in the following format:**

1. Name or work station of the individual called
2. Name or work station of the individual calling
3. Message Text
4. Ask for a repeat back
   a. Directives—verbatim
   b. Information gathering or giving—jist of the conversation
5. Confirmation of repeat back by the caller

Figure 3

Front side of 3" x 5" laminated pocket card
Appropriate Communications Techniques

**When Reporting Abnormal Conditions, remember to:**

1. Speak deliberately & distinctly
2. When unknown to the person called, identify yourself & your watch station
3. Describe the nature of the problem
4. State the location of the problem

**PROFESSIONALISM — ACCURACY — FORMALITY**

CONDUCT OF OPERATIONS
Operations Training Branch — Human Factors Section
Power Operations Training Center
P.O. Box 2000
Soddy Daisy, TN 37379

Figure 4

Back side of 3" x 5" laminated pocket card

Key Points in Reporting Abnormal Conditions.

# PERFORMANCE BASED TRAINING FOR QUALITY SURVEILLANCE PERSONNEL

Geoffrey M. Edelman

ABSTRACT

Quality surveillance in real-time is a growing industry trend to improve nuclear plant performance. However, training to support this function currently is not structured as systematically as tasking addressed through the INPO-coordinated accreditation program. This paper describes an effort by the ASQC Operations Quality Surveillance Subcommittee to produce a Quality Surveillance Handbook. The handbook will include recommendations for training content based in part on an industry-wide job analysis for the position being conducted by the subcommittee. This paper also describes a methodology for implementing a performance-based, quality surveillance program. The plan by design involves personnel who will be subject to surveillances as well as personnel who will conduct the surveillance. Design that includes both groups is the key to reducing conflict and promoting a consensus approach. Additionally, personnel must have a common process for defining weaknesses/problems and for determining corrective action.

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## INTRODUCTION

The purpose of this paper is to present a current project of the Operations Quality Surveillance Subcommittee of the Energy Division of the ASQC. The output of this project can be used to establish quality surveillance programs and supporting training at nuclear power plants. This paper also describes an implementation plan targeted to excellence that will involve both surveillance and plant personnel.

## BACKGROUND

One of the most prevalent themes in INPO plant evaluations is the utilities' weakness in self-assessment of performance. Contributing factors include:

- assessments are excessively focused on documentation reviews
- assessments too frequently address only violations of specific requirements
- the scope of observations is too narrow

NRC similarly has been critical of industry quality verification efforts. Temporary instruction 2515/78, "Inspection of Quality Verification Functions," establishes the following quality organization objectives:

- Act in a measurement and advisory function, monitoring the overall performance of the plant.
- Identify substandard or anomalous performance, or precursors of potential problems.
- Report finding in an understandable form in a timely fashion to a level of line management having authority to effect corrective action, and
- Promptly verify the effectiveness of the corrective action.

Further, they state that an "effective quality verification organization is technically and performance oriented; it focuses its efforts towards end products as opposed to being concerned only with processes and procedures." Additionally, "the licensee's verification should be in depth, not superficial, and should emphasize technical achievement more than programmatic conformance."

It is apparent that both INPO and NRC are encouraging verifications of quality to include not only audits but technical accuracy as well. Audits traditionally are "after the fact," and have centered on compliance to programmatic criteria through documentation reviews. What has been missing is a more "real-time" assessment of what is actually happening in the field. The significance of "real-time" quality surveillance is that quality problems are found as they occur, not weeks or months afterward. A real-time surveillance observation also allows verification of performance elements not available through documentation reviews.

On recognizing the need to improve, expand, and share surveillance experience, the ASQC Energy Division Operations Committee established the Operations Quality Surveillance Subcommittee. Subcommittee objectives are to:

- Define operations quality assurance surveillance at nuclear power plants.
- Establish a methodology and identify attributes for quality surveillance activities performed at plants.
- Establish guidelines for training and qualifying personnel performing quality surveillance.
- Establish guidelines for determining which plant activities should be monitored and assessed.
- Sponsor training seminars on quality surveillance.
- Develop a plan for educating plant personnel in the importance of quality surveillance of their activity.
- Write an Operations Quality Surveillance handbook.

The ASQC Energy Division Operations Committee has 99 members representing 64 utilities and 35 contractor/consulting organizations.

Their output provides a broad-based industry consensus, and can be used in the manner of NRC/INPO guidance to evaluate and re-direct plant-specific, quality surveillance efforts. It also can be used to establish, define, and validate training needs.

## DEVELOPING AN EFFECTIVE QUALITY SURVEILLANCE PROGRAM

Moving from a compliance-focused audit program of self-assessment to a situation in which the Quality function is a partner in operations improvement suggests a long leap in how business has been done. Some would target attitude adjustments as necessary in such a cultural sh . "Attitude," however, is very elusive. Perhaps the more controllable aspects of the work environment offer a greater opportunity for an effective sur illance function. Steps in the change process include:

- Develop consensus and commitment
- Define objectives and measures
- Flow-chart the surveillance process
- Enhance the performance system
- Provide training
- Implement/maintain the program

### Develop Consensus and Commitment

"Ok, Ok! Whatever you guys want to do, I'll go along with it. But remember, it wasn't my idea."

Anyone who has ever tried to implement change probably has heard these words. What follows usually is a nominal effort, possibly even subversion, and the prediction for lack of success comes true. To follow the teachings of quality, "do it right the first time."

Consensus doesn't mean that all involved unanimously embrace an idea. But there must be shared value. There must be commitment from those responsible for equipment operation and maintenance if a surveillance program is to be effective. Points of disagreement must be confronted, articulated, and restated until they represent all involved. The output of this step is agreement to change and the nature of the change.

Develop Objectives and Measures

"So we're nine months into a full scale surveillance program. What has it accomplished?"

Unless targeted against performance goals and improvement, this is a good question. "How's it going?" can only be answered in the context of what was supposed to be accomplished. Objectives must be clearly identified, and agreed upon by those affected. Objectives should be realistic and measureable, expressed in both qualitative and quantitative standards. Perhaps the greatest return on investment is to target surveillance against known performance weaknesses rather than randomly or in areas already effective.

Against the objectives, control points and measures should be positioned to collect effectiveness information. They should allow regular and timely capture of surveillance performance.

Flowchart the Surveillance Process

"Seems like every time we get ready for a surveillance, it's like the first one we've ever done."

Just as an electrical or mechanical system operates consistently and predictably according to engineered standards, people-oriented activities can be conducted systematically.

Given objectives which describe necessary outputs of this "system" it remains to identify cross-functional involvements and resources necessary to support performance targets. Consistency will occur by defining cross-functional responsibilities in documentation which describes the surveillance program. Consistency also will occur by building in a process to define each group's contribution for solving performance "problems," choosing between alternative approaches, and thinking "beyond the fix" to address other performance improvement opportunities.

The value of this step is widespread. Only if plant and surveillance personnel jointly design such a system, will they be committed to its results. Such a cooperative activity also would help reduce the "culture" gap traditionally in place between plant and quality groups. Having ownership and a common process and being driven by documentation rather than individual managers are key aspects in making the surveillance program systematic.

Enhance the Performance System

"So they didn't like the way we did that last job and they wrote us up. Give it a couple of weeks and it'll be business as usual."

Performance targets have been set, and processes integrated into the work system. People are enthused about the program. Despite good intentions, people have a way of reverting to old habits without a balance of consequences. Whether outstanding or substandard, performance will remain in a comfort zone unless reinforced.

Few managers are qualified to "counsel" personnel in motivation or attitudinal behaviors. All managers, however, have control over the working environment of positive and negative reinforcement, Interestingly, as a reward, money does not tend to sustain behavior. A good way to find out what encourages wo rs to perform well and what discourages their poor performance is to ask them. Without attention tc this detail, success will be limited and short-lived.

Train to the Surveillance System

"Last time it was communications training and next we learn how to write. Just tell me when and how I'm supposed to use this stuff."

Training too oft is individually focused with no direct application. A way more likely to produce results is to practice with the tools and documentation that are part of the job. It is particularly critical that personnel involved in cross-functional activities such as surveillance be trained together and learn to work together addressing real performance issues. Developing better ways to perform tasks can be confrontational, especially if surveillance and maintenace workers train separately and individually. Given common training, with a process for solving problems and determining corrective action, plant gro s will focus on the issues rather than conflict.

Implement and Maintain the Surveillance System

"On paper it all sounded good, but once we tried to use it, there were too many holes. After awhile, people lost interest."

Any system involving people and processes has to be validated and maintained. Often it's worthwhile to pilot test a new idea in a limited application to ensure useability and fix weaknesses before releasing it on a wider scale.

By definition, a "system" has some means of evaluation and updating. Thus, a healthy system of quality surveillance is targeted to performance improvements through objectives, and addresses its weaknesses for improvement. Such a system also captures the benefit and savings it creates, and recognizes the people who make it possible.

## SUMMARY

Quality surveillance offers a real-time opportunity to improve plant performance. A current project to produce a Quality Surveillance Handbook offers an industry model. Plants can use this model to develop plant-specific programs. Development and implementation of plant programs requires an involvement of both quality surveillance and maintenance personnel. It also requires a process for effective problem solving and determining corrective action.

APPLICATION OF QUALITY PRINCIPLES
TO TRAINING OF QA AUDIT PERSONNEL

Willia . Glasse
John Espy

ABSTRACT

One of the major demands on nuclear QA audit programs today is their ability to determine and address the effectiveness of the activity being audited. Management wants to know with certainty whether an activity is effective or what must be done to make it effective. This demand stems largely from past experience where highly significant quality problems occurred with little, if any, forewarning by audit results. In many cases, audit results made no attempt to address effectiveness. Concurrently, a similar demand has been placed on training to teach auditors how to determine the effectiveness of an activity.

This paper consists of two parts. Part 1 compares an auditor training program, developed in accordance with INPO's Training System Development methodology, with typical auditor training programs considered as satisfying ANSI N45.2.23 requirements. This comparison highlights the need to develop analytical techniques in addition to cognitive knowledge if auditing for effectiveness is to be taught. Part 2 identifies challenges encountered in implementing a skills-oriented training program for QA audit personnel and describes possible approaches for meeting these challenges. Both parts of this paper highlight those fundamental quality principles that should be ingrained into the auditor training program in order to address analytical techniques.

## PART I

## COMPARISON OF HISTORICAL AUDITOR TRAINING WITH THE TSD APPROACH

### Introduction

Historically, the auditor training programs employed by nuclear utilities have used "subject matter experts" to define the curriculum. Only within the past two or three years have some power companies applied Training System Development (TSD) methodology to their auditor training program. A comparison between the historical training and that produced by TSD methodologies is offered for two major purposes. First, the relationship between the two is indicated. Secondly, insight is given on a possible cause for recent criticism of audits within the nuclear power industry, namely that audits have had little impact on the safe and reliable performance of the nuclear power plant.

### Requirements for Training of Nuclear Plant Auditors

Training of quality assurance (QA) audit personnel is based on the requirements of the governing QA standard.[1] These requirements are listed in Table 1 for auditors and in Table 2 for lead auditors. Except for the management tasks of leading the audit team, the training and experience requirements for both auditors and lead auditors are essentially identical and can be grouped into four areas. These areas are:

1. Knowledge of regulations, codes, and standards.

2. Knowledge of and skills in performing the mechanics of an audit.

3. Knowledge of and skills in using evaluation techniques.

4. Knowledge of the subject to be audited.

| Table 1 |
|---|
| Requirements For Training of QA Auditors |

1. Experience or training commensurate with the scope, complexity, or special nature of the activities to be audited.

2. Training or orientation to develop competence by one or more of the following methods:

   a. Orientation to provide a working knowledge and understanding of QA program and audit standards and the organization's audit program procedures.

   b. Training to provide general and specialized training in audit performance.

      (1) General training includes fundamentals, objectives, characteristics, organization, performance, and results of quality auditing.

      (2) Specialized training includes methods of examining, questioning, evaluating, and documenting specific audit items and methods of closing out audit findings.

   c. On-the-job training, guidance, and counseling under the direct supervision of a lead auditor. Such training includes planning, performing, reporting, and followup action involved in conducting audits.

## Historical Training to Meet Requirements

Whether the QA department or the training department was responsible for training of QA audit personnel, a "subject matter expert" determined the design of the training. The subject matter expert identified the training topics and either assigned instructors to develop the training or selected contractors' off-the-shelf courses. On-the-job training was governed by the organization's procedures for qualification of audit personnel. Such OJT typically had little structure and gave much discretion to the audit team leader on what training actually occurred. Also, audit team leaders were not necessarily qualified in the skills required to achieve effective conduct of OJT.

The TVA JTA identified 28 tasks requiring training and listed the associated task elements, knowledges, and skills for each. All of the knowledges and skills could be easily correlated with the four areas of required training. Further, the JTA confirmed that prior enhancements to auditor training programs were in the proper direction. The JTA confirmed that historical training covered, at least in part, all the knowledges and skills that should be possessed by audit personnel. Therefore, the decision was easily made not to require currently qualified auditors to immediately participate in the new training program. As will be seen shortly, this decision led to downstream implementation problems.

During the design phase, the most pressing problems involved determination of the training setting. For several reasons that were good at the time, the program was designed to cover in the classroom all knowledges and skills except for knowledge of the subjects to be audited. A concept was adopted that classroom training (with laboratory sessions) would equip the trainees with all of the identified knowledges and where possible, the skills as well. As a minimum, the classroom phase would address the principles and techniques associated with the skills. OJT would test the skills and provide further training as necessary. This approach resulted in the classroom hours being increased as indicated in Table 4.

Table 4

Comparison of TVA Historical and 1987 Classroom Hours

| Personnel | Historical* | 1987** |
|---|---|---|
| Auditor | 0 to 40 hrs | [illegible]15 hrs. |
| Lead Auditor | 8 to 40 hrs | 64 hrs. (in addition to auditor training) |

* Varied with time and with the trainee's prior experience.

** If all knowledges and skills (except audit subjects) are to be covered by the classroom phase.

Table 3

Historical Training For QA Audit Personnel

| Areas of Requirements | Early Programs | Enhancements |
|---|---|---|
| Regulations, codes, standards | QA only | all |
| Mechanics of auditing | Classroom and OJT | ___ |
| Evaluation Techniques of auditing | Little treatment. OJT, typically unstructured. | classroom:<br>o Communications, esp.<br>- oral presentations<br>- interviewing techniques<br>- technical writing<br>o Observations training<br>o Problem solving techniques |
| Audit subjects | Little Treatment* | classroom:<br>o Plant Technology<br>o Special processes<br>o Software QA |

* Experience of audit personnel relied upon.

## Application of TSD

In 1986, the Tennessee Valley Authority (TVA) completed a job/task analysis (JTA) for auditors and lead auditors and commenced the design and development of a training program based on the JTA. This program was implemented in 1987 and enhancements are continuing to be made.

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Table 4

Comparison of TVA Historical and 1987 Classroom Hours

| Personnel | Historical* | 1987** |
|---|---|---|
| Auditor | 0 to 40 hrs | 116 hrs. |
| Lead Auditor | 8 to 40 hrs | 64 hrs. |

* Varied with time and with the trainee's prior experience.

** If all knowledges and skills (except audit subjects) are to be covered by the classroom phase.

With the practical difficulties associated with releasing audit personnel for training, the classroom phase obviously needed to be shortened. Thus, some of the learning objectives have been (and are being) shifted from the classroom phase to the OJT phase. Experience indicates that those learning objectives associated with the mechanics of auditing are most easily shifted to the OJT phase.

## A Quality Principle Employed

During the design and development of the TVA auditor training program, the training department employed the quality principle that the customer's requirements need to be satisfied. In this case, the QA audit department was the customer and the relationship is illustrated in Figure 1.

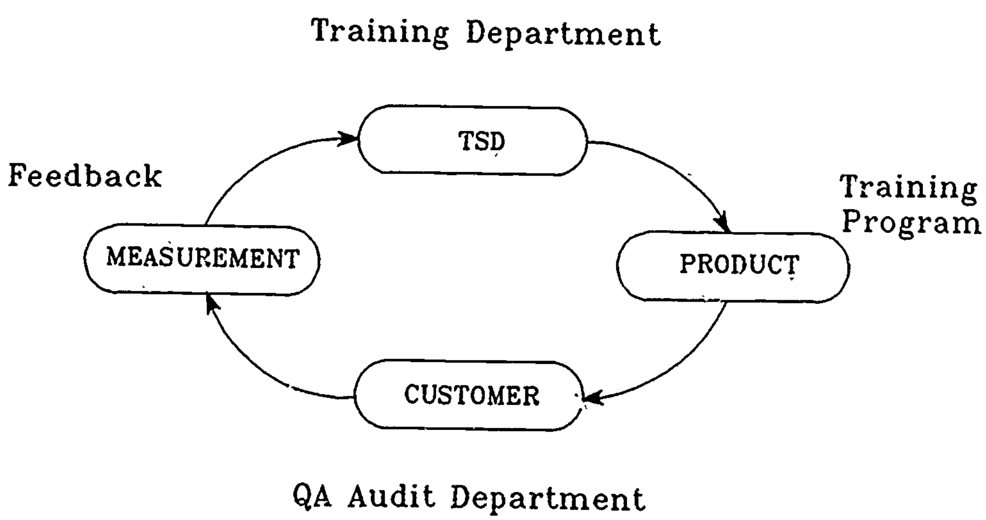


Figure 1. Applying Customer Requirements

Specifically, the training department obtained customer input as follows:

1. The QA audit department co-approved the documented JTA and the design of the training program.

2. The QA audit department concurred with all terminal and enabling learning objectives.

3. The QA audit department attended and critiqued the pilot session of each course.

4. The QA department co-approved the OJT manual.

Nonetheless, measurements of the effectiveness of the training program revealed that a major problem existed.

## Need for Analytical Techniques

The TVA JTA clearly identified the need for audit personnel to possess analytical skills. These skills are associated with tasks involving identification (characterization) of a quality problem and determination of the effectiveness of a quality assurance program or activity. Thus, the training program included principles and specific techniques for observing, reviewing, evaluating, and analyzing. To a large degree, this area of training involved new materials that were not part of the historical training. Historically, OJT had been relied upon to somehow train auditors in analytical techniques.

## The Problem

Indication that a problem existed came from discussions between instructors and graduates of the training program. These discussions revealed that the analytical techniques were being mis-used or not used at all by the graduates.

Further evaluation revealed that the training program had introduced changes into the auditing methodology that were neither endorsed nor fully understood by previously qualified lead auditors. As graduates of the training program attempted to use the analytical techniques, the team leaders were unable to assist in the proper use of these techniques, and in some cases, were stopping such use because the techniques represented foreign methodology to the team leader.

The resolution of this problem recognized the need to provide certain training to the existing staff. Working with management of the audit department, the TVA training department has developed plans for training of supervisors and previously qualified lead auditors in the latest auditing techniques.

Even with the implementation problem, TVA is still convinced that skills-oriented training developed by TSD methodology is the preferred approach. It simply presents challenges that are discussed in Part 2 of this paper.

## PART II

## CHALLENGES IN IMPLEMENTING SKILLS TRAINING FOR QA AUDIT PERSONNEL*

### Introduction

Part I of this paper concluded by identifying a specific problem that occurred with TVA's implementation of a skills-oriented training program for QA audit personnel. Evaluation for causes of this problem and the on-going measurement of the effectiveness of the auditor training program indicate that the training department is faced with several challenges. These challenges and the recommended role of the training department are described in this part.

### Listing of Challenges

This list will undoubtedly grow, but presently, challenges in the following are recognized and further discussed by this paper:

1. Auditing for effectiveness.
2. Performance-based audits.
3. Retraining and continuing training.
4. Retraining unique to lead auditors.

### Auditing for Effectiveness

Since 1970, nuclear QA audits have been required to verify compliance with all aspects of the quality assurance program and to determine the effectiveness of the program.[3] But even today, it is difficult to obtain consistent replies to the question "what is meant by effectiveness of the program?" The question "how does one audit the effectiveness of the program?" produces a variety of answers and the question "how does one train auditors to audit for effectiveness?"

* This Part represents the author's views relative to industry-wide training and does not necessarily represent TVA's position.

produces a greater variety of responses. From the trainer's perspective, the answers to the first two questions must be provided by the QA audit department in greater detail than has typically been the case.

The focus of an audit and the resultant audit methodology depend on the answers to these questions. As illustrated in Figure 2, an audit can be focused toward verifying compliance with commitments of the license or determining the effect of the QA program on the safe and reliable operation of the plant. That is, an audit can measure effectiveness in terms of compliance with commitments or in terms of effect on plant operation.

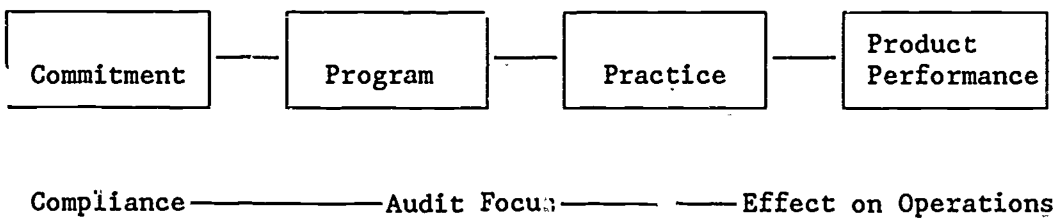


Figure 2. Audit Focus

While a single audit can measure both compliance with commitment and effect on operation, experience indicates that the focus of an audit is on one or the other and not both. Whichever direction it is focused represents the primary objective of the audit. Any findings corresponding to the other direction tend to be those that "fall out" fortuitously.

The intended focus of an audit, as established by the audit program manager, guides all aspects of auditing. Audit planning, performance, and reporting reflect such guidance. Where the emphasis is on compliance, audits look for proof of compliance and tend to find the proof in documentation. Hence, audits that are focused on compliance tend to concentrate on documentation. On the other hand, audits that focus on effect on plant operation must evaluate actual practices and the effect of such practices on operability. The auditing techniques of these two approaches differ.

Differences in auditing methodology for the two approaches exist in all audit activities. For illustration, consider the planning phase for a compliance audit and for an "effect on operations" audit. Planning for the compliance audit considers all source requirements whereas the other may consider only those having an affect on plant systems. Also, the compliance audit planning might totally omit evaluation of the effect of activities on the operability of the plant but the other would focus on such evaluations. Obviously, if differences in audit methodology permeate all audit activities for the two approaches, training is equally impacted throughout. Thus, it is incumbent on the training department to obtain a clear and detailed description from the QA audit department of the policy on auditing for effectiveness. This description should be obtained at the outset of TSD. In TVA's case, the JTA and the training program design, development, and implementation were completed before a sufficiently detailed policy was obtained.

## Performance-Based Audits

The Nuclear Regulatory Commission (NRC) staff has recently refocused NRC inspection toward determining the effect of plant activities on the safe and reliable operation of the nuclear power plant.[5] It is evident that NRC expects the nuclear industry to also perform performance-based audits.

Where prior audits have focused on determining the effect of QA programs on plant operations, performance-based auditing (PBA) may appear to be a new term for an old practice. But at least two key differences exist. First, PBA requires a large quantity of observations of actual practice within activities affecting the ability of the plant to operate safely and reliably. Even where QA surveillance (monitoring) will be relied upon to perform these observations, the PBA program must establish techniques for obtaining and using the data. Secondly, PBA focuses the evaluation of programmatic controls toward only those controls made suspect by the results of the observations of activities. Also, PBA requires that programmatic controls be evaluated in terms of their effect on activities that affect plant operation. Therefore, the PBA program must define its policy for evaluation of programmatic controls. This definition can be expected to be considerably different from the existing policy governing conventional QA audits.

Similar to the prior challenge on auditing for effectiveness, it is incumbent on the training department to obtain from the QA auditing department the detailed policy for performance-based audits. The details should cover the following:

1. Definition of performance-based observation.

2. Plans for establishing and using the performance-based observations data base.

3. Policy for selecting programmatic areas for audit.

4. Policy for evaluating both programs and activities for effectiveness.

### Retraining and Continuing Training

Because skills-oriented training includes methodology for the mechanics and techniques of auditing, any change in audit methodology affects the training program content and implementation. The transition to performance-based auditing will have a large effect. Other changes made by management of the QA audit department may have a small effect but each change can be expected to have some effect.

Changes in auditing methodology appear to be inevitable as expectations for the audit program change. In addition to measuring effect on the safe and reliable operation of the plant (performance-based auditing), audits are now being expected to assess achievement of performance indicators, help programs to improve, and prevent large problems by detecting and correcting those problems that lead to the larger problems.

A two-fold challenge exists for the training department. Once QA audit personnel are qualified, further training is not specifically required by regulations or standards, and therefore, resistance to retraining and continuous training is common. If retraining and continuing training of auditors is to occur, the training department may need to convince the audit department of the worth of such training. Secondly, the decisions to establish or revise retraining and continuing training curriculum need to reflect the audit policy established by the QA audit department. That is, each decision to establish or revise retraining and continuing training programs must include a determination that the training and the audit policy continue to agree and, if not, one or the other needs revision to bring them into agreement. Otherwise, the skills developed by training and the skills used during the audit will deviate.

Gary Ward[6] provides a model for a curriculum development system for retraining and continuing training that can be applied to the skills-oriented auditor training program. This model identifies four sources of information to monitor. These are the demands of (1) technology, (2) work, (3) personnel, and (4) organization. By monitoring and evaluating these areas, the curriculum development committee can objectively establish and revise the retraining and continuing training program for auditors.

Examples of changes in these four areas can be readily identified. Where the QA audit program is expected to stay abreast of technology or to serve in new roles, training should be an important ingredient. A few examples are offered in the following paragraphs that illustrate the need for the training department and the QA audit department to jointly evaluate and determine the retraining and continuing training needs for QA audit personnel.

Plant Performance Indicators

Utilities with operating nuclear power plants have set short-term and long-term goals for most of the plant performance indicators used by INPO to report on overall plant performance.[7] Will QA audits be used to measure progress toward these goals or to evaluate areas of shortcomings? If so, the audit will be more of an assessment of performance than an audit of compliance and different techniques would apply.

Reliability-Centered Maintenance

Whether the term is predictive maintenance or reliability-centered maintenance, many utilities are revamping their maintenance programs to obtain more technically-sound and cost-effective programs. The maintenance program described by J. W. Dickey and B. R. Sculthorpe in a recent issue of Nuclear News provides an example.[8] These efforts present two challenges to the QA auditor that probably warrant training. Both the principles of reliability centered maintenance and the specific diagnostic techniques need to be understood by the auditor.

Human Performance Evaluation System

An increasing number of utilities are participating in INPO's Human Performance Evaluation System (HPES) which helps plant personnel identify and correct factors that contribute to human performance problems.[7] Any role in HPES defined for the QA audit program would need to be evaluated for impact on training.

Information Systems

While computer-aided information systems are certainly not new, applications of these systems continue to evolve. Automated inventory control and replacement ordering and automated drawings offer examples. The QA auditor may need training on both the specific applications and the principles of software QA.

## Retraining Unique to Lead Auditors

In their role as audit team leaders, lead auditors direct the planning, performance, and reporting of an audit and, in essence, supervise the audit team members. Thus, the lead auditor greatly influences the mechanics and techniques of auditing as used by the team members. As described in Part I of this paper, TVA experienced implementation difficulties due to failure to retrain previously qualified lead auditors in newly adopted evaluation techniques.

To avoid problems in the implementation phase, the retraining needs for lead auditors deserve special attention. As TVA's experience proved, audit program management can agree with training program content that changes auditing mechanics or techniques and still not recognize the need to ensure that each previously qualified lead auditor needs to be made knowledgeable on the changes. While the evaluation phase of TSD should detect such problems (as occurred in TVA's case), preventive measures can avoid the problem altogether. By using a formal curriculum development system to address retraining needs for lead auditors, the training department can ensure that lead auditors receive updates as needed.

## Conclusions

Skills-oriented training of QA audit personnel introduces additional challenges for the training department. Because the "how-to-audit" is affected by both audit policy and previously qualified team leaders, and because the audit policy is changing, skills training needs to be designed in a manner that will avoid implementation problems. Full consideration must be given to the customer's requirements, i.e., those of the QA audit program management. The challenges are (1) to obtain such requirements in sufficient detail to ensure that the skills taught agree with those intended to be used and (2) to establish a mechanism for continuously monitoring for changes in customer requirements and evaluating these changes for impact on training.

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# SYSTEMATIC PROBLEM SOLVING PROCESS (SPSP) - ROOT CAUSE ANALYSIS THAT WORKS

J. H. Kubenka

ABSTRACT

In January, 1988, the Nuclear Training Department began to research a methodology for Root Cause Analysis in response to a Nuclear Safety Review Board (NSRB) request. As a result, the Systematic Problem Solving Process (SPSP) was developed to provide a simple methodology which encompasses all elements needed to perform a competent and thorough problem analysis and to project valid solutions to those problems.

The SPSP assumes that errors which result in undesirable events (problems) will be made in a sequence of actions during some work activity. It assumes that the errors will be made by very capable, carefully selected, trained and qualified people who are strongly biased against making errors that have undesirable or dangerous effects. The process also assumes that the organizational "system" is at fault more often than the individual and tries to find out how the <u>system failed the individual</u> rather than how the <u>individual failed the system</u>.

The SPSP training course describes and provides practical exercises in the thought processes and techniques used by experienced accident and incident investigators. The course provides a potential investigator with a "tool box" which contains all the necessary tools to deal with problems both simple and complex. The course also provides instruction on how to use each of the tools individually and in conjunction with each other to effect reasonable solutions to problems encountered. The techniques are specifically applicable to the nuclear power plant environment and its organization.

# SYSTEMATIC PROBLEM SOLVING PROCESS (SPSP) - ROOT CAUSE ANALYSIS THAT WORKS

J. H. Kubenka

In late 1987 the Nuclear Training Department at the South Texas Project was requested by the Nuclear Safety Review Board to develop a training program to be given to persons performing Root Cause Analysis under our Station Problem Report procedure.

It was a task we accepted out of self defense as I'm sure this audience is only too aware of a tendency for persons doing a Root Cause Analysis to jump on a lack of training as a major root cause. And why not? Almost anything that happens which involves people can be due in some part to insufficient knowledge on the part of the individuals involved. And the person performing the analysis probably has ten other high priority deadlines to meet so he looks at lack of training as a potential root cause, is reasonably comfortable that more training would have prevented the problem, writes his report, and goes back to more challenging activities. And as a bonus, from the investigator's point of view, the fix lies with another department.

On the training side of the fence, we end up with what we call jump up training which wrecks havoc on our work plans as we have to either squeeze the training into the existing schedule or drop something off. We've even said, tongue in cheek, that we were going to add another module to GET called "other stuff" which would include all those extra training items that someone thinks, as a result of some problem, should be covered. And when that module grew to be longer than the rest combined and we were asked why GET was so long, we'd be able to point to the "Root Cause". It is not that we believe training is never a root cause but we do like to feel comfortable that it is not being used as a "band aid" and that the plant is getting its money's worth from the time they spend in training. We looked at the request to develop a Root Cause course as a real opportunity.

The Station Problem Report procedure that kicks us into a root cause analysis contains good guidance as to when the analysis is required but lacks specific methods to use in performing the analysis. The results produced by the analyses performed up to that time seemed inconsistent and there was a general lack of confidence that the real root causes had been determined. Because the plant had recently loaded fuel, this was really just a "gut feeling" as we had not seen any recurring problems which could indicate that we were not fixing the problems. However, we did want to have comfortability that we were learning from our mistakes.

So our mandate from the Nuclear Safety Review Board was to identify a consistent methodology to use in performing the analysis and then to provide training on that methodology.

Upon review of the available material, it was found that this specific field is still relatively young. We reviewed the work done by the Department of Energy (contracted to EG&G Services, Inc.) to build an accident investigation process. The result of that work was the introduction of the Management Oversight & Risk Tree (MORT) concept which provides a technique for thoroughly searching programs. While the original MORT is somewhat complex, a modification of the concept was developed by staff members of the Savannah River Laboratory for use in analyzing and coding reactor incidents to a root cause level. In conjunction with the MORT concept was the development of the Events and Causal Factors chart or diagram by the National Safety Transportation Board. The Events and Causal Factors diagram not only helps analyze and evaluate an accident but aids in validation of determined root causes.

At first, it seemed like the answer to the task of developing a root cause analysis methodology was to simply modify the Savannah River Laboratory methodology to meet specific South Texas Project requirements. Upon further review it was realized that much "front-end" work was necessary to <u>initiate</u> proper analysis and that a <u>consolidation</u> and <u>summary</u> of results along with an <u>action plan</u> would be required to close, verify, and allow revision to the analysis. Therefore, it was determined that simply performing Root Cause Analysis is not sufficient to the desired end.

As a result, the Systematic Problem Solving Process (SPSP) has been developed to provide a simple methodology which encompasses all those elements needed to perform a competent and thorough problem analysis and to project valid solutions to those problems. The Systematic Problem Solving Process has been developed from components of a number of various industrial improvement programs, the modified investigative tools of MORT and E&CF charting, the Human Performance Evaluation System of INPO, and original work. We believe that the process encompasses all the elements needed to perform a competent and thorough problem analysis and that the methodology projects valid solutions to those problems.

The Systematic Problem Solving Process course describes and provides practical exercises in the thought processes and techniques used by experienced accident and incident investigators. It provides a potential investigator with a "tool box" which contains the necessary tools to deal with problems both simple and complex. The course also provides instruction on how to use each of the tools individually and in conjunction with each other to effect reasonable solutions to problems encountered. The techniques which will be discussed are specifically applicable to South Texas Project's nuclear power plant environment and its organization.

What do we mean by an organization? An organization is composed of people, the physical plant, and documentation. An organization is intended to operate as one unit, with all its parts in efficient coordination, but too often it does not. The parts operate at different levels of efficiency, or they overlap responsibilities, or they work against one another's best interests and therefore, against the best interests of the organization as a whole. In other words, the parts cause problems for the whole. To accept this fact and to provide direction for the thought processes taught in this course, it is first necessary to define just what a problem is; A Problem is a situation in which something has gone wrong without explanation. More specifically, a Problem is a deviation between expected and actual performance levels that is of an unknown cause.

The Problem Solving Process as taught at South Texas Project is aimed at trying to find out how the system failed the individual rather than "blame placing" or how the individual failed the system. Young children seldom take responsibility for their actions. Instead, they tend to point the finger or direct the blame to others. As people mature, they begin accepting responsibility for their actions. A mature individual is able to accept his or her own short comings and realize that they do occasionally make mistakes, even though they have no intention of doing so, and to learn and improve from them.

We believe organizations evolve similarly to individuals. They begin as immature and grow into maturity. The organization functions as the result of a myriad of individual inputs and relationships. This multifaceted system sometimes fails because it is difficult, if not impossible, to integrate all of these inputs and relationships into a smooth and flawless whole. So as the organization matures, it changes to accommodate errors and makes the changes which will hopefully improve the total system operation. Many times, a given change will be no more than a best guess of what might be an improvement, and it can fail miserably. At other times the change may be just "what the doctor ordered". However, many solutions which may be a perfect fix for a specific application may not be ideal for a closely related application and the change has to be modified to fit the "best of both worlds".

It is the mature organizational outlook which addresses how the system failed the individual. Of course, people do make mistakes simply because they are inattentive or distracted, but this is the exception and not the rule (especially in this carefully selected and trained workforce). In this course the investigator is taught to be skeptical of recurrence control measures which only result in the counseling of people involved without a critical review of how the system (e.g., design, administrative control, procedures, training, human factors, etc.) contributed to the event. The investigator is also taught to be extremely skeptical towards conclusions that an event was the result of an "isolated instance" and is unlikely to reoccur.

By acknowledging an imperfect organizational structure, some assumptions can be drawn. These assumptions presuppose that problems will occur and that errors will be made which result ~~in undesirable~~ events. These undesirable events usually result from a sequence of actions which occur during some work activity. It is also assumed that these errors will be made by very capable people....people who have been carefully selected, trained and qualified for their jobs. These people do not want to make errors which have undesirable, even dangerous effects to both themselves or others. In fact, these people have a strong bias against making errors, yet they happen. These facts are acknowledged by assuming that the organizational SYSTEM is at fault more often than the individual.

Since the organization is always striving to increase it's effectiveness and thus it's productivity, it is insufficient to treat only the symptoms or superficial causes of the problems. Once a severe problem (either accident or incident) has happened, we have "paid the price", therefore, we must learn all we can from it. Once the investigation is complete, we must provide information feedback so that others are able to learn how to do it better the next time. The Systematic Problem Solving Process addresses the identification and treatment of the Root Causes of undesirable events or problems. Hopefully, this will result in corrections which can be made to prevent or at lest minimize the possibility of recurrence.

Before going further in this discussion I should define the term Root Cause as used in this training program. Root Cause is defined as "THE ABSENCE OR FAILURE OF A BARRIER(s) WHICH, IN AND OF ITSELF, IF CORRECTED, WILL PREVENT RECURRENCE OF THE UNDESIRABLE EVENT". Our students are taught to be skeptical when they discover only a single root cause as a result of their investigations. The process should uncover several root causes and thus provide management a menu of options when seeking a solution to prevent recurrence.

But enough of the background and philosophy, for the remainder of my talk I would like to introduce you to the steps in the process as well as some details on the course itself.

The actual course length is 32 hours and includes the following:

An overview of the process

- Lecture on each step
- An exercise led by the instructor and involving the entire class
- The class divided into groups for a group exercise with minimal direction by the instructor
- The instructor critiques each group's exercise and provides feedback

The Systematic Problem Solving Process as used at South Texas Project involves several steps (Figure 1). There is the General Problem Statement which is used to focus the scope of the analysis and solutions which is followed by Fact Finding which generates all the facts about the problem area. The facts uncovered are then used to generate a Definitive Problem Statement and includes development of both an Events Time Line and a Definitive Narration. The actual identification of the root causes occur during the Cause Analysis/Identification phase and these results are used for Solution Selection and Prioritization. The final phase is Implementation.

It should be emphasized that although the Systematic Problem Solving Process is presented as a set of discrete steps in the discussion that follows, it is recognized that implementation of the process does not necessarily follow that pattern. The investigator may and should move back and forth through the steps as the investigation progresses.

What follows is a slightly more detailed look at the process steps:

STEP 1 GENERAL PROBLEM STATEMENT

At the beginning of a problem solving process there may be only suspected problem areas and/or conditions and they may be not well-defined or substantiated by facts. They may also be very subjective, opinionated or intangible. Therefore, a General Problem Statement is needed to focus the scope of analyses and solutions which are to be generated later in the process. A general Problem Statement may also reveal multiple problems which may have to be handled separately. The student is taught criteria that can be used to evaluate or write a problem statement. Through the use of examples and exercises these criteria are applied and the problem statements generated are used during the latter steps.

STEP 2 FACT FINDING

Divergent thinking methodologies of Data Collection and Interviewing are used to generate all the facts about the problem area. These facts can take on many forms and some facts revealed will be new problems in themselves. Others will point to causes of the problem. Analyzing this information and converging on the substantive facts helps to crystallize the problem area. A key element to this step is the development of an investigation plan and the student is given tools to use and practice in preparing a plan. The student is also given sources and ideas to use to help collect data as well as information and practice on skillful interviewing techniques.

STEP 3 DEFINITIVE PROBLEM STATEMENT

From the Fact Finding Process a Definitive Problem Statement is created. The Definitive Problem Statement consists of both an Events Time Line and a Definitive Narration.

The Events Time Line orders events progressively and ensures proper sequencing. Transcribing an in-the-head perception of what happened and when it happened to a visual on-the-paper perception usually provides a clearer understanding of the situation, even for simple situations.

The Definitive Narration follows the Events Time Line and tells the "story" of the problem in detail so that all audiences can understand what happened.

Again, the student is given ample opportunity to practice these techniques.

STEP 4 CAUSE ANALYSIS/IDENTIFICATION

Cause Analysis/Identification utilizes a number of different techniques which can be used either separately or in combination with other techniques. The technique used will depend upon the investigator and the complexity of the problem. A second technique is often used to validate the results from the first technique. The majority of the overall class time is spent teaching the techniques presented in this step and providing and reviewing practical exercises.

The first technique is Barrier Analysis. Barrier Analysis seeks to identify barriers associated with the situation and how each barrier failed to prevent the situation. Forms have been generated to assist an investigator in this technique.

The next technique is Change Analysis which seeks to identify whether any changes have occurred which could have resulted in the problem situation or event. It is useful when other methods imply the root cause is either unknown or that the event is an "isolated instance". It involves asking "What is different about this event from all the other times the same task or situation was performed?". Again forms have been provided to aid the student perform the exercises and hopefully to carry into the field.

A third technique is Events and Causal Factors Charting which utilizes the previously generated Events Time Line to provide a pictorial representation of the sequence of events involved in the program, the circumstances or causal factors associated with each element of the event sequence(s), and the relationship of the circumstances or causal factors to the event sequence. The causal factors are then plotted on the Events Time Line, tied to their associated event generated during the Definitive Problem Statement step, and used for input into the next analysis technique, Root Cause Code Tree.

The Root Cause Code Tree (Figures 2 through 6) is a hierarchical structure that is used to determine and provide consistent codification of root causes to the previously determined causal factors. It is based on the Savannah River Laboratory modified MORT chart and is specific to South Texas Project. It expands the definition of Root Cause to two further levels beyond the Barrier level. It explains the inadequacies of why a barrier failed and thus why an event was not prevented, detected, or corrected. In keeping with the philosophy that the System fails the individual rather than vice versa it is interesting to note that personnel error is not a coded outcome when usir this tree. The Student Text provided during this lesson is actually . User Guide for the Root Cause Code Tree.

A fifth technique which draws on group synergy is Brainstorming. Brainstorming is a method of idea generation which builds on the ideas and suggestions of the group members. Brainstorming can be used to identify all potential barriers in Barrier Analysis, changes in Change Analysis, or causal factors associated with events involved with Events and Causal Factors Analysis.

STEP 5 SOLUTION SELECTION AND PRIORITIZATION

In this step of the process, the root causes are listed for each causal factor on the Events and Causal Factors chart and a remedial solution for removal of that cause is determined. Each solution is then methodically evaluated as to its effect on preventing or minimizing recurrence of the problem. Of the solutions which are generated and evaluated as to their effect, some will have an obvious priority while others will not. For those which are not obvious, the priority must be established. This can be done by a group effort using Multivoting. Multivoting is a convergent process for the orderly reduction and/or prioritization of a large number of items. Once solutions are prioritized, recommendations can be made and implemented. Again the student is given ample opportunity to put this step to practical use.

STEP 6 IMPLEMENTATION

Once solutions have been listed along with corresponding recommendations, implementation can start. However, it is important that all the mechanics of implementation be planned formally. Implementation thus includes an implementation plan and may require a presentation to management for approval of recommendations.

An implementation plan must include all major action items specifying who must approve and when, who must implement and when, as well as the method and time frame for tracking and verifying results.

The implementation plan should be written since management is more likely to respond affirmatively to a well established plan than to verbal suggestions or opinions. An implementation plan shows management that the investigator has thoroughly investigated the problem, evaluated the solutions, scheduled the implementation, determined the benefits, and anticipated needed follow-up actions.

When management approval for the implementation plan is required, a management presentation should be made. The contents of the presentation should include a statement of the problem, a summary of analyses performed, identification of root causes and associated recommendations, the implementation plan, and request for approval.

The final evaluation tool of this course is a written report of an exercise that is given to the students which involves the use of all the Systematic Problem Solving Process steps. The students are taught that this report format contains all the necessary components for presentation to management.

This completes an overview of the process. To summarize, we believe the Systematic Problem Solving Process training course achieves its goal of describing and providing practical experience in the thought processes and techniques used by experienced accident investigators. It provides a "tool box" which contains all the necessary tools to deal with problems both simple and complex. Finally, it provides instruction on how to use the tools individually and in conjunction with each other to effect reasonable solutions to problems.

To date, approximately fifty people have been trained and the training is already showing results which include increased confidence by management that the true root causes have been discovered. The results of an analysis performed using these techniques are more thoroughly documented. Currently there is a waiting list 250 people for the course, so obviously it is proving very popular.

The techniques taught are specifically applicable to the nuclear power plant environment at the South Texas Project and its organization, but is has paid a dividend by providing a systematic approach which can be used more broadly. The techniques can be widely applied and there is currently an interest in including this course as part of our Supervisory Skills Program.

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# SYSTEMATIC PROBLEM SOLVING PROCESS (SPSP)

**STATION PROBLEM REPORT (SPR) PROCESS INPUT**

**GENERAL PROBLEM STATEMENT**

**FACT FINDING**
- DATA COLLECTION
- INTERVIEWING

**DEFINITIVE PROBLEM STATEMENT**
- EVENTS TIME LINE
- NARRATIVE

**CAUSE ANALYSIS/IDENTIFICATION**
- BARRIER ANALYSIS
- CHANGE ANALYSIS
- E&CF CHARTING
- ROOT CAUSE CODE TREE
- BRAINSTORMING

**SOLUTION SELECTION/PRIORITIZATION**
- ROOT CAUSE(S) LISTED FOR EACH CAUSAL FACTOR
- ROOT CAUSES PRIORITIZED FOR SOLUTION RECOMMENDATIONS
- MULTIVOTING

**IMPLEMENTATION**
- RECOMMENDATIONS
- IMPLEMENTATION PLAN
- MANAGEMENT PRESENTATION

**NORMAL SPR PROCESS**
- IMPLEMENT SOLUTIONS
- TRACK SOLUTIONS

FIGURE 1

NTC-0411

ROOT CAUSE CODE TREE FOR USE AT THE SOUTH TEXAS PROJECT

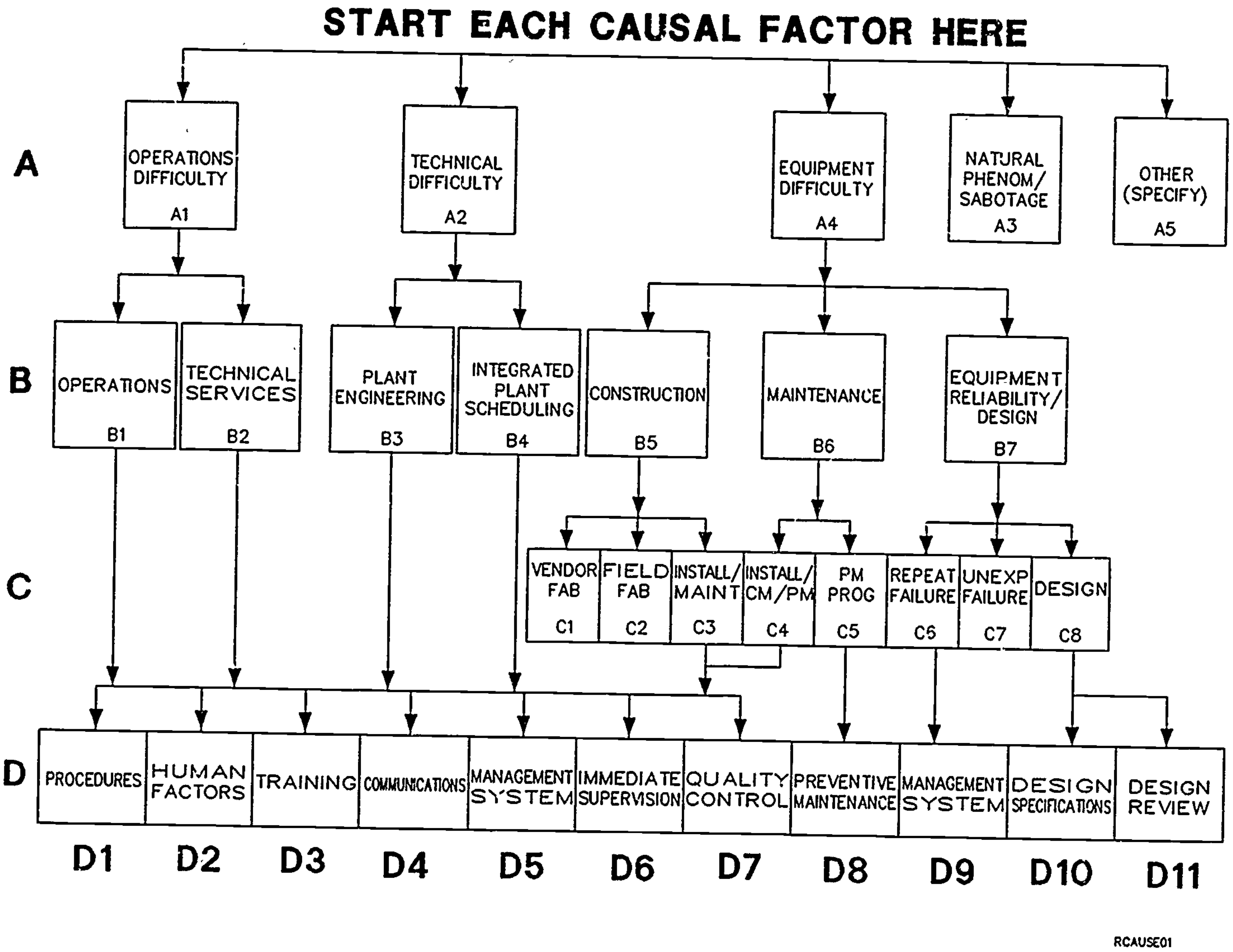


FIGURE 2

IV-A.5.14

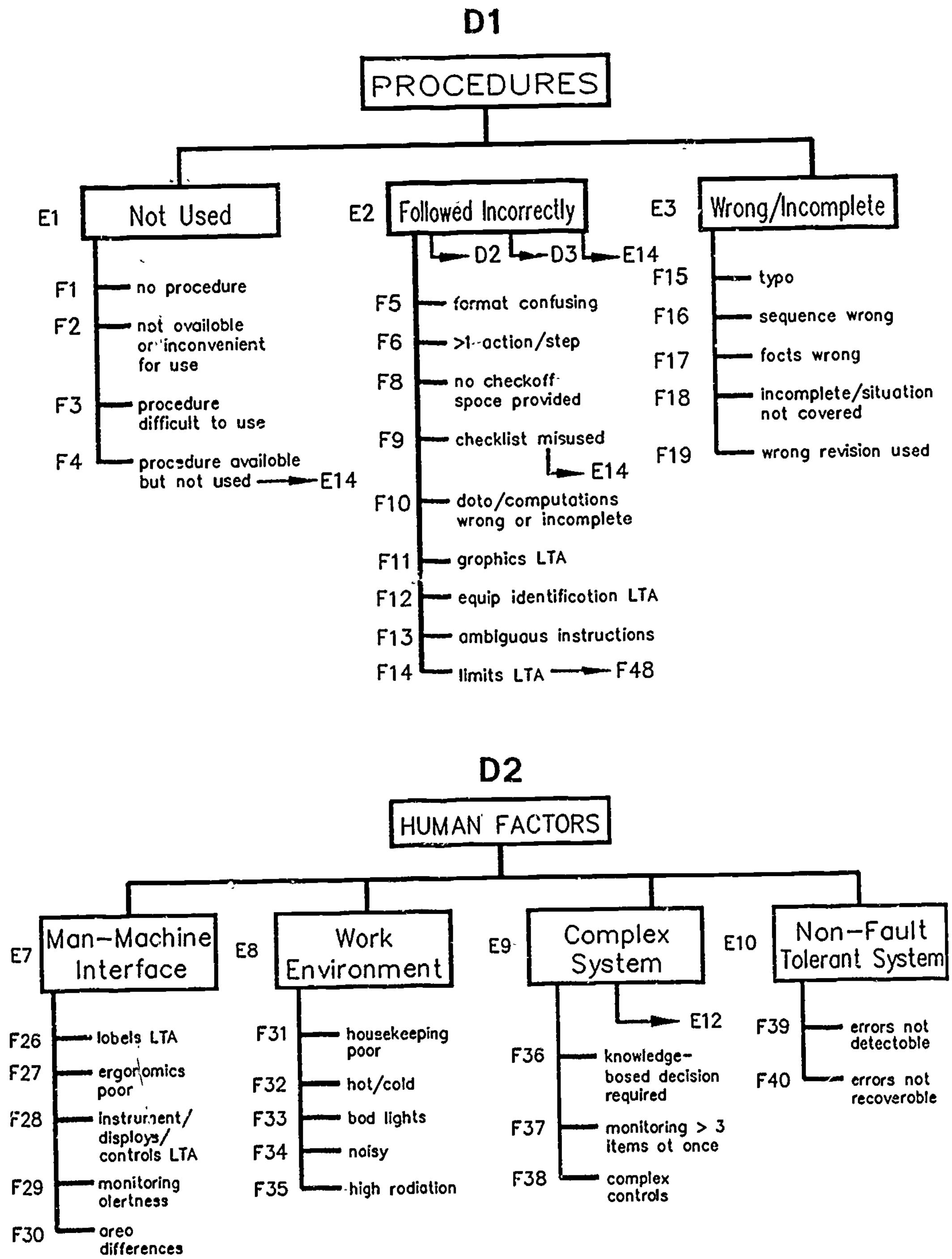


**FIGURE 3**

RCAUSE02

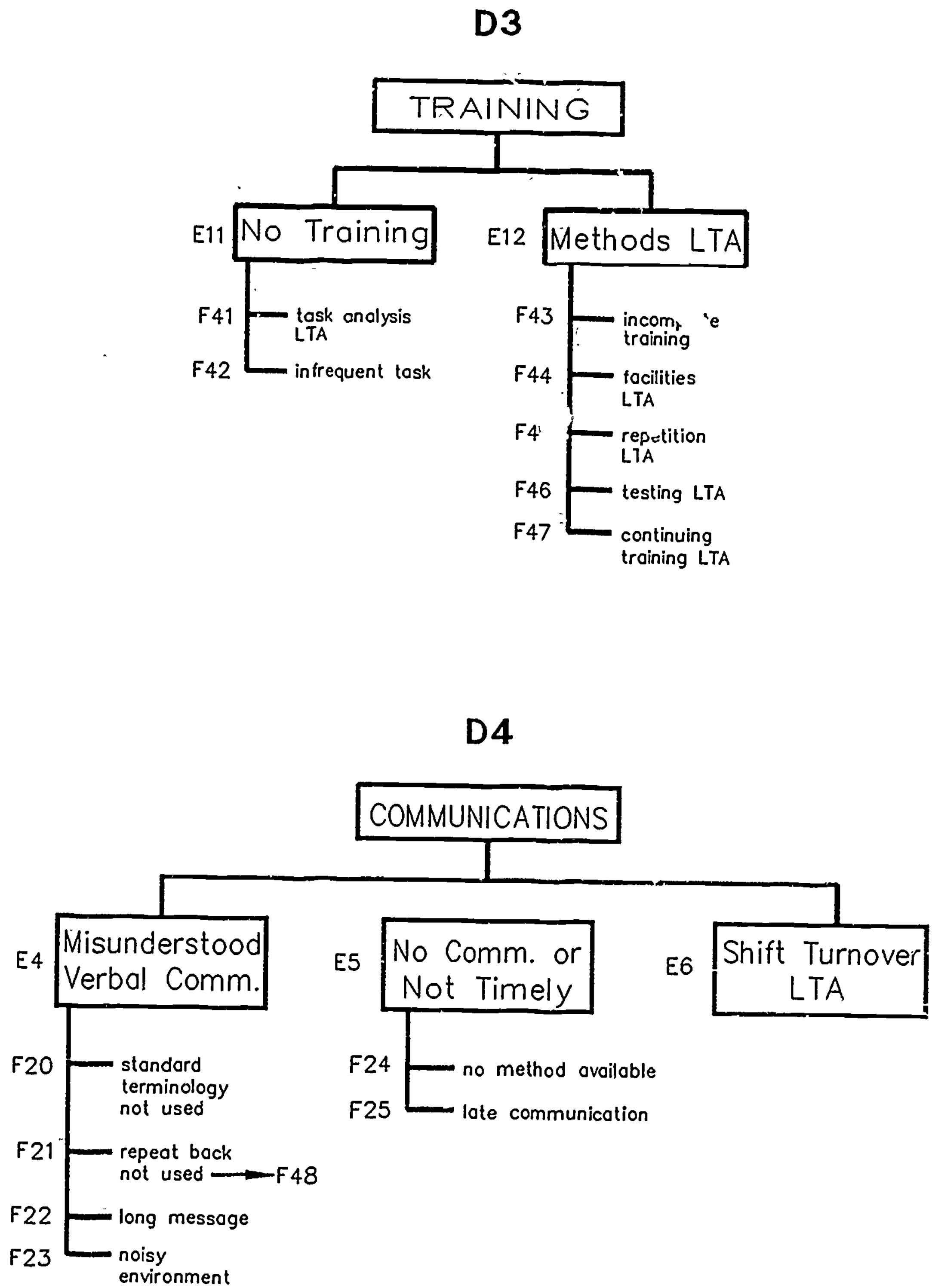


**FIGURE 4**

RCAUSE03

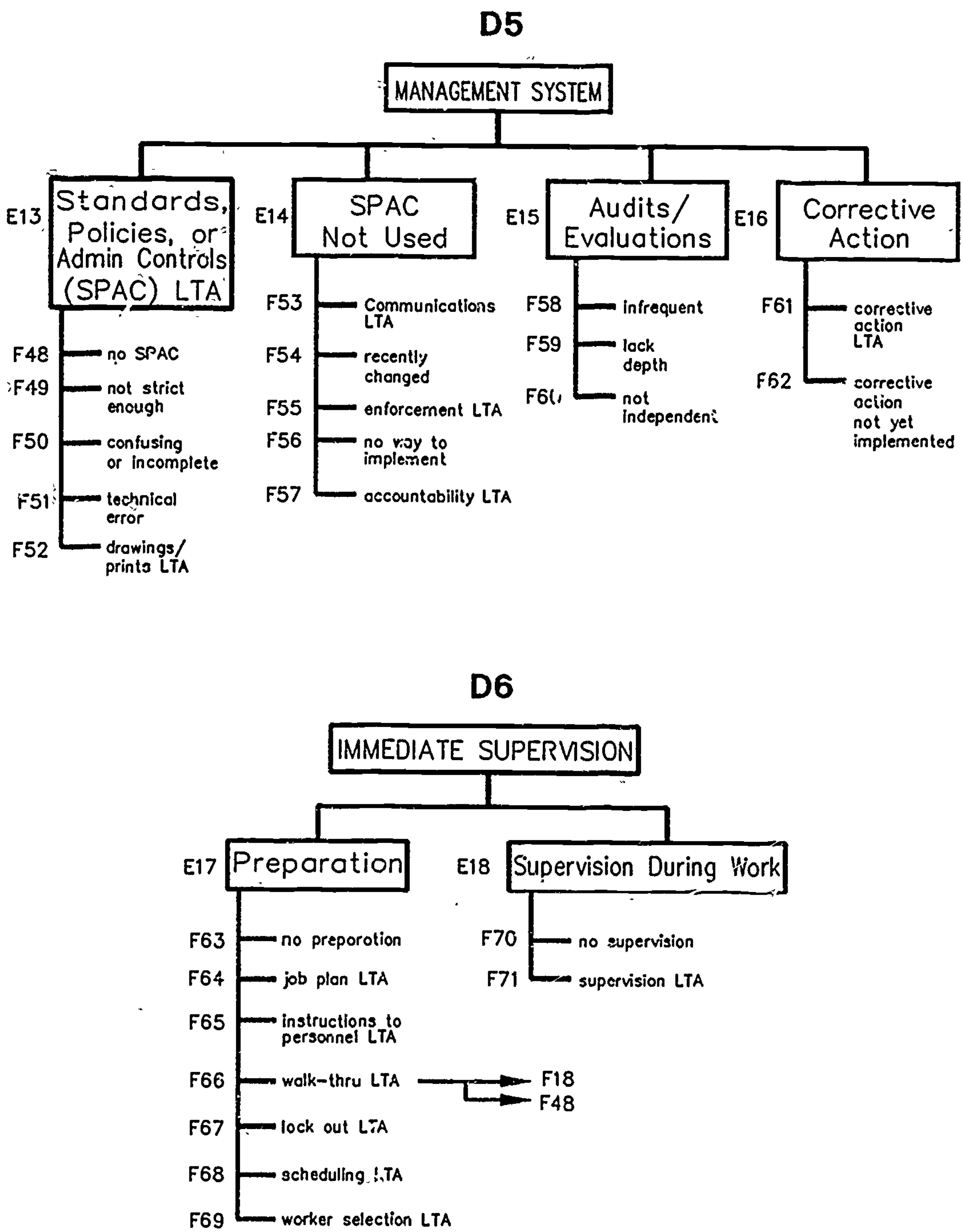


**FIGURE 5**

RCAUSE06

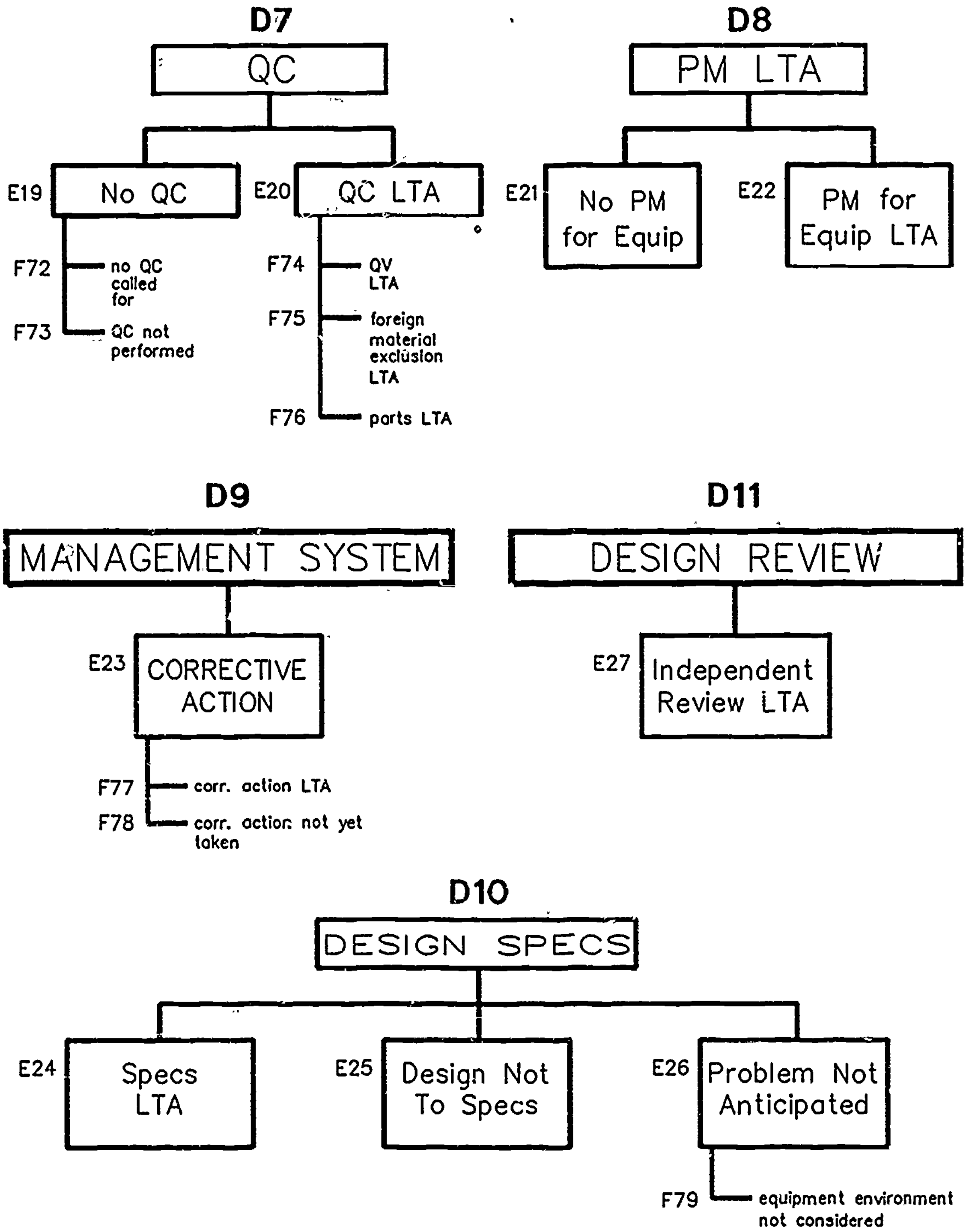


**FIGURE 6**

RCAUSE04

# ASQC SUPPORT OF THE QUALITY PROFESSION IN THE UTILITY INDUSTRY - IS IT SUFFICIENT?

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## ABSTRACT

A professional society provides a process and a forum to provide for the recognition, nurturing and maintenance of a profession. Periodically, the professional society should evaluate whether it is providing these supportive roles to the profession as intended.

About two years ago, the Education and Training Committee of the Energy Division of the American Society of Quality Control (ASQC) was reactivated. Quality Assurance professionals from six nuclear utilities have been involved in that reactivation. The perception of that utility group was that ASQC neither provided relevant support to them nor provided sufficient leadership for the quality profession in the utility industry. In spite of this negative perception, this group felt that ASQC did represent the quality profession and set out to identify what certification and training support is relevant to the quality profession in the utility industry. It was acknowledged by this group that their negative perception might also have resulted from (1) a lack of knowledge of how ASQC does in fact support the quality profession in the utility industry; and, (2) a lack of consistent understanding on their own part of what the quality profession does or should consist of in the utility industry.

A process for characterizing the certification and/or training support that ASQC should provide to the quality profession in the utility industry is being addressed through a systematic self evaluation. The analysis phase of the Training System Design process is currently being conducted by the Education & Training Committee to formulate the "body of knowledge" associated with the quality engineering function in the utility industry. Once formulated that body of knowledge will be compared to that

represented by the ASQC Quality Engineer and Reliability Engineer Certification Programs. That comparison should provide for a determination of the sufficiency of the ASQC certification and training support of the utility industry or suggest performance based improvements.

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## INTRODUCTION

The purpose of this paper is to inform training professionals of a utility industry initiative currently ongoing within the Energy Division of the American Society of Quality Control. This initiative is generically directed toward reducing the perceived or real variation in the performance and capability of the "quality professional" within the energy industry. The initial focus of this initiative will be the utility industry.

The term "quality professional" as used in this paper is not limited to those personnel who are assigned to "quality assurance" departments. As used in this paper, a "quality professional" is a person who has the knowledge and ability to evaluate and control the quality and reliability of a product or service. Such personnel might for example be assigned to quality assurance, plant maintenance, plant engineering or purchasing departments etc.

This paper provides an overview of the American Society of Quality Control with emphasis on the certification process which it provides. This emphasis was chosen because the existing ASQC certification process and its associated professional and technical development programs would be the most direct means to address variability of performance within the quality profession.

## AMERICAN SOCIETY OF QUALITY CONTROL - OVERVIEW

The American Society of Quality Control (ASQC) is the leader in the development, promotion and application of quality and quality related technologies for the quality professional, private industry, government and academia. ASQC was founded in 1946, as a direct result of WWII efforts, to improve the quality of defense materials. This leadership is provided through (1) certifications, (2) technical training programs, (3) periodicals, (4) publications, (5) conferences and exhibits, (6) promotions; and, (7) quality awards.

Quality related technologies are those specific methods of measurement, examination, evaluation and analysis, which relate to the evaluation and control of the quality and reliability of product, system and/or service performance. These methods generically rely on the knowledge of statistical reasoning and/or analytical methods; and, the proper application of such methods (i.e. sampling, metrology, inspection, test, vendor certification, audit, etc. processes).

The organization of ASQC is structured to represent principle industry groups (e.g. aerospace, energy, biomedical, defense etc.); to represent principle quality technologies (e.g. metrology, reliability, inspection, statistics); to provide standards development, maintenance and coordination; to provide professional development and certification; and, to provide other services (e.g. publications, awards etc.).

## ASQC ENERGY DIVISION

The utility industry is represented within ASQC by the Energy Division. The Energy Division was first formed as a Technical Committee in May, 1971 with the expressed purpose of responding to the specific quality needs of the emerging nuclear power industry. That scope was expanded in 1978 to encompass all forms of energy production including fossil fuels, fusion, solar, geothermal, offshore oil and gas, as well as nuclear. This scope has been expanded further to include the emerging high level radioactive waste management industry.

The Energy Division is organized into committees. One of these committees is the Education and Training Committee. In December 1986, under the leadership of the Chairman of the Energy Division, the Education and Training Committee was reactivated. At that time, the Chairman of the Energy Division had established, as a general objective, that the Energy Division would take the initiative(s) to increase its support of and the involvement of the utility industry. The innovative environment established by this objective has fostered and sustained the current Education and Training Committee initiatives and pace of activities.

## THE EDUCATION AND TRAINING COMMITTEE

The Education and Training Committee ("the Committee") has been guided by these generic objectives:

- o contribute to improving human performance
- o contribute to national uniformity and consistency
- o seek industry endorsement instead of utilizing consensus standard development

The Committee is focused on the two generic activities of identifying and addressing strategic education and training issues associated with; and, promoting the professional growth of the quality professional in the energy industry. This focus has continued for the past two years.

The underlying feeling of the committee has been that the role or job of the quality professional in the utility industry (especially nuclear) is not consistently understood within the utility industry. This lack of consistency has resulted in large variations in the performance and expected capabilities of the quality professional.

The Institute of Nuclear Power Operations' (INPO) accreditation process would have provided the means to partially reduce this variation. However, the accreditation of the Quality Control and Nondestructive Examination Technician training programs had to be deferred. This deferral, although a disappointment, did in fact provide the opportunity for the Committee to take the initiative to motivate ASQC to assume a leadership role in reducing this variation in performance and capabilities.

It is currently planned by the Committee to provide for the reduction in this performance and capability variation by utilizing the Institute of Nuclear Power Operation Training System Design process to at least formulate a body(s) of knowledge for the quality professional in the utility industry. The Committee has been authorized by the Energy Division to take action(s) necessary to formulate a proposal to either revise or develop additional ASQC certifications as may be needed to better reflect the body of knowledge and skills of the quality profession initially within the utility industry and eventually within the energy industry.

Actions taken by the Committee to date have included (1) the development of a catalogue of training courses and sources specific to the energy industry; (2) the conduct of a general training needs scoping survey; and, (3) the formulation of a model task list for quality engineer for a utility industry review for concurrence.

## THE BODY OF KNOWLEDGE = THE "PROFESSION"

A primary act of ASQC is the issuing of professional and paraprofessional certifications. Each of these certifications are awarded on passing a written certification examinations. The first such examination were administered in June, 1968. Education, experience and professional competence criteria must be meet prior to being permitted to take the written certification examination. The certification examinations are derived from a body of knowledge defined for each of the certified functions. Certifications as (1) quality engineer, (2) quality technician, (3) reliability engineer, (4) mechanical inspector; and (5) auditor are being issued by ASQC.

The Committee is currently utilizing the TSD process to formulate the body of knowledge associated with the quality engineering function in the utility industry. Once formulated this body of knowledge will be compared to that which has been defined and is the basis for the ASQC Quality Engineer and Reliability Engineer certifications. The result(s) of this comparison will help determine if there is in fact a sufficient difference in the quality profession as practiced in the utility industry to warrant the development of a new or revised ASQC certifications and/or training programs.

The significance of a body of knowledge is that it defines the "profession". The act of issuing a certification then represents peer recognization of a level of competence to practice the "profession".

The current ASQC certifications are not "licenses". Of significance to the Committee is that the body of knowledge associated with the "quality engineer" in the nuclear utility industry has not been defined either directly or indirectly to any extent comparable to that definition provided by the ASQC quality engineer certification.

## CURRENT BODY OF KNOWLEDGE - PERCEIVED RELEVANCE

The bodies of knowledge currently defined for the ASQC quality and reliability engineer certifications are formulated to represent the general principles of evaluating and controlling the quality and reliability of products, systems and/or services. This general principles orientation assures that "industry specific" factors are eliminated for purposes of certification. Within the ASQC context, a body of knowledge is delineated by a bibliography and an examination bank derived from that bibliography.

The body of knowledge represented by the current ASQC quality engineer certification is perceived by some utility personnel to be biased toward manufacturing processes. This perception tends to limit the apparent value of this certification in representing a level of competence for the quality professional in the utility industry. However, the perception of the manufacturing bias may also be an indication of insufficient utilization of quantitative evaluation techniques in the routine performance of quality assurance activities.

The body of knowledge associated with the ASQC quality engineer certification is directly relatable to the evaluation and control of the quality of services and products. This body of knowledge includes the knowledge and ability to:

- o develop and operate quality control systems;
- o apply and analyze testing and inspection procedures;
- o apply metrology and statistical methods to assure product and service conformity to prescribed standards;
- o apply metrology and statistical methods to diagnose and correct improper quality control practices;
- o understand human factors and motivation;
- o apply quality cost concepts and techniques;
- o develop and administer management information systems; and
- o audit quality control systems to identify and correct deficiencies.

The perceived bias appears to derive from three primary factors; (1) methods of controlling utility industry process are different; probably of most importance, (2) human performance is the determining factor in controlling the quality of service; and, (3) statistical process control techniques are not directly related to human performance evaluation. These factors do suggest that the quality technologies currently represented by the ASQC certified quality engineer bibliography and examination may be somewhat incomplete because the quality technologies necessary to properly evaluate and/or control human performance have not been incorporated.

The body of knowledge associated with the ASQC reliability engineer certification is directly relatable to the principles of the performance evaluation and prediction of product or system safety, reliability and maintainability. It is more quantitative/analytically oriented, and, appears to have more direct relation to activities (e.g. safety assessment, maintenance engineering, spare parts engineering, etc.) within the utility industry. As a point of emphasis, with the renewed interest in reliability centered and predictive maintenance, and safety system and general plant availability, this certification could be readily used to represent a level of competence in the utility industry.

In general, this evaluation of the relevance of these ASQC bodies of knowledge does suggest the hypothesis that most of both of these bodies of knowledge with some deemphasis of statistical process control and replacement with human performance evaluation technologies may be close to the "relevant" body of knowledge for the quality professional in the energy industry. The Committee is currently testing this hypothesis through providing a "model task list" derived from this hypothesis to the utility industry to conduct an utility industry wide job analysis.

## ASQC CERTIFICATION PROGRAMS - DEVELOPMENT

As previously mentioned, the bodies of knowledge which are the basis for the ASQC certification examinations cumulatively define the quality profession. The Committee currently perceives that the most direct way for ASQC to provide for the consistent recognition of the capability of the quality profession within the utility industry would be to provide a certification that more directly relates to what the quality profession as specifically practiced is within the utility industry.

The following criteria are currently utilized by the Certification Committee of ASQC to evaluate proposals for new certification programs ("i.e. the discipline"):

- o The discipline shall be in a unique area of quality technology generally practiced in the quality profession.
- o The discipline shall be generic in nature, generally applicable to the production of any product, by any process and/or to the rendering of any service.

- The discipline shall have a substantial and authoritative body of knowledge in the public domain describing proven principles and practices of the technology.
- The discipline shall be consistent with ASQC objectives, policies and procedures.
- The training in the principles and practices of the technology shall be readily available on a geographically dispersed basis.
- The area of technology shall have the commitment and active support of one or more ASQC Divisions or Technical Committees with the capability of providing adequate testing criteria for proficiency in the technology.
- There must be a definable and continuing market and a justified need on a broad geographical basis for certification.

As can be noted, the body of knowledge associated with the utility industry would have to be sufficiently substantial and generic to justify either a new or revision to an existing ASQC certification.

## PROFESSIONAL AND TECHNICAL DEVELOPMENT

ASQC has established an Education and Training Institute (ETI). ETI provides courses and seminars to sustain and expand the quality profession. Such education is provided through universities, junior colleges, consulting firms, practicing quality professionals, etc. Educational courses are designed to meet a variety of needs from a review of basic principles to skills development in advanced quality and reliability technological concepts. Professional and technical development courses in principle areas of the certification programs are regularly schedule. Such areas include management of the quality function, quality engineering, quality audit, reliability engineering, procurement quality, software quality, statistical process control and quality cost systems.

In addition to the ETI programs, courses are sponsored through ASQC Divisions, Technical Committees and Regional Sections. Such training provides exposure to or education on specific industry applications, technical trends or technical developments. Comprehensive refresher courses are routinely provided by the Regional Sections at the local level to prepare quality professionals for the certification examinations.

## CONCLUSION

The American Society of Quality Control does provide generic support to the quality profession through its certification; and, professional and technical development programs. This support process is utilized or endorsed by the utility industry only to a limited extent. Ongoing efforts of the Education and Training Committee of the Energy Division of ASQC are directed towards increasing the knowledge and relevance of ASQC support processes for the quality profession within the utility industry.

# *PERSONNEL DEVELOPMENT PROGRAM*

*(an enhancement to GET)*

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***ABSTRACT***

***Cooperation, common sense, and training together helped lower the error rate at the Duane Arnold Energy Center. One training activity, procedural awareness training, has been made a badging requirement. Its use is correlated with a significantly reduced rate of certain errors. Iowa Electric Light and Power believes the effectiveness of this class is based on its continually evolving content. What's presented in class is defined by the plant supervisors and current site or industry concerns.***

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## BACKGROUND

In 1985, the management of the Duane Arnold Energy Center (DAEC) concluded that the overall rate of personnel errors had risen to an unacceptable level. In response, several plant groups worked together to establish the root cause for this increase. A common theme appeared often during the discussions that plant supervisors held with their workers. Errors were being made by talented and well-meaning workers who were ignorant of some administrative controls and safety requirements. The resulting errors most commonly appeared in the control of maintenance work, worker authorization/qualification for task performance, lifted lead/jumper control, and tag-out requirements. The number of reported errors increased matically during a 1985 refuel outage. It appeared that adequate training on certain procedures was not being provided to those new to the work site.

The utility started a combination of activities as corrective action. These activities included specific training on the administrative controls most commonly violated. When such training was later made mandatory for the 1987 refuel outage, the combination of corrective actions was correlated with a decrease in the rate of certain personnel errors.

## INITIAL CORRECTIVE ACTIONS

As part of the cooperative effort in reducing errors, the site safety coordinator, formerly a contractor, was hired as a utility employee. He worked closely with site groups in emphasizing the importance of maintaining a safe working environment. Some procedures that controlled maintenance work were revised in accordance with human factors concerns to make comprehension and compliance easier for both workers and supervisors. A representative of the technical support group worked with members of the training staff to hold training meetings with maintenance supervisors and workers so all could jointly discuss the administrative controls that were placed on maintenance work.

First line supervisors had been holding weekly meetings with their workers to discuss site and departmental issues; these supervisors now reviewed procedural violations that had occurred. Finally, new workers were asked to complete a course (that had been created by the Training Department) on the identified areas of concern. This new course on procedural compliance was referred to as the Personnel Development Program and has been called "PDP" since its inception.

## EVOLUTION OF PDP

The PDP course was initially a self-study course to be completed by all new utility employees. These employees were allowed to complete the course on company time in a self-paced manner with assistance from their supervisor. After course work was completed by the employee and reviewed by the supervisor, the employee would attend a previously scheduled exam session. This format was continued for approximately 18 months and met with limited success.

In preparation for the 1987 refuel outage, it was decided ALL new employees should receive the benefits of the PDP course in a classroom setting. After surveying plant supervisors and management about areas of concern, several topics were added to the PDP course content and a revised classroom course was developed. Outage laborers and craft workers were required to attend a four hour lecture and pass a written examination. Outage foremen, supervisors, and new permanent utility employees were required to attend a 16 hour lecture and reading course and pass a written examination. This requirement was suspended after the outage while its effectiveness was being determined.

As a result of the study, the PDP course was made a badging requirement in preparation for the 1988 refuel outage. Its effectiveness had been established and the course viewed as an effective tool in a cooperative effort to reduce personnel errors.

The goal of PDP was to help correct site identified performance weaknesses and to provide industry or in-house operating examples of how procedural non-compliance could affect job safety and performance. The course included case studies to emphasize personnel errors that had occurred and had the potential to recur. Many industry sources supplied other case studies to supplement descriptions of events that had taken place on-site. The original themes in PDP included the importance of worker authorization/qualification, control of plant maintenance work, lifted lead/jumper control, and tag-out procedures. The procedures directing these activities were examined in detail. Problem areas were stressed using examples to illustrate consequences of non-compliance.

## PDP's PERFORMANCE

Prior to badging, all new hires receive DAEC's INPO certified General Employee Training. Of the approximately 1000 persons badged for the 1987 refuel outage, more than 99 percent completed PDP. As the intent of PDP was to help reduce the number of certain types of errors, it was important to use reported error rate as a gauge of the program's effectiveness. Raw data had to be converted into a meaningful unit so error rate was defined as personnel errors per 1000 manhours. This unit placed information in an understandable and convenient form. The data indicates the implementation of PDP as a badging requirement is correlated with a reduction in the rate of reported personnel errors. As a result of this study, PDP was not only made a badging requirement for DAEC's 1988 refuel outage but has also been made an ongoing badging requirement for all who wish to be granted unescorted access to radiologically controlled areas of the plant.

## PDP's PATTERN OF EFFECTIVENESS

When the content of PDP stressed a particular topic, e.g., tagouts, the observed number of problems with tagouts during an outage was reduced. When the course stressed the administrative requirements associated with the control of plant work, the errors in this area were reduced. Logically, as these concerns are addressed in PDP, other types of errors rise in relative frequency. Thus other errors are now the most frequently observed, yet the total error rate was reduced. Prior to the 1988 refuel outage the plant supervisors and management were surveyed to identify any areas of weakness that could be addressed by PDP in an attempt to further reduce the occurance of personnel errors. These people identified the procedures they believed were most commonly violated. The course was revised to address the needs of the plant rather than a pre-determined set of academic objectives. The course was then placed in the outage processing plan. We feel this makes the course uniquely powerful and well-adapted to meet the changing needs and priorities of an operating plant. It appears the pattern of effectiveness established during the 1987 refuel outage held during the 1988 refuel outage. The topics addressed by PDP had a lower frequency of error, other topics appeared to rise in relative frequency as errors.

## LIMITATIONS

PDP will not make personnel errors disappear; it is unlikely any amount of training can do that. Some types of personnel errors are not addressed by PDP, such as Operating errors in the reactor control room. The class cannot hope to address all types of errors due to time constraints. This makes it important that the course manager decide, with the help of plant personnel, what types of errors will be addressed by material presented in class. Another limitation is the typical response when an employee learns that they are to take a procedures course. To combat this lack of enthusiasm, it is paramount that the instructors be completely knowledgeable about course content and convinced of the importance of presenting the class in an interesting manner. Any letdown can spell disaster for a course of this type.

## UTILITY MANAGEMENT COMMENTS

Plant Superintendent, Rick Hannen, had these comments:

"DAEC management remains committed to the principal of reduction of personnel errors by use of improved training and awareness of procedural requirements. There will be further reviews on the effectiveness of PDP to make sure that the reduced errors correlate with the PDP program and not other fa~tors that were simultaneously applied to reduce personnel errors".

## THE FUTURE

PDP's future is what we decide it to be. Plant management, supervisors, and training personnel know they have available a mechanism for use in effectively responding to any recognized trends indicating performance weaknesses. Procedural awareness training can be used when a thorough review of plant procedures would help reverse these trends. Most importantly, Iowa Electric Light and Power is convinced a combination of cooperation, common sense, and training can work together to help lower personnel error rate.

## SUMMARY

One of the inevitable results of standardizing General Employee Training is that sites now hesitate to revise the course once it meets industry acceptance criteria. With PDP a badging requirement, the site has created an activity over which it has local control. The D^EC can continually define and re-define the content of PDP. It has a mechanism to quickly respond to the changing conditions and priorities presented by plant activities. This makes a procedure course such as this especially valuable in combating personnel errors.

It is evident we have witnessed a significant decrease in the personnel error rate. The Personnel Development Program and other activities specifically targeted at reducing personnel errors have significantly reduced the chances for large increases in the personnel error rate during refuel outage situations. We recommend that a procedural awareness training program be considered as part of any utility's effort in reducing the rate of personnel errors.

# USING COMPUTER-BASED TRAINING TO FACILITATE RADIATION PROTECTION REVIEW

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## ABSTRACT

In a national laboratory setting, it is necessary to provide radiation protection overview and training to diverse parts of the laboratory population. This includes employees at research reactors, accelerators, waste facilities, radiochemical isotope processing, and analytical laboratories, among others. In addition, our own radiation protection and monitoring staffs must be trained. To assist in the implementation of this full range of training, ORNL has purchased prepackaged computer-based training in health physics and technical mathematics with training modules that can be selected from many topics. By selection of specific modules, appropriate radiation protection review packages can be determined to meet many individual program needs.

Because our radiation protection personnel must have some previous radiation protection experience or the equivalent of an associate's degree in radiation protection for entry level, the computer-based training will serve primarily as review of major principles. Others may need very specific prior training to make the computer-based training effective in their work situations.

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## INTRODUCTION

It is necessary to provide radiation protection overview and training to very different types of personnel in a research installation such as the Oak Ridge National Laboratory (ORNL). Radiation protection and monitoring personnel must have adequate training and demonstrate proficiency in radiation protection. Other ORNL employees must also be trained to protect themselves and the environment, particularly those working at research reactors, accelerators, waste facilities, radiochemical and isotope processing and research laboratories, and analytical laboratories. To assist in the implementation of this full range of training, ORNL has purchased prepackaged computer-based training (CBT) in health physics and technical mathematics with training modules that can be selected from many topics. By selection of specific modules, appropriate radiation protection review packages can be determined to meet many individual program needs. The strategy development and training implementation is reviewed below.

## CBT FOR RADIATION PROTECTION/MONITORING STAFF

Radiation protection personnel at ORNL serve indispensably as the sentinels to protect the plant population and their surrounding environments from risks associated with the presence of ionizing radiation. Relying upon their technical knowledge, these individuals discharge duties involving detection, monitoring, and classification of the radiation. Some perform protective surveillance-type tasks, others monitor dosage uptake and accumulation. Additionally, radiation protection staff members provide guidance in project design, development, and implementation with regards to health physics. These combined efforts assure that radiation control measures are executed in accordance with applicable regulations.

A crucial element we use in verifying the mandatory technical knowledge and skills is the Resource Technical Services Health Physics and Technical Mathematics Computer-Based training packages.[1] Administered by ORNL's Technical Resources and Training Section, these programs address established training needs plus those brought about by a recently issued Department of Energy operating order. The packages consist of thirty-four health physics and nineteen technical math separate instructional modules.

Applications of modules, most often in a cluster, are being made to fulfill technical training requirements stipulated in ORNL technical document ORNL/TM-10119, "Technical Qualifications Requirements and Training Programs for Radiation Protection Personnel at Oak Ridge National Laboratory".[2] That charter along with DOE Order 5480.11, "Radiation Protection for Occupational Workers",[3] promulgates that radiation safety training and retraining include, but not be inclusive to, certain topical items. The level of instruction in each is commensurate with the employee's assigned duties. Table 1 lists the major sections of the ORNL formal program while Tables 2 and 3 compare the 5480.11 topical subjects and the computer-based training module titles.

The purpose of the formal Radiation Protection training qualification program is to prepare Radiation Protection Section and Radiation Monitoring Section employees to work at and support activities of various ORNL reactor and nonreactor nuclear facilities. Personnel qualifications are separated into two major categories, those being (1) technician staff and (2) professional staff. Most of the professional staff positions are filled by individuals with academic training and/or specialized degrees in health physics. The professional staff members are evaluated before assignment, and are not necessarily subjected to the same program as the technicians unless it is deemed that they can benefit from review of one or more modules of training. Openings in the technician staff are filled with individuals who have completed either an associate degree curriculum or its equivalency (professional training, service training, etc.).

Representatives from both staff groups are assigned to complex areas geographically located within the plant proper. In those areas it is typical to find assorted types of radioactive material processes. Likely to be found are hot cells, accelerators, glove boxes, research reactors, hoods, x-ray devices, bench tops activities, and others. Domination of type operations varies from complex to complex.

Technician training for these geographical areas incorporates three distinct components (as directed by ORNL/TM-10119). Those are :

- topical material required by 5480.11
- laboratory specific information
- complex area based on-the-job training.

The topical material is delivered by the computer-based training programs. IBM AT/XT compatible personal computers are located at each of the fifteen-plus complexes at ORNL. Approximately twenty-five PCs are available for use. Traditionally these have been used to support the day-to-day activities of the employees but with the versatility of the RTS computer package, they serve efficiently as training devices. With time constraints placed on employees due to heavy work schedules, these PCs are available at each complex office when the trainee has some free time. That is the time educational psychologists calls the teachable moment (Boone, 1985):[4] When people are ready to learn. Most training programs experience violations of that principle when trying to achieve regulatory compliance plus convey information.

Since the purchase of the CBT in mid-1988 approximately thirty radiation protection/monitoring employees (technicians and professional staff combined) have participated in formal training utilizing applicable modules. Participants included individuals with tasks oriented in dosimetry systems, research reactors, waste management processes, and/or hot cells, each including field survey duties. Employees were assigned a series of modules to complete. Then certain groups gathered to review the instructional material. These reviews were conducted by professional trainers from the Technical Resources and Training Section. Table 4 lists RTS modules used to this date in each application.

## GENERAL APPLICATIONS

In addition to use of the RTS modules in the Radiation Protection/Monitoring qualification program, the Technical Resources and Training Section also provides radiation protection training for radiation workers in reactor and non-reactor nuclear facilities at ORNL and more general radiation protection information for other ORNL workers. Though we have not completed the implementation of the RTS CBT packages in these more general programs, we plan to use them in a variety of divisions to meet differing needs. We are setting up specific training clusters for several divisions by determining their information/training needs and selecting the modules that best fit those needs. For example, the radiochemists working in Analytical Chemistry or Biology Divisions can review theory and applied health physics related to the type of work environment; because of the level of prior training and education, the RTS modules can serve as a quick self-review of radiation protection needs and controls.

In each of these cases, the CBT modules will be supplemented by formal and/or informal training such as classroom instruction or on-the-job training. Though they can be placed on any PC at ORNL, we control the final testing function by requiring that the final test must be completed at the Technical Resources and Training Center machines in a proctored environment. It may be possible to use these modules to verify the prior knowledge of some employees, thereby letting them "test out" of certain classroom training requirements. We anticipate development of procedures for this option during the next twelve months.

As these special applications are implemented in the coming year, we will document them extensively and have better data to use in evaluating the overall effectiveness of the CBT. Overall we already can say that the RTS program with its ability to cluster modules is very useful for:

- multiple training applications
- review of principles and applications
- documentation of prior knowledge
- economic operation on existing machines.

## REFERENCES


1. Available from Resource Technical Services, Inc., P. O. Box, Toledo, OH 43606.
2. E. D. Copenhaver et. al., Technical Qualification Requirements and Training Programs for Radiation Protection Personnel at Oak Ridge National Laboratory, ORNL/TM-10119 (April 1986).
3. Radiation Protection for Occupational Workers, U. S. Department of Energy Order DOE 5480.11 (December 21, 1988).
4. E. J. Boone, Developing Programs in Adult Education, Prentice-Hall, Englewood Cliffs, NJ, 1985.

## Table 1. Training Elements in ORNL Radiation Protection/Monitoring Training Program

**SECTION 1**
Fundamental Math, Sciences, and Techniques As Applied to Radiation Protection Activities

**SECTION 2**
Health Physics Theory

**SECTION 3**
General Principles and Administration

**SECTION 4**
Radiation Survey

**SECTION 5**
Radioactive Contamination Control

**SECTION 6**
Radioactive Material Control, Including Transportation and Waste Disposal

**SECTION 7**
Health Physics Dosimetry

**SECTION 8**
ORNL Systems/Operations/Experiments

## Table 2. Training Topics Stipulated by DOE Order 5480.11

Radioactivity and radioactive decay
Characteristics of ionizing radiation
Man-made sources
Acute effects of exposures to radiation
Risks associated with occupational exposure
Special considerations in the exposure of women of reproductive age
Dose-equivalent limits
Mode of exposure -- internal and external
Dose-equivalent determinations
Basic protective measures -- time, distance, shielding
Special plant procedures for maintaining exposures ALARA
Radiation survey instrumentation -- calibration and limitations
Radiation monitoring programs and procedures
Contamination control
Personnel decontamination
Emergency procedures
Warning signs and alarms
Employee/ management responsibilities
Interaction with radiation protection staff
Operational procedures associated with specific job assignments

## Table 3. Applicable Modules Selected from RTS Package

**HEALTH PHYSICS**
1. Atomic Structure
2. Types of Radiation
3. Radioactive Decay Schemes
4. Interaction of Radiation with Matter
5. Physical Decay of Radioactive Materials
6. Radiation Dosimetry Quantities and Units
7. Environmental Radiation and Radioactivity
8. Cell Chemistry and Acute Effects
9. Biological Effects of Ionizing Radiation
10. Internal Dosimetry
11. Detector(s) Theory
12. Thermoluminescent Detector theory
13. Counting Systems
14. Counting Statistics
15. Instrument Operation Characteristics
16. Health Physics Instruments
17. Contamination Control/ Decontamination
18. Radiation Surveys
19. Radiation and Shielding
20. ALARA
21. Airborne Radioactivity Surveys
22. Respiratory Protection
23. Radioactive Waste Control
24. Radioactive Materials Control
25. Shipment and Transportation of Radioactive Materials
26. 10 CFR 19 / 10 CFR 20

**TECHNICAL MATHEMATICS**
1. Fundamental Concepts and Operations I,II,III
2. Functions and Graphs
3. Trigonometric Functions I,II,III
4. Right Angles
5. Systems of Linear Equations
6. Special Products and Factoring
7. Fractions
8. Quadratic Equations
9. Radians
10. Vectors
11. Oblique Triangles
12. Graphs of Trigonometric Functions
13. Exponents and Radicals
14. Logarithms I,II

## Table 4. RTS Modules Used for Radiation Protection Applications

**DOSIMETRY SYSTEMS**
1. Fundamental Concepts and Operations
2. Atomic Structure
3. Types of Radiation I,II
4. Radioactive Decay Schemes
5. Interactions of Radiation with Matter I,II
6. Physical Decay of Radioactive Materials
7. Biological Effects of Ionizing Radiation (Delayed)
8. Thermoluminescent Detector Theory

**RESEARCH REACTORS**
1. Atomic Structure
2. Types of Radiation I,II
3. Radioactive Decay Schemes
4. Interactions of Radiation with Matter I,II
5. Physical Decay of Radioactive Materials
6. Biological Effects of Ionizing Radiation (Delayed)
7. Neutron Detector Theory

**WASTE MANAGEMENT PROCESSES**
1. Atomic Structure
2. Types of Radiation I,II
3. Radioactive Decay Schemes
4. Interactions of Radiation with Matter I,II
5. Physical Decay of Radioactive Materials
6. Biological Effects of Ionizing Radiation (Delayed)
7. Radioactive Waste Control

**HOT CELLS**
1. Atomic Structure
2. Types of Radiation I,II
3. Radioactive Decay Schemes
4. Interactions of Radiation with Matter I,II
5. Physical Decay of Radioactive Materials
6. Biological Effects of Ionizing Radiation (Delayed)

# ANNUAL CRITIQUE: AN EFFECTIVE PROGRAM EVALUATION TOOL

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ABSTRACT

Accreditation by the Institute of Nuclear Power Operations' (INPO), indicates a Utility has made a formal commitment to a systematic approach to training. Duke Power Company had implemented INPO's Training System Development (TSD) model to achieve accreditation of its programs in 1986. The last phase of the five step model includes a systematic evaluation of the effectiveness of the training program. This evaluation relies on data collected from the client group, and the training group's ability to respond and affect needed changes to the training program. This paper will discuss using an annual critique to accomplish specialization of on-the-job (OJT) training requirements for the Health Physics discipline at Duke Power Company. The discussion will detail the feedback process that lead to specialization, the process involved to get changes made, and the cost savings and results of implementing these changes. The paper also addresses the client-training group relationship that created the ability to make this happen.

## BACKGROUND

Duke Power Company has three Nuclear Sites. Two facilities, Catawba and Oconee Nuclear Stations are located in South Carolina and are two and three unit plants, respectively. McGuire Nuclear Station, a two unit plant, is the third facility and is located in North Carolina. Each facility has a Health Physics (HP) complement of approximately 71 hourly personnel and 25 Supervisory/Staff in management. The Health Physics personnel are the client group in this paper and are members of the Nuclear Production Department. Three HP instructors at each site provide the training needs for Health Physics personnel, and the teaching staff are organized within the Production Support Department. A Health Physics

Working Group was established between the two departments to aid in the identification and resolution of training issues. This working group includes the Radiation Protection managers and Directors of Technical Training from each Site. The working group coordinates global evaluation of the HP training program by using several methods of assessing program effectiveness. These modes include trending trainee test performance and on-the-job performance, feedback from supervisors, trainee and instructor critiques, evaluation of training staff performance, and a formal annual critique of the program. The annual critique is the feedback process that is the item for discussion in this paper.

## IDENTIFICATION OF THE PROBLEM

The Annual Critique (Shown on Figures 1 and 2) conducted in 1986 modeled questions recommended for program evaluation from INPO 85-006, Principles of Training System Development (February, 1985). Surveys were distributed to all non-exempt (hourly) employees and exempt (first line supervisors) employees. The data collected from this subjective questionnaire indicated 94% of the respondents felt employees were required by promotion criteria to train and qualify on many tasks that they seldom or never performed as part of their daily assignments in their respective work disciplines. Further, supervisors indicated the higher level or more difficult tasks were not required for promotion. Consequently, the utility relied on vendors to perform these tasks during refueling outages. The original promotion requirements are shown in Figure 3. There were three classifications: Assistant Technician, Technician, and Specialist. The original philosophy was a Specialist could do all tasks in all areas. He/she was omnipotent, omniscient, and omnipresent. The feedback from the client indicated they were omni-disorganized, omnifrustrated and omnibroke, i.e. the program was not cost effective in utilizing resources.

## PROCESS FOR APPROVAL

Once the problem was identified, the training directors summoned a Working Group meeting between the two departments. (Figure (4) is the process flow chart used for approving specialization.) The Station Health Physicists (Radiation Protection Managers) from each site agreed the survey indicated a serious problem. Indeed, they were surprised by the overwhelming resentment concerning the current program's promotion criteria regarding mandatory tasks. NPD management requested the training group propose a cost effective alternative. The instructor staff was directed to survey the employees and supervisors, to identify the tasks they felt were necessary for promotion, and would also fulfill the job function of their respective technical disciplines. The client received a list of all tasks in the OJT program. They identified five (5) separate technical disciplines and those tasks each discipline wanted as a mandatory requirement. This information was collated by the Instructors and a "Specialization" proposal was presented to the Station Health Physicists at a second working group meeting. The Section Heads resolved their individual organizational differences by adopting a band of tasks for each job classification. The requirements included 20 tasks for Assistant Technician, 29 for Technician, and 36 for Specialist. Each classification had a band of ± 5 tasks. This equates to a task range of 15-25 for Assistant, 25-34 tasks for Technician, and 31-41 tasks for Specialists, as shown on (Figure 3). The underlying job analysis remained consistent among Stations. The band of tasks at 20, 29, 36 ± 5 tasks for each classification allowed the flexibility for task consolidation and/or the development of new tasks. Each Station is permitted to unilaterally add or detract tasks from the mandatory list until the minimum or maximum range of tasks are exceeded. The final proposal was forwarded to the Manager of Training, Planning, and Assessment. He verified promotion criteria was equitable among the three sites, and approved the proposal. The Directors and Section Heads agreed on how and when Specialization would be implemented. Although daily feedback was given to the instructors after implementation, another formal evaluation was conducted to determine the effects of Specialization.

## RESULTS OF SPECIALIZATION

Eight months after the change was put into effect, the instructor staff distributed a survey to determine effectiveness as judged by the client. The instructors also trended the number of errors made by technicians and analyzed the cost savings to the company. The survey revealed a tremendous increase in morale of the employees due to the following factors:

(1) Increased Accessibility of Qualifiers
(The first line supervisor was a qualifier for the vast majority of mandatory tasks for his/her given work area.)

(2) Increased Efficiency in Maintaining Qualifications
(Employees are not expected to maintain proficiency for tasks they never perform in their work area.)

(3) <u>Increased Program Flexibility</u>
(Employees could learn other disciplines by transferring to other work groups. New tasks could be added to the discipline within the band of tasks.)

(4) <u>Transfer of Ownership</u>
(The client feels they have a large voice in directing their program.)

When trending the number of tech spec violations, there was a decrease in employee errors under the new program. (This is shown in Figure 5.) A qualitative trend of technician performance was noted with improved SALP ratings as shown in Figure 6. A cost savings of $2,400,300 was realized by the company over a six year period as shown on Figure 7.

## CONCLUSION

Evaluation of training program effectiveness is an essential ingredient in assuring the first four phases of the TSD approach are working. One method of assessing the program is by means of conducting an annual survey of the client group. A stronger client-training group relationship is the result of the "team" approach in identifying and resolving training issues. From the training group perspective it cannot be overemphasized how beneficial this sense of team ownership has been. The client, because of this perception, provides a resource base that is invaluable in the age of reduced budget and zero growth.

## Figure List

1986 ANNUAL CRITIQUE OF THE EMPLOYEE TRAINING AND QUALIFICATION SYSTEM (ETQS)

EXEMPT SURVEY

Please answer the following questions as thoroughly as possible. Give specific examples for positive responses.

1. How well do employees (both newly trained and experienced) perform on the job? ______________________________

______________________________

2. What tasks were newly trained employees best prepared to perform?

______________________________

______________________________

3. For what tasks were they inadequately prepared? ______________________________

______________________________

4. Are employees able to diagnose conditions and identify alternate solutions for accomplishing a task? ______________________________

______________________________

5. What kinds of errors have employees committed? ______________________________

______________________________

6. Were the errors due to a lack of skill or knowledge? ______________________________

______________________________

7. Which tasks require excessive time for employees to complete? ______________________________

______________________________

8. How do recently trained employees compare to those who received earlier training? ______________________________

______________________________

Fig. 1. Exempt Survey.

9. What additional training have they received since they were assigned job responsibilities? ____________________

____________________

10. Have employee errors caused equipment failure or damage? If yes, please explain. ____________________

____________________

11. Has rework, (i.e. jobs that must be repeated), by Health Physics personnel been required due to personnel errors or lack of adequate training? If yes, please explain. ____________________

____________________

12. Have increases in rework, unscheduled maintenance, or overtime occurred in jobs performed by recently trained employees? If yes, please explain. ____________________

____________________

13. Have employees been commended or warned for unusually good or bad job performance? If yes, please explain. ____________________

____________________

14. Have you observed unexpected results from training? If yes, please explain. ____________________

____________________

15. Has training created any new problems? If yes, please explain. ____________________

____________________

16. What suggestions would you make to improve initial, on-the-job, or continuing training? ____________________

____________________

Fig. 1. Exempt Survey.

17. Do you expect any changes in job assignments or equipment that will require additional training or changes in current training? If yes, please identify needed changes. ______________________________

______________________________________________________________________

18. What current training do you consider to be excessive or unnecessary?

______________________________________________________________________

______________________________________________________________________

AREA OF RESPONSIBILITY ________________________________

NAME (OPTIONAL) ________________________________

DATE ______________

Fig. 1. Exempt Survey.

## NONEXEMPT SURVEY

1. What additional training have you received since being assigned to your job?________________________________________

________________________________________

2. What unexpected difficulties or problems in job performance have you experienced?________________________________________

________________________________________

3. Has your supervisor given you instructions different from those you learned during training? If yes, what were they?________________

________________________________________

4. Have you noticed other differences between the training you received and what is expected of you now? If yes, cite differences.________

________________________________________

5. Have changes occurred in your job since you were assigned?________

________________________________________

6. How were you prepared to handle these changes?________________

________________________________________

7. What tasks do you find easiest?________________________________

________________________________________

8. What tasks do you find especially challenging?________________

________________________________________

9. Looking back, what specific training benefited you the most?________

________________________________________

10. What kind of errors have been committed on the job?____________

________________________________________

Fig. 2. Non Exempt Survey.

11. Were the errors due to a lack of skill or knowledge?______________

______________________________________________________________

12. How could training have better prepared you for your job?__________

______________________________________________________________

13. What suggestions would you make to improve initial, on-the-job, or continuing training?______________________________________________

______________________________________________________________

14. What additional training do you need for your job?________________

______________________________________________________________

Job Classification: ____________________

Area of Responsibility ____________________

Name (Optional) ____________________

Date ____________________

Fig. 2. Non Exempt Survey.

| Before Specialization | Number of Tasks Mandatory for Promotion | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Station | MNS | | | CNS | | | ONS | | |
| Classification | A | T | S | A | T | S | A | T | S |
| All Disciplines | 24 | 42 | 56 | 24 | 42 | 56 | 24 | 42 | 56 |

| After Specialization | | Number of Tasks Mandatory for Promotion | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Station | | MNS | | | CNS | | | ONS | | |
| Classification | | A | T | S | A | T | S | A | T | S |
| Discipline: | | | | | | | | | | |
| RPIC | Respiratory/Instrument Calibration | 20 | 29 | 33 | 22 | 31 | 35 | 21 | 32 | 40 |
| CR | CountRoom | 21 | 29 | 35 | 20 | 31 | 34 | 21 | 24 | 31 |
| S&C | Surveillance & Control | 19 | 28 | 35 | 18 | 33 | 36 | 21 | 28 | 32 |
| Shift | Effluent Control | 21 | 31 | 40 | 19 | 31 | 34 | 18 | 32 | 34 |
| RMC | Radioactive Materials Control | 20 | 24 | 32 | 21 | 30 | 35 | 21 | 27 | 32 |

| | | | |
|---|---|---|---|
| BAND OF TASKS | 20, 29, 36 ± 5 | | for each respective classification |
| | 15 - 25 | Tasks | For Assistant |
| | 25 - 34 | Tasks | For Technician |
| | 31 - 41 | Tasks | For Specialist |

Fig. 3. Promotion Requirements Before and After Specialization.

PROCESS FLOW CHART
INTERFACE

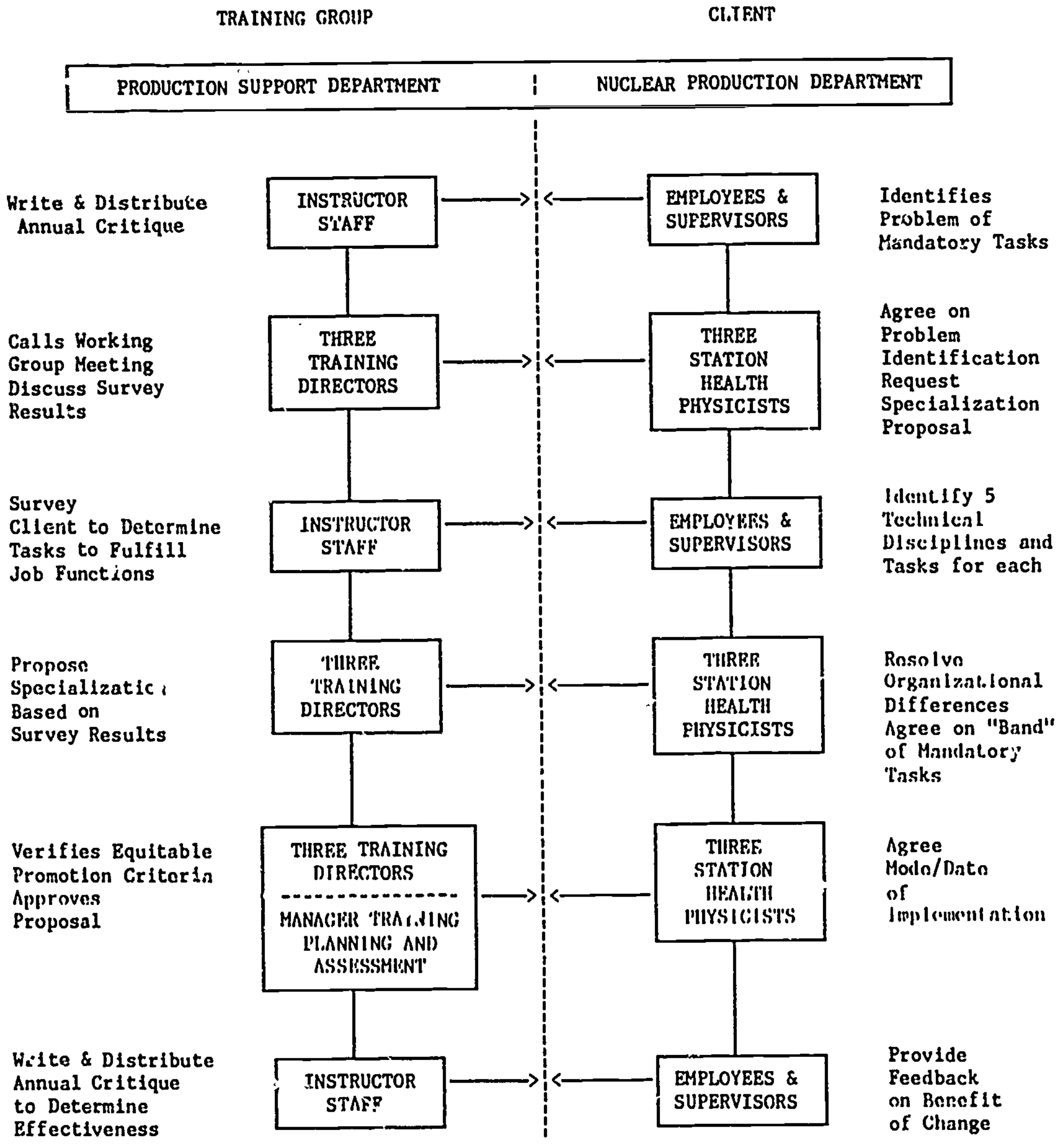
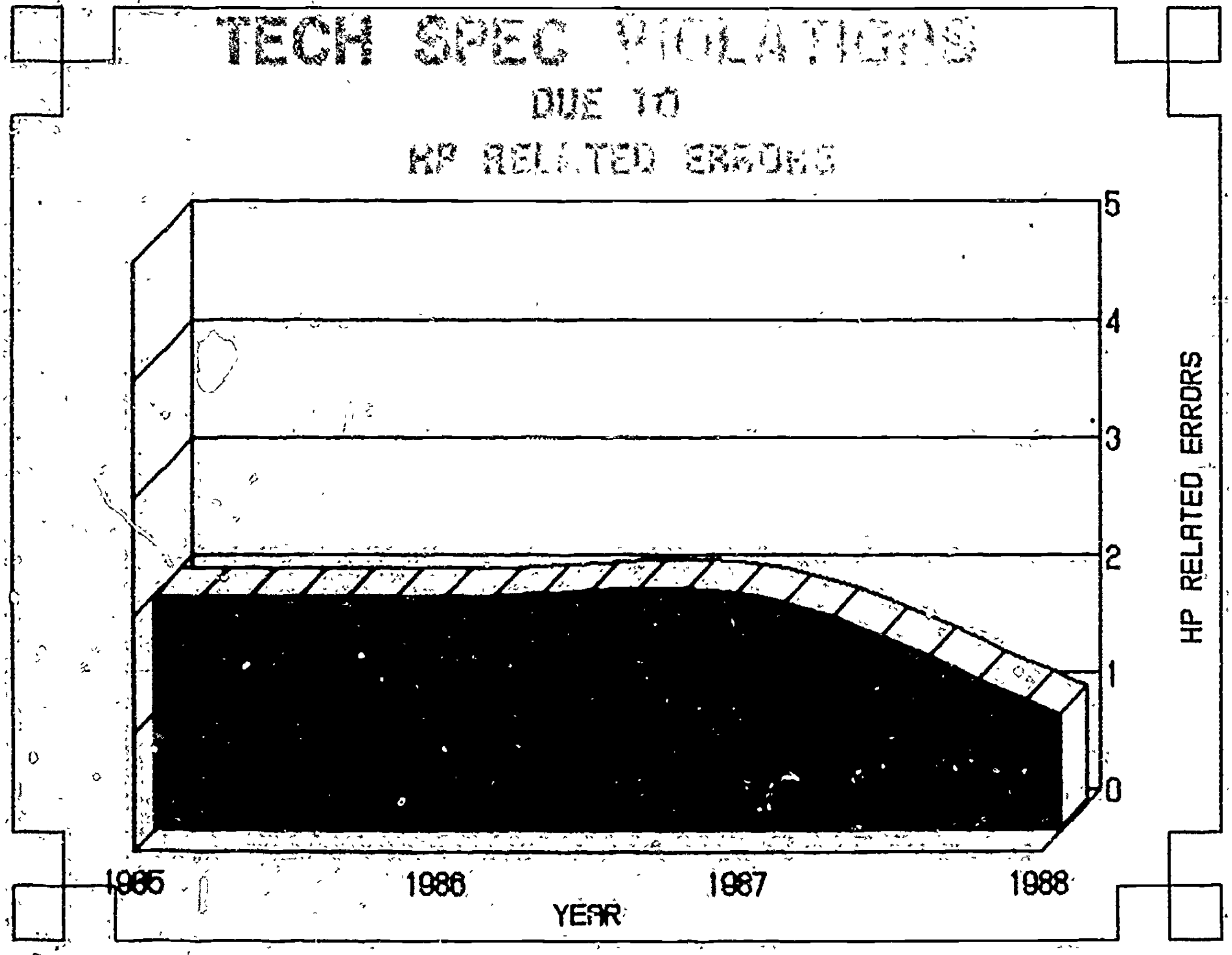
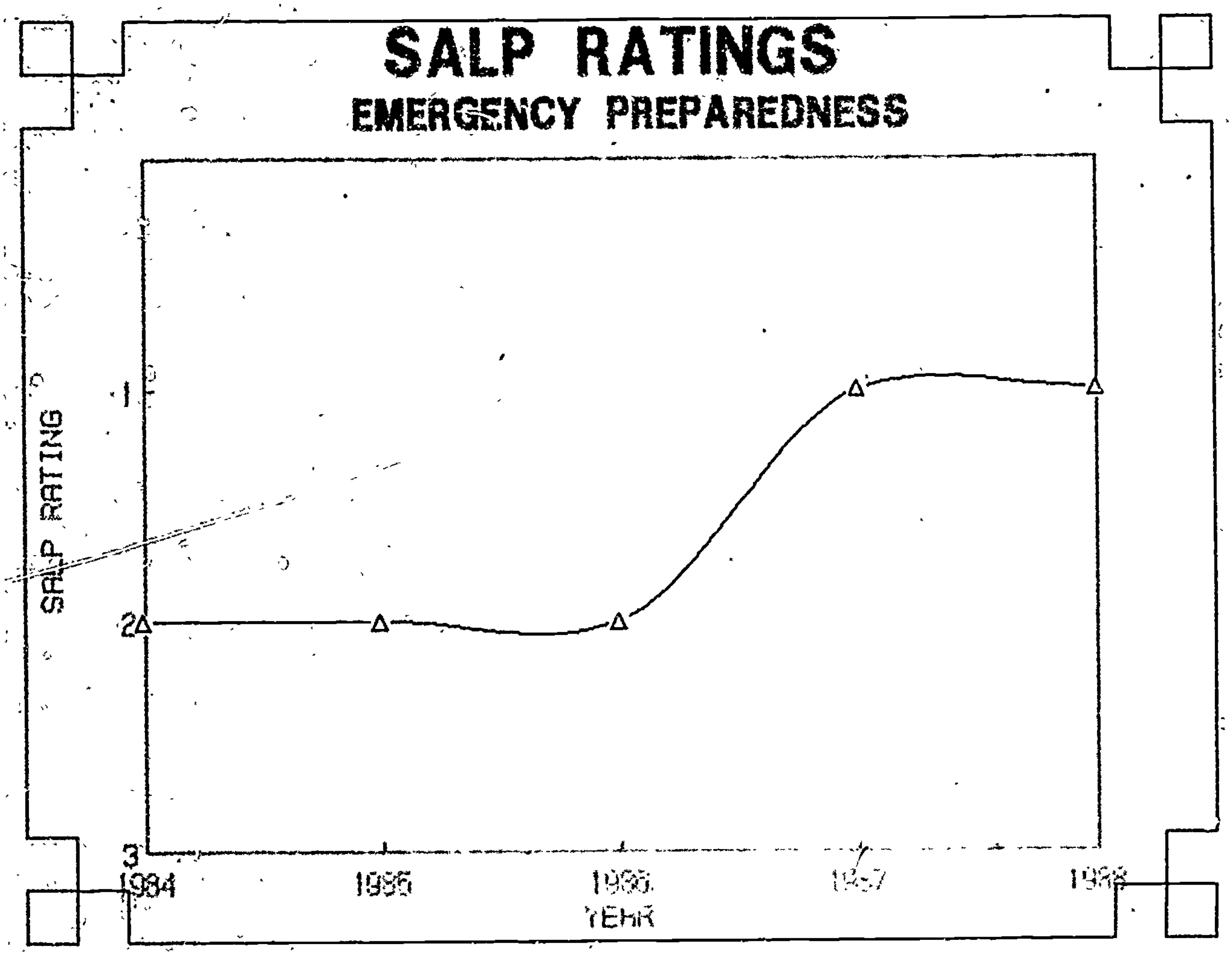



Fig. 4. Process Flow Chart for Approving Specialization.


TECH SPEC VIOLATIONS
DUE TO
HP RELATED ERRORS
5
4
3
2
1
0
HP RELATED ERRORS
1985
1986
1987
1988
YEAR

IV-B.3.14


SALP RATINGS
EMERGENCY PREPAREDNESS
SALP RATING
1
2
3
1984
1985
1986
1987
1988
YEAR

IV-B.3.15

## Calculations for Cost Savings

Average number of tasks required for promotion from Assistant Technician to Specialist classification at each Station:

| | |
|---|---|
| Before Specialization: | 56 Tasks |
| After Specialization: | 36 Tasks |
| Average # of HP employees at each station | 71 Employees |
| Total # of employees | 213 Employees |
| Average # of tasks eliminated for qualification for each employee | 20 Tasks |
| Average time required to train | 16 Hours |
| Average cost for training per task per hour | 24 Dollars |
| Average time required to qualify per task | 4 Hours |
| Average cost for qualification per task per hour | 30 Dollars |
| Average total time for training & qualifying/task | 20 Hours |
| Average cost per hour for training & qualification per task | 30 + 24 ÷ 2 = 27 Dollars |

### Total Cost Savings Equation (Gross)

$$213 \text{ Employees} \times \frac{20 \text{ Tasks}}{\text{Employee}} \times \frac{20 \text{ Training/Qualifying Hours}}{\text{Task}} \times \frac{27 \text{ Dollars}}{\text{Training \& Qualification Hours}} = \underline{\$2{,}300{,}400.00}$$

Fig. 7. Cost Savings Due to Specialization.

# THE DOE CONTRACTOR TRADE NETWORK: A DECADE OF EXPERIENCE IN TRAINING RESOURCE EXCHANGE

Phil Croll
Westinghouse Savannah River Company
Marcus Weseman
Oak Ridge Associated Universities

## ABSTRACT

Training Resources and Data Exchange (TRADE) refers to a series of activities designed to increase communication and exchanges of ideas, information, and resources among U. S. Department of Energy contractor operated facilities in the field of training and human resource development. TRADE activities are planned and implemented by the DOE Contractor TRADE Executive Committee.

TRADE objectives are accomplished through the following:

- -Conference/Workshops,
- -Publications
- -Special Interest Group.

TRADE Special Interest Groups include the following:

- -Computer-based Training
- -Emergency Preparedness
- -Industrial Hygiene Training
- -Human Resource Issues
- -Radiation Protection Training
- -Safeguards and Security Training.

The authors will discuss how TRADE has evolved to meet changing contractor needs to improve human performance over the last 10 years. TRADE currently has working agreements to share training information with INPO, the Federal Laboratories Consortium, and the National Registry of Radiation Protection Technologists.

TRADE

## THE DOE CONTRACTOR TRADE NETWORK: A DECADE OF EXPERIENCE IN TRAINING RESOURCE EXCHANGE

Phil Croll
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Marcus Weseman
Oak Ridge Associated Universities

### BACKGROUND

Training Resources and Data Exchange (TRADE) is a network of DOE and contractor training personnel formed to increase the exchange of ideas, information and resources in training and development among U.S. Department of Energy contractor facilities.

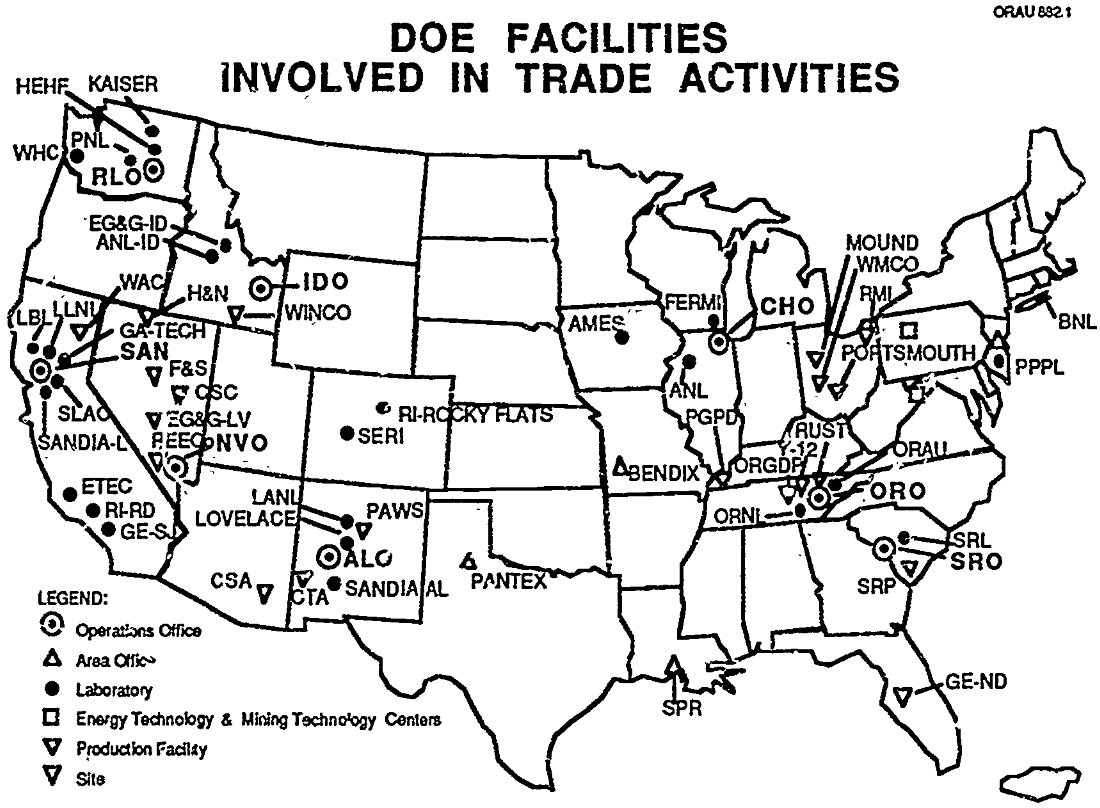
The TRADE network has existed since 1978; at the present time, six DOE offices support a range of activities in training areas related to safeguards and security, radiation protection, industrial hygiene, emergency preparedness, material control and accountability, security education, human resource issues, and the use of advanced training technologies.

TRADE is managed by Oak Ridge Associated Universities for DOE. All TRADE activities are completed by DOE contractor personnel for use by the entire DOE system. Policy development and leadership comes from the TRADE Executive Committee comprised of representatives from ten DOE facilities and advisors from the DOE Office of Industrial Relations and Office of Safety Policy and Standards. An additional eight DOE program managers are members of the TRADE DOE Advisory Group which meets to review TRADE activities and ensure that they benefit the entire DOE system. To date, training personnel from more than 50 DOE management and operating facilities have participated in TRADE activities.

### LESSONS LEARNED

The TRADE network provides the framework through which contractor personnel collectively address new training requirements. The DOE offices which support TRADE advise as training tools are designed and alert contractor training personnel to impending requirements. TRADE's role is to help contractors implement the policies directed by DC ecause they have stated, and implied, training requirements.

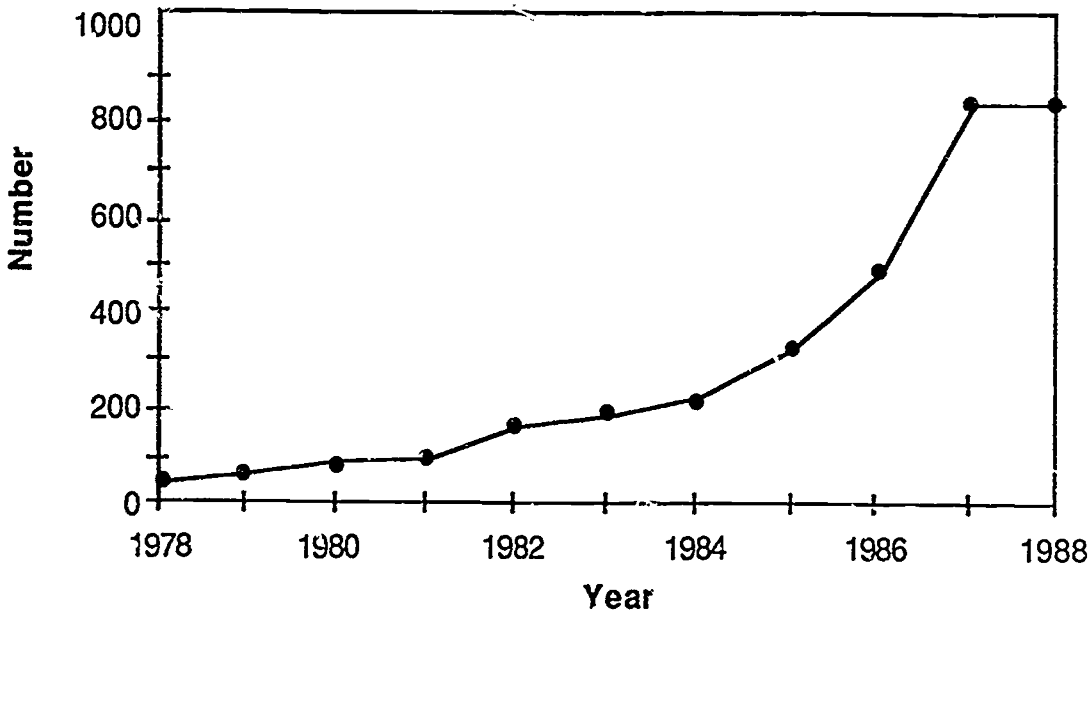
TRADE has provided many lessons. New concepts have been tested for increasing exchanges among the varied facilities of the DOE system. We have learned, for example, that the collective consideration by DOE facilities of new training technologies (CBT and interactive videodisk) can result in the



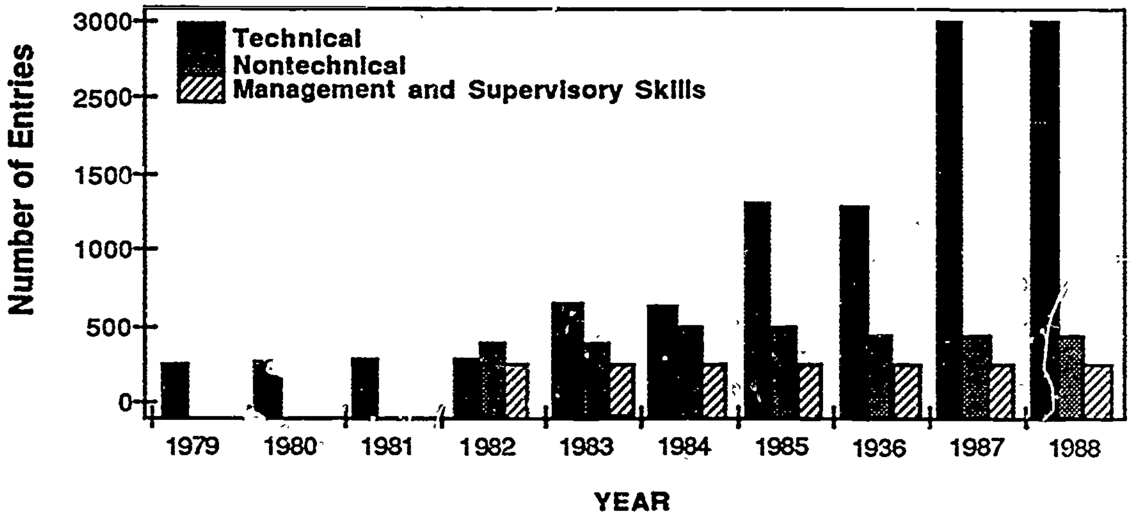

definition of generic content for the design of training programs. DOE facilities do differ one from another--and much of the training required must be site specific--but the consideration and adoption of new training technologies results in a consensus of what these technologies can be used for. Ultimately we identify what portion of the training and how the use of these technologies can be shared within the system.

There is a pattern to the DOE system's response to new training initiatives. TRADE works at the grass roots level. The contractor personnel who are faced with new training requirements first want to know who their peers are and next what their responses are. The number of training personnel at DOE facilities has grown dramatically over the last 10 years. Once the collective WHO is identified, trainers concentrate on establishing working definitions of WHAT is needed and HOW to respond. From this emerges outlines of training tools: resource guides, data bases, bibliographies, guides to good practice, and continuing education programs. Through TRADE, the training personnel create the training resources, distribute them to their peers, and prepare to implement the next stage of policy presented by DOE. One mechanism for identification and distribution of training resources developed and used by DOE facilities is the TRADE Training Inventories.

ENTRIES IN DIRECTORY OF DOE AND CONTRACTOR TRAINING AND DEVELOPMENT PERSONNEL 1978-1988



## ENTRIES IN TRADE INVENTORIES OF DOE CONTRACTOR TRAINING PROGRAMS 1979-1988




Over the past ten years, TRADE has shown that trainers need increasingly more information and that they must use data in more sophisticated ways. Large amounts of information are needed when applying systematic approaches to the training process. Performance-based training has been adopted across the DOE system as the most effective way to improve worker performance. Designing training courses, for example, requires the creation of realistic scenarios and similar applications. To create the scenarios, trainers must first understand thoroughly what the trainee needs to do and what knowledges, skills, and abilities are required by the job. Trainers must understand and perform detailed job and task analysis from which to derive viable training objectives to ensure that the course being designed is realistic and will result in significant changes in the trainee's performance.

TRADE has watched as the need grew for trainers to provide the general contractor employee population with steadily increasing types of knowledge. Within the past five years, new knowledge requirements have been established by DOE in industrial/laboratory safety, hazard communication, radiation protection, emergency preparedness, and security awareness. New training is required at all levels from the general employee population to top contractor management.

## TRADE SPECIAL INTEREST GROUPS

TRADE has developed a number of Special Interest Groups to respond to specific needs identified by DOE and contractor personnel responsible for various disciplines and functions. Selected activities of Special Interest Groups are briefly described below.

### Computer Based Training

-Operate on-line electronic bulletin board system
-Developed a Guide to Computer Based Training

### Emergency Preparedness

-Developed a Crisis Management Program for Senior Officials
-Developed a Glossary and Acronyms of Emergency Preparedness Terms

### Industrial Hygiene Training

-Developed Instructional Materials for SARA/OSHA General Site Worker Training
-Developed a Hazard Communication Training Resources Guide

### Radiation Protection Training

-Developed a DOE Guide to Good Practice in Radiation Protection Training
-Developed a training videotape on Biological Effects of Ionizing Radiation
-Conduct continuing education courses for radiation protection instructors

Safeguards and Security Training

- -Conduct job/task analysis training courses
- -Compile Security Inspector Job Analysis Results
- -Developed a Security Education Training Resources Guide

TRADE IN IT'S SECOND DECADE

DOE mandated training for contractors, and requirements for adoption of systematic approaches to training, have increased dramatically in recent years. As DOE requirements increase in the next decade, and contractors search for more effective and efficient methods of improving human performance, TRADE will develop new activities and mechanisms to address the collective needs of the DOE system. Future initiatives will likely include appropriate uses of state-of-the-art training technologies; an increasing emphasis on environment, safety and health issues; and expanding interactions with training networks outside the DOE system.

# TRANSFERRING GENERIC SARA/OSHA TRAINING TO U.S. DEPARTMENT OF ENERGY FACILITIES

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## ABSTRACT

The Technical Resources and Training Section staff at Oak Ridge National Laboratory have developed three extensive training programs for hazardous waste treatment, storage, and disposal facility workers as required by SARA/OSHA, 29 CFR 1910.120. The ORNL program is widely recognized as one of the best in the DOE system. ORNL and ORAU, who manages the Training Resources and Data Exchange (TRADE) network for DOE, entered into a cooperative relationship to respond to the many requests from DOE contractors for copies of the ORNL training materials.

This discussion will describe the ORNL program and the process of turning it into a series of generic tools which can be used by additional DOE facilities to meet the training requirements established by SARA/OSHA, 29 CFR 1910.120. The speakers will describe how the materials are being used by DOE facilities as well as plans for additional resources to be developed through TRADE.

TRADE

INDUSTRIAL HYGIENE TRAINING

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# TRANSFERRING GENERIC SARA/OSHA TRAINING TO U.S. DEPARTMENT OF ENERGY FACILITIES

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Tina McKinley
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## BACKGROUND

Among the requirements set forth by the interim final rule, 29 CFR Part 1910.120,[1] promulgated by the Occupational Safety and Health Administration (OSHA) in response to the Superfund Amendments and Reauthorization Act of 1986 (SARA),[2] are specific provisions for health and safety training of employees involved in hazardous waste operations. Employees involved in operations at uncontrolled hazardous waste sites must receive a minimum of 40 hours of initial instruction off the waste site, and a minimum of 3 days of actual field experience under the direct supervision of a trained and experienced supervisor at the time of job assignment. This requirement applies to employers and employees engaged in the following operations:

* Operations involving hazardous substances that are conducted under the Comprehensive Environmental Reponse, Compensation, and Liability Act of 1980 (CERCLA),[3] including initial investigations of CERCLA sites before the presence or absence of hazardous substances has been ascertained;
* Clean-up operations involving major corrective actions conducted under the Resource Conservation and Recovery Act (RCRA) of 1976;
* Operations at hazardous waste sites that have been designated for cleanup by state or local government authorities.

The interim final rule also regulates facilities involved in hazardous waste treatment, storage, and disposal operations as regulated under RCRA Section

3004. These sites generally have more routine working conditions and the hazards are better identified and controlled than at those hazardous waste disposal sites created prior to passage of RCRA. For this reason, the interim final rule requires 24 hours as the basic level of training appropriate to these working conditions.

Managers and supervisors who are directly responsible for or who supervise employees engaged in hazardous waste operations must complete 8 additional hours of training related to management of hazardous waste site activities.

## ORNL SARA/OSHA Training Program

A training program has been developed by the Technical Resources and Training Section staff at Oak Ridge National Laboratory (ORNL) to comply with the need to protect the safety and health of hazardous waste workers. All hourly requirements established by the OSHA requirements are met by a comprehensive program structure involving three stages of training.

Most ORNL hazardous waste workers are involved in routine treatment, storage, and disposal operations and require 24 hours of classroom instruction and field exercises. For those employees who may engage in remedial action waste clean-up operations, 16 additional hours for a total of 40 total hours of training are provided. In addition to this training offered the hazardous waste worker, managers and supervisors involved in hazardous waste operations also receive 8 hours of training relevant to their responsibilities.

OSHA made use of the guidance manual entitled "Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities" [5] as an outline in preparing the interim final rule. This manual was developed as a result of the collaborative efforts of professionals representing OSHA, the Environmental Protection Agency (EPA), the U.S. Coast Guard (USCG), and the National Institute for Occupational Safety and Health (NIOSH). It has proved to be a valuable reference tool in the development of the ORNL training program.

## Basic SARA/OSHA Training for General Site Workers

Basic Training for General Site Workers is offered to meet the 24-hour requirement for employees engaged in treatment, storage, and disposal of hazardous waste. This training, which is a prerequisite to the other two courses, includes fundamentals of industrial hygiene presented to the workers in a format that encourages them to assume responsibility for their own safety and health protection. Consistent with health and safety guidelines for hazardous waste site activities developed jointly by NIOSH/OSHA/USCG/EPA, this program addresses the following topics:

| | |
|---|---|
| * Overview of Regulations | * Site Control |
| * Types of Hazards | * Site Characterization |
| * Sources of Information | * Medical Surveillance |
| * Toxicology | * Decontamination |
| * Respiratory Protection | * Emergency Response |
| * Personal Protective Equipment | |

Much of this course is concerned with recognition of the types of hazards that may be encountered in hazardous waste operations and what the worker may do to minimize those hazards. General categories of hazards that are discussed include chemical hazards, ionizing radiation, confined spaces, noise, heat stress, cold stress, asbestos, biological hazards, and safety hazards.

Each of the topics listed above as well as each type of hazard has been developed into a complete training "module" with lesson plan and supporting visual aids and/or demonstrations. Each module contains learning objectives, basic information, site-specific information, and a review of key points.

## SARA/OSHA Training for Remedial Action Workers

ORNL, like many other DOE sites, is embarking upon some large-scale remedial action cleanup activities. For those ORNL workers engaged in remedial action activities on site, an additional 16-hour course is offered to build upon the prerequisite 24-hour course and meet the 40-hour training requirement. Compared to the Basic course, this training allows more time for site-oriented exercises, "hands-on" activities, and more intensive practice with protective clothing and equipment involving all of the trainees.

SARA/OSHA Training for Remedial Action Workers:

* Acquaints the trainee with various planned and ongoing remedial action projects at ORNL,
* Provides more detailed information on site characterization and decontamination techniques,
* Introduces trainees to risk assessment,
* Discusses handling of drums and other containers,
* Provides intensive training with the use and limitations of a self-contained breathing apparatus,
* Gives hands-on training in the use of select monitoring instrumentation, and
* Involves the trainee in protective clothing dress-out and decontamination exercises.

SARA/OSHA Training for Managers and Supervisors

An 8-hour course has been developed for supervisors and managers of hazardous waste operations and waste cleanup activities. This training begins with an overview of factors influencing remedial action strategies at ORNL sites. Other topics covered in this training include selection of personal protective equipment, emergency response and community right-to-know, and legal strategies to be utilized in interview situations. An out-of-class exercise on accessing ORNL's computerized Material Safety Data Sheet System is included. Because the interim final rule requires three days of training in the field under direct supervision of a trained and experienced supervisor, a workshop in on-the-job training skills is included, with discussions about documentation of this type of training. A group-oriented exercise in potential problem analysis and contingency plannir. applied to cleanup of a hazardous w ste site completes the day of training.

Considerable effort was spent developing the ORNL SARA/OSHA Training for Hazardous Waste Site Activities. The training staff at ORNL realized that much of the material developed for this program, particularly the Basic 24-hour course, is generic in nature and could be used as the basis for programs developed by other facilities. Not unexpectedly, as the program became recognized, requests for training materials began to arrive from other DOE sites that were addressing comp ance with this new regulatory training requirement. Oak Ridge Associated Universities manages the Training Resources and Data Exchange (TRADE) network for DOE. Close to 50 facilities across the national DOE system participate in TRADE activities designed to exchange training-related information and develop consensus-based resources. To provide these materials across the DC ystem, ORAU and ORNL entered into a cooperative relationship to publish generic portions of the ORNL training program in a series of TRADE documents.

## CREATING A GENERIC RESOURCE

### Site-Specific versus Generic Considerations

The program missions, types of employees, and hazards on site vary widely across DOE facilities. Although all DOE facilities must comply with requirements established in DOE orders and policies, decisions about compliance with other federal statutes can depend on the jurisdictional DOE operations office and, in some instances, on the decision of the individual facility. (All DOE facilities, however, are required to meet standards promulgated by OSHA according to DOE Order 5480.4 and 5483.1A.). Given these differences in DOE facilities and their adherence to various standards, the process of creating a generic resource required recognition of this variance across the DOE system. During a working session held several years ago, representatives from more than 20 DOE facilities who were directly involved in providing training in areas related to industrial hygiene and waste management identified three primary drivers for the development of hazardous materials training: training to the regulation, training the worker, and training for the hazard. Each approach has inherent site-specific issues associated with it which must be addressed in the process of designing a generic series of tools which can be used by many facilities. Some of the issues are identified below:

Issue Set 1: Training to the Regulation

Site-Specific Considerations:

* Site-specific interpretation of the regulation
* Site-specific liabilities and legal issues (personal and corporate responsibilities)
* Site-specific issues associated with review of compliance (for example, who visits the site to assure compliance?)

Generic Considerations:

* Establishing training required by minimal standards
* Meeting training specifications established in regulations

Issue Set 2: Training the Worker

Site-Specific Considerations:

* Site-specific worker knowledge and skill requirements
* Site-specific issues associated with unions, grievance procedures, other employee processes
* Site-specific scenarios, lab exercises

Generic Considerations:

* Processes for assessing worker baseline knowledge
* Processes for establishing worker performance measures

Issue Set 3: Training for the Hazard

Site-Specific Considerations:

* Site-specific hazards
* Site-specific policies and procedures for dealing with hazards

Generic Considerations:

* Characterizing the hazard (unless unknown or mixed)
* Distinguishing between real and perceived hazardous environments
* Interactions required with external organizations
* Minimal procedures required by specific hazards (protective clothing, etc.)

Because the ORNL training program was developed in response to 29 CFR 1910.120, it clearly used the requirements of the new regulatic as a driver. The decisions made by ORNL management to comply with the requirements and to develop the training in 24-, 8-, and 16-hour segments were made after extensive analysis of the new regulations, hazardous sites within the facility, and ORNL worker baseline knowledge. Each DOE facility will go through a similar analysis to determine how best to comply with training requirements. The intent of the generic materials is to provide DOE facilities with tools which will prove helpful in implementation once each has determine a course of action.

Developing Generic Resources

The first step in the process of transforming the ORNL training program into a series of generic training tools was to have the ORAU members of the devlopment team participate in the training session as trainees. Once all the players were knowledgeable about the training program, the team concentrated on transforming the site-specific materials used in the ORNL course into training tools which could be used by a range of DOE facilities. Three primary skills and knowledge were determined to be needed by team members:

1) Subject matter expertise (provided by ORNL)
2) Knowledge of training needs across the DOE system (provided by ORAU)
3) Instructional design skills needed to look beyond site-specific information and create checklists, generic exercises, scope statements, and similar tools which could be used by other facilities (provided by ORNL and ORAU)

All of the overhead transparencies which had been assembled by the ORNL staff (the initial 24-hour training session used almost 400) were reviewed and site-specific references were removed. To each module, the development team added a statement of scope, a listing of participant goals, a checklist for instructor preparation, and a listing of recommended instructional activities.

ORNL provided a copy of the instructor's written notes for each module. The notes consisted of the actual words used to present each overhead, keyed to the overhead. ORAU used the notes to prepare the "instructional activities" pages and to make sure that the overheads were cited with the correct subject matter. Because ORAU prepared the document for use by subject matter experts at DOE facilities; the "instructor preparation" and "instructional activities" pages were written in outline form rather than as all-inclusive notes. For modules without written instructor's notes, ORAU drafted the "instructor preparation" outline and met with the ORNL instructor who presented the training to verify the actual procedure used to prepare the module. This approach was used extensively to ensure that the ORNL-specific modules (e.g., Facility Overview and Site Characterization) described the actual procedure that had been used to prepare them.

The ORAU draft of each module was reviewed and critiqued by the ORNL instructor who prepared and presented the training. All comments and corrections were incorporated into the document. The final document was reviewed and approved by ORNL before publication.

If ORNL used a videotape with a particular module, the instructor activities list provided detailed information on ordering that videotape or recommendations for considering others. When exercises, such as an emergency drill, were used the development team wrote the same components (scope, goals, preparation, and activities) and also included an example of a drill scenario which identified the situation, roles involved and objectives of the exercise. This was followed by a description of the actions that would be expected in response to the situation presented. Thus, the user was provided with performance measures against which to evaluate the implementation of such an exercise at his/her own facility.

Distributing Generic Resources

Volume I of the TRADE Instructional Materials for SARA/OSHA Training (General Site Worker Training) includes approximately 500 pages of overheads and associated materials divided into twelve modules. Volume I has been distributed to 120 staff members in about 60 DOE offices and facilities. Recipients report using Volume I in a variety o ways from stric'' following '' preparation and activities list to incorporating some of the overheads into existing training programs. Most frequently, Volume I is being used as a guideline for creating facility-specific versions of hazardous site training programs. Again the training-to-regulation and training-to-worker approaches appear to be valid considerations in each facility's use of the training tools. All recipients contacted noted that they are eagerly anticipating Volumes II (Manager/Supervisor Training) and III (Remedial Action Worker Training), both of which will become available in the Spring of 1989.

## REFERENCES

1. "Hazardous Waste Operations and Emergency Response; Interim Final Rule," 29 CFR 1910.120, December 19, 1986, 52 FR 45654.

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3. Comprehensive Environmental Response, Compensation and Liability Act (CERCLA or "Superfund"), Public Law 96-510, December 11, 1980, 94 Stat. 2767.

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# COMPUTER BASED TRAINING STATE OF THE ART SYSTEMS

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## ABSTRACT

The use of Computer Based Training (CBT) in the nuclear industry has increased significantly in the last five years. Training professional are faced with many options in selecting instructional systems to help get the job done, and need to know if CBT is an appropriate solution to meet organization needs.

The purpose of this paper is to help you assess the advantages and limitations of Computer Based Training and considerations for selecting and implementing CBT systems as one part of an overall training program. Four CBT courses dealing with control of ionizing radiation are reviewed.

This paper is written an compiled by the staff of Oak Ridge Associated Universities based on work performed over the last five years for the Department of the Navy, Department of the Army, and the Department of Energy.

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The use of Computer Based Training (CBT) in the nuclear industry has increased significantly in the last five years. Training professionals are faced with many options in selecting instructional systems to help get the job done, and need to know if CBT is an appropriate solution to meet organization needs.

The purpose of this paper is to help you assess the advantages and limitations of Computer Based Training and considerations for selecting and implementing CBT systems as one part of an overall training program. Four CBT courses dealing with control of ioniz[illegible]diation are reviewed. This paper summarizes the following capabilities of CBT systems:

- Assessment/Benefit.
- Costs Involved in CBT.
- Assessment/Selection of a CBT system.
- Implementation of CBT Programs.
- Review of CBT Programs [illegible] Radiation Protection.

This paper [illegible] written and compiled by the staff of Oak Ridge Associated Universities based on work performed over the last five years for the Department of the Navy, Department of the Army, and the Department of Energy. ORAU's expertise in Computer Based and Interactive Videodisk Training has grown steadily since the initial development of a course in 1984. ORAU has continued to increase its expertise and is committed to utilizing the best technological systems to provide the highest quality training solutions.

In general, CBT systems are computer terminals which present courses to users who learn by reading, listening, viewing graphics or video, taking notes, and responding to test questions. More specifically, CBT is a term used to refer to the delivery or management of an instructional program using computers. CBT systems allow instructional material to be delivered to trainees through self-paced interaction with specialized software running on the computer. Testing (question and answer), assessing comprehension (score and evaluate), and recording individual results are also incorporated during the development.

ASSESSMENT/BENEFITS

It is especially important to exercise caution before deciding to use CBT. While it is true that CBT can be a very cost-effective investment, it can also be a very costly mistake. In deciding what role (if any) CBT may play in a training program, one must heavily weigh factors such as financial costs and availability of hardware, software, and courseware.

In order to decide whether CBT may play a role in training the following must be taken into consideration:

- CBT CAN allow individualized pacing of instruction based upon the learner's performance.

- CBT CAN remove some negative aspects of classroom instruction. The computer system cannot be impatient or inconsistent. In a well constructed CBT course feedback to the learner is immediate, personalized and rewards the learner's successes while constructively pointing out deficiencies.

- CBT CAN simulate real-world experiences that might otherwise be to expensive, time-consuming, complex, or risky to attempt in a training environment.

- CBT CAN standardize training and testing criteria. By using competency-based testing procedures, learners can be evaluated on the same criteria, and specific levels of proficiency can be established and audited.

- CBT CAN reduce training time. Typical CBT learners take less time to master material than do classroom learners. Evaluative studies have repeatedly found the average time to learn in a self-paced program to be from 25 percent to 60 percent less than the scheduled time in a conventional program.

- CBT CAN improve the availability of learning resources. Students may begin the program when their work schedule allows. Off-site trainee costs and prolonged time away from the job can be significantly reduced. This feature makes it unnecessary to pull people off the job for classroom training.

- CBT CAN improve administrative control a record keeping procedures. Information regarding learners, courses, course materials, tests, and other aspects of interest ca be automatically stored and made available for reports and analyses.

- CBT CAN facilitate exchanges of training resources. CBT programs may be shared intra or inter organizationally. A common program segment containing some primary level training can be developed for all of sites while site or task specific segments can be customized for particular locations.

The above benefits can be derived only from a properly implemented CBT system. If a system is poorly operated or implemented without planning or proper foresight, outcomes can be marginal or even detrimental.

It is also important to recognize what CBT cannot do:

- CBT CANNOT replace human contact with a learner. CBT may at times appear threatening to instructors. Having to shed old habits and learn new ones often stirs up anxiety, insecurity, and resistance in most people. Successfully implementing CBT requires that instructors be adequately trained for their new roles and responsibilities.

- CBT CANNOT achieve training objectives by itself. It is only one part of a total training program and, as such, must be incorporated into the rest of a training system.

- CBT CANNOT guarantee the quality of instruction. Quality is a product of the training staff, subject matter experts, and instructors. The computer is only a medium through which instruction may be delivered.

COSTS INVOLVED IN CBT

The criteria used to decide whether or not to use CBT should reflect the economics of achieving particular training objectives. The value of the benefits listed above must be compared with the costs most likely to incur when adopting this technology.

The following is a list of criteria that should be considered while investigating CBT as a possible addition to your training programs:

- If CBT offers a unique solution to an important instructional program, the computer should be used.

- If CBT provides more effective and efficient learning per unit cost than other instructional alternatives, then the computer should be used.

- If the cost of developing and using CBT is high and the computer provides only marginal instructional effectiveness and efficiency, then the computer should not be used.

Cost Benefit Analysis

The fact that a computer technology exists which will support effective training is a necessary but not sufficient reason for adopting this technology. The computer, like any technology, must also be economically efficient; that is, it should provide the most economic means of achieving training objectives if it is to be rationally integrated into the training program.

Hardware Costs

An important determinant in the economic feasibility of adopting CBT is the relative productivity per dollar spent on the technology. Any significant change in either productivity or cost will probably determine the relative ratio of CBT use to other alternatives in training. In computer technology, productivity has increased substantially while total hardware and average processing costs have dropped.

However, while computing costs have been steadily declining the labor costs of training have been increasing. These changes in relative costs have shifted the economic advantage to training systems that employ computers as opposed to those based on relatively expensive human trainers.

Software Costs

Software development is extremely labor intensive and therefore very costly. Any increase in the use of hardware will be accompanied by an increase in the commitment of resources to software development. In the long run, software costs will be the dominant cost factor in the selection of a CBT system.

The importance of software considerations in the decision-making process cannot be underestimated. If you decide to use CBT for instruction, courseware must be designed to meet your training needs. If you also wish to use the computer for managing training, software must be selected which meets these management needs.

ASSESSMENT/SELECTION OF A CBT SYSTEM

Once it has been decided to introduce CBT into a training program, an evaluation tool should be developed for selecting the type of system most responsive to the organization's needs. The following section describes the components of a typical CBT system and list some key questions that might be considered in evaluating a CBT system. The answers to these questions, after being weighted by their relative worth, can serve as selection criteria. The system chosen ca' then be the one meeting the greatest number of the organi: atio.n's needs.

Although some items may not seem important now, keep in mind that future training demands may differ from present ones. The best CBT system may be one that allows for upgrades and the ^ddition of new capabilities as needs evolve or as technologies change.

Assessing Hardware Systems

In assessing any hardware system, here are some pertinent questions which should answered:

- Does the terminal have adequate display resolutions? (320 x 256 dots, minimum)

- Does it have color?

- Can it be interfaced with a touch screen monitor? Light pen? Graphics tablet? Mouse?

- Is it reasonably fast? (10Mhz ᴗ. higher)

- What is the quality of the keyboard? Layout? Feel? Electronic or mechanical?

- How much memory (RAM) is possible? (512K minimum)

Assessing Authoring Software

..uthoring software runs th.. computer and peripheral devices and allows he creation of courseware. Most authoring software will require specific hardware configurations for its proper operation. In selecting a system the authoring or other software must usually be selected first as it will specifically determine what hardware is to be used to run it.

IMPLEMENTING CBT PROGRAMS

The constraints under which you must assess CBT depends on your management, physical facility, mission, and work force. Five general areas have been identified which should be kept in mind during implementation.

- Although many consider dollar costs to be the most obvious constraint, there are other less evident costs that also need to be recognized, such as opportunity costs and staff costs.

- In their analysis "Cost-Effectiveness of Computer-Based Instruction in Military Training," Orlansky and String (1979) found that the attitudes of instructors appeared unfavorable to CBT compared to conventional instruction. Resistance can be minimized through the involvement of trainers and human resource development personnel throughout the assessment stage, rather than presenting them with CBT as something new they are being forced to accept.

- Everything from management attitudes to political turf boundaries that may (now or in the future) relate to CBT must be taken into consideration. In short, this constraint is the organizational framework within which training must take place.

- During the assessment of the feasibility of CBT, consider introducing it slowly into the overall training program. Most organizations begin with a pilot program. If the pilot proves successful, then CBT is applied in other areas. Many organizations are using CBT to provide refresher material and tests to employees who require periodic certification.

- Personnel security, physical security, and procedural security requirements for computers processing classified information are stringent.

<u>In Review</u>

The manner in which the computer relates to a training operation should be clearly understood before attempting to evaluate any hardware, software, or courseware. If you are investigating CBT here are some of the criteria you should consider.

- Does CBT offers a unique solution to an important instructional program.

- Can CBT provide more effective and efficient learning per unit cost than other instructional alternatives.

If CBT may play a role in your training program a number of the following considerations must be positive.

- Allow individualized pacing of instruction based upon the learner's performance.
- Simulate real-world experiences.
- Standardize training and testing criteria.
- Reduce training time.
- Improve the availability of learning resources.
- Improve administrative control and record keeping procedures.
- Remove some negative aspects of classroom instruction.

It is also important to recognize what CBT cannot do:

- Replace human contact with a learner.
- Achieve training objectives by itself.
- Guarantee the quality of instruction.

These benefits can be derived only from a properly implemented CBT system. If a system is poorly operated or implemented without planning or proper foresight, outcomes can be marginal or even detrimental. However, the appropriate use of computer based materials can provide a high quality economical alternative to standard centralized delivery of training in selected areas.

## RADIATION PROTECTION COMPUTER-BASED TRAINING COURSEWARE

An increasing number of nuclear facilities are using computer-based training (CBT) in their radiation protection training programs. In 1988, four computer-based training courses dealing with the control of ionizing radiation were reviewed by Oak Ridge Associated Universities staff. A summary of the results of the review is presented below.

The criteria used to select courses for evaluation were:

- The course must be presented on a personal computer (PC),
- The course must present basic theory and concepts for health physics technicians, radiation workers, or general employee training.

Each of the courses was considered to be appropriate for initial instruction, refresher and requalification training, and remedial training (See Table 1).

Health Physics Theory, Resource Technical Services, has 34 instructional modules, each of which contains an optional pretest, instructional objectives, summary, and a posttest. Trainees may exit and enter the instruction at any time.

The course can be managed so that the trainer can access the status of each trainee, see recent execution errors made by a group of trainees, and perform file operations on the group. Each trainee's curriculum can be individually established.

The course was originally developed to meet INPO guidelines for radiation protection technicians at nuclear power plants. A separate 19-module technical math course is also available from the vendor.

Nuclear Science Modules, Power Safety International, has 11 training modules in which trainees are instructed to take specific actions in response to given plant conditions. Each module provides programmed instruction with different levels of material for technicians, operators, radiochemists, and engineers. The course is developed using an ISD approach and includes detailed terminal and enabling objectives automated pretesting and posttesting, and the capability to manage student records.

Health Physics Fundamentals, General Physics Corporation, is organized to correspond to the chapters in the accompanying Health Physics Fundamentals textbook. The instruction was developed for health physicists and technicians at nuclear power plants. The complete training package includes courseware diskette, instructor's guide with courseware diskettes, tutorial diskette, instructor's guide with course administration instructions, student guides, and textbooks.

Radiation Worker Safety, Westinghouse Hanford Company, includes instructional material required by DOE for radiation worker training. The course is based on an assessment of common training needs at DOE sites. It is available to DOE contractors at no charge. The trainer may choose to present the course in one of three different instructional modes. Topical material is presented in a programmed sequence in the standard mode. The intensive mode presents the same material but includes trainee comprehension checks after each major topical section. The trainee can go on to the next topic after acceptable performance on the comprehension check. The manual mode allows the trainee to choose a lesson, topic, or section as desired. The instructional material includes both text and task simulations.

TABLE 1

| Course Title | Health Physics Theory | Nuclear Science Modules |
|---|---|---|
| Vendor | Resource Technical Services, Inc.<br>P.O. Box 2882<br>Toledo, OH 43606 | Power Safety International<br>3315 Old Forest Road<br>P.O. Box 11886<br>Lynchburg, VA 24506 |
| Target Audience | Health physics technicians and professional | Reactor operators, health physics technicians, radiochemists, plant engineers |
| Supporting Materials | Management Module Writer | Tutorial |
| Hardware | IBM or IBM-compatible PC | Apple, Macintosh, IBM or IBM-compatible with Hercules graphics card |
| Cost | $10,000 | $25,000 |
| Subject Content | Atomic structure<br>Types of radiation<br>Radioactive decay schemes<br>Interaction of radiation with matter<br>Physical decay of radioactive materials<br>Radiation dosimetry quantities and units<br>Environmental radiation and radioactivity<br>Cell chemistry and acute effects<br>Biological effects of ionizing radiation<br>Internal dosimetry<br>Gas ionization detector theory<br>Scintillation detector theory<br>Neutron detector theory<br>Semiconductor detector theory<br>Thermoluminescent detector theory<br>Counting systems | Atomic Theory<br>Radioactivity<br>The Fission Process<br>Neutrons<br>Neutronics<br>Nuclear Fuel<br>Reactivity<br>Reactivity Control<br>Reactivity Coefficients<br>Fission Product Poisons<br>Reactor Power |

TABLE 1 (continued)

| Course Title | Health Physics Theory | Nuclear Science Modules |
|---|---|---|
| Subject Content | Counting statistics<br>Instrument operating characteristics<br>Health physics instruments<br>Contamination control<br>Decontamination<br>Radiation surveys<br>Radiation and shielding<br>ALARA<br>Airborne radioactive surveys<br>Respiratory protection<br>Radioactive waste control<br>Radioactive materials control<br>Shipment and transportation<br>10 CFR 19 and 20 | |

TABLE 1 (continued)

| Course Title | Health Physics Fundamentals | Radiation Workers Safety |
|---|---|---|
| Vendor | General Physics Corporation<br>10650 Hickory Ridge Road<br>Columbia, MD 21044 | Westinghouse Hanford Company<br>P.O. Box 1970<br>Richland, WA 99352 |
| Target Audience | Health physics technicians and professional | Radiation Workers |
| Supporting Materials | Textbook, tutorial diskette, instructor and student guides | |
| Hardware | Apple II or IIe | IBM or IBM-clone PC with 256K RAM, color graphics card, one hard disk drive |
| Cost | $1,995 | No cost to DOE Contractors |
| Subject Content | Atomic and nuclear properties<br>Radioactivity<br>Properties and interactions of radiation<br>Units of radiation measurement<br>Biological effects of ionizing radiation<br>Internal exposure<br>Gas-filled detectors<br>Scintillation counters<br>Neutron detectors and dosimetry<br>Semiconductor detectors<br>Radiation spectroscopy<br>Counting statistics<br>Dose rate determination<br>Radiation shielding<br>External dosimetry or beta-photon monitoring | Basics of Radiation<br>The Relationship between Units and Mill-units<br>Radiation Measurements Units<br>Classification of Biological Radiation Exposure<br>Biological Effects and Risks of Radiation Exposure<br>Radiological Warning Signs and Symbols<br>Radiation Exposure Limits<br>Personnel Dosimetry<br>Radiation Worker Rights and Responsibilities<br>Basics of Contamination<br>Area Contamination Control<br>Personnel Contamination Control<br>Basics of the ALARA Program<br>Reducing External Radiation Exposure |

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# INDOCTRINATION: USING INTERACTIVE VIDEO TO TEACH ATTITUDES AND KNOWLEDGE IN GENERAL EMPLOYEE TRAINING

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ABSTRACT

The Westinghouse Hanford Company (WHC) has developed a prototype Interactive Video (IV) course, Hanford General Employee Training (HGET). Interactive video combines sound, motion and still photographs from a videodisc with the graphics, text and instructional capability of computer-based instruction. The course includes indoctrination on over 40 topics identified by the Institute of Nuclear Power Operations (INPO), the United States Department of Energy, and the Westinghouse Hanford Company that are to be included in the indoctrination of new and requalifying employees. In addition, the course requires trainees to make positive choices when confronted with real life scenarios showing violations of safety, security and quality standards. This courseware is different from most GET courses because it puts the trainee in a role-playing mode and requires the trainee to recognize and respond "in the WHC way."

Initial data project a reduction of 40 - 60% in training time for HGET as compared to stand-up instruction.

## INTRODUCTION

Instruction at nuclear facilities has traditionally used a variety of formats and designs to accomplish prescribed purposes. These purposes have included increased knowledge and improved practices. It has been recognized that both knowledge and skill improvement can be impacted by trainee attitude. How to impact attitude through the training process has, however, been elusive. Outside industrial training circles, the use of role-playing has been a recognized technique for affecting behavior and attitude, but applying role-playing to normal plant tasks has not been successfully accomplished to any extent.

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## INDOCTRINATION

The terms "indoctrination" and "orientation" are often used synonymously, but actually have quite different connotations. Orientation generally refers to coursework designed to give a broad-brush view of a process or practice, rather than a detailed, practical, how-to instruction. Those how-to's are usually presented in formal classroom or on-the-job training, or in some form of self-study. Both are important in providing trainees with the knowledge and skills necessary to perform their jobs.

Indoctrination, however, means literally to indoctrinate, to create a set of beliefs, ethics or outlooks. Such attitudes or beliefs can affect greatly the behavior of workers toward quality, safety and security, and in turn toward the way in which they perform their work. Workers may be technically skilled but consider attention to the safety, security or quality aspects of their jobs a nuisance. Indoctrination should focus on improving attitudes by reaching measurable goals in the Affective Domain of learning.

Westinghouse Hanford Company (WHC) was faced with a need to indoctrinate 10,000 employees on the "WHC way to do business" following consolidation of three separate contractor functions into one function in 1988. Three different ways of conducting business, three different views of how to emphasize and practice safety, security and quality, and three different management organizations were to be replaced by a Total Quality approach, with a single organization and set of standards.

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## GENERAL EMPLOYEE TRAINING

Traditionally, General Employee Training (GET) courses have been approached as orientations. A variety of topics, ranging from attendance policies to radiation safety to emergency procedures have been presented in a broad view format, with numerous details to support the broad view.

Writing HGET objectives has been difficult because of the breadth and depth of content to be given. In addition, the use of examinations has been difficulty. The questions tend to emphasize specific detail rather than broad concept, and much content is simply not tested. Trainers have often felt torn between the demand to teach specific details, and the reality of time and trainee tolerance to detailed questions.

In approaching the design of the Hanford General Employee Training (HGET) course, it was decided to put emphasis on Affective Domain terminal objectives that would connect together the detailed enabling objectives. The eight objectives used stress making choices to support WHC policies in the three major content areas: quality, safety and security. Given typical work situations, employees are progressively required during training to recognize good and bad practices, to choose the good practices over the bad, and to choose to mitigate violation of good practices.

## INTERACTIVE VIDEO

Interactive video (IV) is a next generation extension of computer-based training (CBT). Using the computer and color monitor to control the program and produce text and graphics, IV also adds a laser videodisc player to provide sound, still photographs and video sequences.

Westinghouse Hanford Company has produced CBT courses for Radiation Worker Training and Hazardous Materials Shipping Training. Both are used throughout the Department of Energy contractor system. HGET expands on our use of technological approaches to appropriate courses. The course utilizes IBM PS/2 Model 70 computers and IBM InfoWindow displays. The InfoWindows has pressure-sensitive touch screens and graphics overlay capability, plus a synthesized voice chip.

The use of IV is a key to allowing training on Affective Domain objectives. It allows an individual trainee to be placed in a role-playing mode. The trainee can view a real-life situation from the video, respond to it, then receive direct feedback on the consequences of their choices. Trainees who would be reluctant to respond to such a condition in a group can respond quite naturally to the same situation in an IV mode.

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## HANFORD GENERAL EMPLOYEE TRAINING

Hanford General Employee Training has as its base a series of 40 lessons based on topics identified in INPO, DOE and WHC documents. These topics range from Total Quality to Electrical Safety, from Computer Security to Attendance Policies. A tour of the entire Hanford site as well as security and safety requirements of specific facilities will be included.

The lessons can be either performance-based or mandatory orientation. The performance-based lessons allow the trainee to "test out" of the lesson. The mandatory orientation requires the new employee to receive the orientation, but can be performance-based for the experienced employee. Our experience with previous courses predicts that experienced employees can reduce training time by up to 75% through the use of the performance-based mode.

The lessons are encountered by the trainee while being conducted on three tours: a plant tour, an office tour and an outside tour. Along the tour, conducted by actual safety trainers, trainees encounter situations where policies are explained, where they are required to recognize violations of safety, security, or quality practices, or where they must take corrective action of a violation of good practices. Their responses are used to 1) give immediate feedback on the correctness of a choice, and 2) determine whether entry into a lesson is necessary.

Once a trainee is directed to a lesson, they are tested to identify exactly which section of the lesson they need. Within the lesson, trainees encounter worker testimonials, expert testimony, and actual case studies, in addition to text, to impress on them the reality of the work conditions and the need to observe good practices. Videos of appropriate procedures are included. For example, in the electrical safety lesson, a trainee encounters a co-worker being electrocuted. The trainee must choose appropriate action from a menu. If a wrong choice is made, the trainee is shown the consequences and required to choose again. The correct choice emphasizes the proper way to remove a worker from the energized equipment by first turning off the power to the equipment.

Attitudes, knowledge and skill are being impacted by several elements in the design. A foundation of information is being presented. Real situations are presented and the student must respond correctly several times to complete a given portion of the training. An overall pattern of safer, more secure, quality behavior is being demonstrated to, and required of, the trainee. These goals all occur within the Observation and Response levels of the Affective Domain.

A final key element in implementing the course is that the training will be conducted with a live trainer present. Our experience supports the belief that CBT and IV do not eliminate the need for instructors. The cost savings occur on improvement in retention of learning (up to 30% increase) and reduction in training time (40 - 60%). The presence of a live trainer supports the student in acquiring the knowledge, attitude and skills the training is designed to impart.

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## STATUS

Westinghouse Hanford Company has developed the HGET prototype, consisting of a registration module, an introduction to the course, orientation of the students to use of a touch screen mode, the office tour and several lessons. The completed course is planned for late summer with training of employees to begin in early Fall.

The basic assumption of the course is that worker attitude can be directly related to performance. Measures are being identified to determine the impact of HGET. These measures include reduction in recordable injuries, reduction in number of certain audit findings, and maintaining currency in required employee training. Future plans include connecting the courseware to the training records data base to correlate the requalification of appropriate parts of HGET with the training identified for near-term requalification in the training records.

WHC has stressed impact of trainee work practices in all CBT courses. The same emphasis is present in HGET. Statistical measures are being designed to measure its impact on workplace practices.

CREATING MENTAL MODELS: THE INSTRUCTIONAL IMPERATIVE

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PAPER WAS NOT RECEIVED AT TIME OF PUBLICATION

# MANAGING INSTRUCTOR TRAINING TO ACHIEVE EXCELLENCE

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by

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# MANAGING INSTRUCTOR TRAINING TO ACHIEVE EXCELLENCE

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The requirements for instructor training in the nuclear electric power industry are clearly set forth in the August 1988 INPO 88-012, Guidelines for Instructor Training and Qualification. To be accredited and re-accredited, companies will need to address the initial and continuing instructional skills development called for. The initial training of instructors presents a special challenge since only a few new instructors will be employed by most companies over the next few years. Another challenge that must be dealt with is providing individualized remedial instruction to remove performance deficiencies identified during staff evaluations.

This presentation will explain how a group of concerned companies formed the Electric Utility Instructor Training Consortium to address this problem in a cost-effective and time-efficient manner. It will further explain how these companies collaborated with The Ohio State University to (1) conduct job and task analysis, (2) develop performance-based instructor modules, (3) conduct a field review of the modules, and (4) revise and publish the 18 modules. Further, the presentation will explain how companies like Duke Power and Virginia Power have organized their instructor training programs to provide for both effective and efficient (1) initial instructor training, (2) advanced training, and (3) continuing development. Transparencies, task lists, and other handout materials will be used to supplement and enhance the proposed presentation.

There is little question about the importance of preparing instructors so that they can effectively teach what they know to others. The most commonly employed criterion for the selection of instructors is their technical expertise. While technical expertise is extremely important, the quality of training is likely to be less than it should be unless these subject-matter experts also acquire the teaching skills necessary to convey their knowledge and skills to others.

Instructors who pay little attention to the needs of the adult learners involved, the learning environment, trainee motivation, and the appropriate selection of instructional techniques and evaluation activities are unlikely to produce the learning outcomes and job performance improvements being sought. Most good instructors acquire their professional expertise through some type of formalized training program.

The situation is much the same for instructors who also design instructional programs. Without adequate knowledge of the principles of effective instructional design and acquisition of the related skills involved, instructors are not likely to develop instruction that will effectively address the company's needs.

The Problem

In today's highly competitive business and industrial environment, most training managers recognize that an effective performance-based and results-oriented training program is one of the factors most critical to a company's survival and success. In the nuclear power industry, for example, the Institute of Nuclear Power Operations (INPO) has established rigorous guidelines for acquiring initial accreditation and for maintaining the accreditation of company training programs. INPO's recently issued guidelines (March 1988; INPO-88-001) on Maintaining the Accreditation of Training in the Nuclear Power Industry states as Objective 2 that "Training staff members (utility and contracted, if used) possess the knowledge, experience, and skills required to fulfill their assigned duties." Three of the nine criteria that will be used to determine whether companies are achieving the objective are as follows:

2.5 The instructional skills training program develops the necessary instructor capabilities to fulfill training program requirements.

2.8 Instructor performance is evaluated regularly.

2.9 Continuing development maintains and improves required knowledge and skills and addresses results of evaluations of staff member performance.

These guidelines make it abundantly clear that utility instructors are to be given effective initial preparation, as well as continuing instruction, that is based on regular evaluations of instructor performance.

More recently, INPO issued revised guidelines (August 1988, 88-012) in Guidelines for Instructor Training and Qualification which specify 28 areas that "should be considered for the instructional skills initial training program." While few disagree with the intent of 88-001 or 88-012, companies are often faced with some challenges as they attempt to respond to these criteria.

One difficulty arises when a company needs to provide initial performance-based training for only one or a few new instructors. The small number of persons involved often makes it very expensive and somewhat impractical to conduct a traditional instructor-led course for these persons.

A somewhat different challenge arises when the evaluations of individual instructor performance reveals that different instructors have quite different skill deficiencies, and hence, different continuing training needs. Again, an individualized or small group, performance-based training approach is required if the unique needs of different instructors are to be met.

It is widely recognized that any performance-based training program, whether for instructors or technical personnel, requires the availability of high-quality instructional materials that focus on and help deliver the specific skills and knowledge needed by the trainees. Unfortunately, performance-based materials that are self-contained and designed specifically for the professional development of instructors in the electric utility industry are still in very short supply.

Many electric utility companies have contacted the Center on Education and Training for Employment (formerly the National Center for Research in Vocational Education) to learn more about the 21-year research and development effort that resulted in the preparation of 132 PBTE (performance-based teacher education) modules that address the teaching skills needed by teachers in the public and private secondary and postsecondary schools and colleges of the United States. Over 1,800 educational agencies and over 400 companies and governmental agencies have purchased these materials.

Some electric power companies, such as Virginia Power and the Public Service Company of New Hampshire, appear to be making effective use of these modules in their current form. Other companies, however, have chosen to use the PBTE materials only as supplementary references, because some of the terminology, case studies, illustrations, and other educational features are not pertinent to industrial trainers and trainees.

What is required to meet the needs of specific companies, the INPO accreditation guidelines, and the needs of individual instructors is a set of high-quality performance-based modularized materials that address the specific training and educational needs of instructors in the electric utility industry.

Recognizing this need, several electric power companies joined with the Center in November of 1986 to organize the Electric Utility Instructor Training Consortium. In a two-phased effort the Consortium began work to accomplish three major objectives as follows:

1. To identify and verify the important tasks performed by instructors in the electric utility industry (Phase I).

2. To adapt and revise existing performance-based instructor modules specifically for use in the electric utility industry (Phase II and III).

3. To develop new performance-based instructor training modules and related support materials to meet utility instructor needs that are not addressed by an existing materials (Phase II and III).

During Phase I (November 1986 - February 1987), a comprehensive analysis of the job of electric utility instructor was conducted utilizing both a review of literature and a DACUM panel of expert instructors. This research phase of the Consortium resulted in the identification and national verification of 130 tasks as important to the job of electric utility instructor. A total of 120 expert instructors, employed at 19 different power plants by 13 companies participated in the verification effort. Phase I concluded with the publication of a job analysis report and the clustering of the 130 tasks into 20 proposed modules that were believed to be needed by all utility instructors. For a list of the 130 verified task statements (competencies) see Attachment A.

To produce the performance-based modules needed, Phase II was begun in September 1987 to develop the proposed modules. Five companies (Consolidated Edison of New York, Detroit Edison, Duke Power, Florida Power, and Virginia Power) sponsored the development effort and provided resources for the development of 11 of the originally proposed 20 modules. Since the initial clustering, one module was deselected and a second was combined with another leaving a need for seven more. The development of the 11 modules was completed on December 31, 1988.

Initial reactions to the modules being developed have been extremely positive. Most reviewers have rated the modules as of very high quality and have stated that they would definitely like to use the modules in their training program. For the reactions of utility instructors and training managers to the modules, see Attachment B. For the titles of the 11 modules developed in Phase II and the titles of the additional modules now being developed, see Attachment C. For more details about the procedures used to develop the modules, see the Work Breakdown Structure of Tasks 1.0 to 8.0 in Attachment D.

What remains to be done is to complete the Phase III development effort which began January 1, 1989. The following nine-electric power companies are supporting this developmental effort which will be completed on or before December 1989: Cleveland Electric Illuminating, Consolidated Edison of New York, Detroit Edison, Duke Power Company.

Florida Power Corporation, Florida Power and Light Company, Indiana Michigan Electric, Southern California Edison, and Virginia Power. Each member company has already made plans or is currently in the process of making plans for integrating use of the materials in one or more of their training programs.

## Company Plans

Some companies are planning to make major use of the modules in their initial certification training program, others plan to utilize them for advanced and/or continuing training, and all companies plan to utilize them for remediation training. Attachment E describes how Virginia Power plans to make extensive use of the modules in their training and certification programs. Attachment F explains briefly how Florida Power intends to utilize the materials. All other member companies are devising similar implementation strategies for their companies.

It is important to make note of the fact that all companies are making adequate provision for one or more resource persons (master instructors) to be available to instructor trainees. While the modules are essentially self-contained, they are not designed as self-instructional materials. A qualified resource person(s) is absolutely critical to maximizing the successful use of these or any other modularized materials.

## Plans for Publication

The Center will be arranging for the commercial publication of the modules and any supportive materials that may be developed. The actual date of publication, terms of publication and sale prices are not known as of this date. Interested persons should write to Dr. Robert E. Norton at the Center on Education and Training for Employment, The Ohio State University, 1900 Kenny Road, Columbus, OH 43210.

Relationship of Modules to INPO Guidelines

We made a comparative analysis of the competencies specified for initial instructor skills training in INPO document 88-012 entitled Guidelines for Instructor Training and Qualification with those addressed by the Consortium modules.

Of the 28 areas specified by the INPO Guidelines, 24 of them are addressed by one or more of the proposed 18 modules. That computes to approximately 86% coverage. In addition, three other important competencies will also be thoroughly addressed as follows:

Module D-4 Conduct Mock-up Training
Module E-3 Determine Test Quality
Module E-4 Evaluate Instructional Effectiveness

The additional modules, like the other 18, were found to be important during the job analysis workshop and verified as important during the national task verification research study. The four areas not scheduled to be addressed at this time (4.2.1.9, 4.2.1.12, 4.2.1.23, 4.2.1.24) could very easily be addressed by the Consortium in a future scope of work, if approved by the board.

The 18 modules would also be appropriate for addressing at least 3 of the 5 areas specified for instructional skills continuing development (INPO 88-012, p. 15) as follows:

- refresher topics from initial instructional skills training
- new and advanced instructional techniques and methods
- performance deficiencies identified during instructional evaluations

Summary

Using the cooperative development approach, Center staff has taken responsibility for module conceptualization, development, revision, and quality control. Appropriate staff from the member utility companies have helped by serving as technical consultants to the module writers and by providing field reviews of all the modules developed so as to assure their technical accuracy and relevance to the electric power industry.

The consortium operates through a Board of Members, comprised of one representative per member company. By joining and financially supporting the consortium, each company participates in policy making and program review meetings held approximately every six months.

A company's involvement in the consortium has resulted in a number of benefits, as follows:

1. For supporting the research and development needed, each company will be receiving 18 modules, targeted specifically for their instructor training needs.

2. By sharing development expertise, the Center and member companies have produced higher-quality materials than could be produced individually.

3. The consortium approach permitted the development of materials that could not be afforded by individual companies.

4. Use of the cooperative approach has resulted in the development of an important sense of ownership and commitment to use the materials produced.

5. The involvement of company personnel provided excellent professional growth opportunities for those who participated in the research, development, and review process.

6. The availability and use of the proposed industry-specific modules will assist companies in meeting and maintaining industry training program accreditation standards.

7. Upon commercial publication, the modularized materials will be available at a reasonable price to any company who can benefit from their use.

## ATTACHMENT A

### COMPETENCIES IMPORTANT TO ELECTRIC UTILITY INSTRUCTORS
Master List of Duties and Task Statements*

DUTY A: DEVELOP AND MAINTAIN TECHNICAL PROFICIENCY (OTHER)

A001. Perform in-plant assignments
A002. Maintain currency with regulatory guidelines
A003. Review industry events
A004. Review procedure changes
A005. Review plant modifications
A006. Participate in technical vendor training
A007. Participate in technical seminars and workshops
A008. Participate in in-house technical training (e.g., cours program)

DUTY B: DEVELOP AND MAINTAIN INSTRUCTIONAL PROFICIENCY (OTHER)

B001. Attain instructor certification
B002. Attain simulator instructor certification
B003. Prepare for instructor recertification
B004. Participate in seminars and workshops
B005. Participate in in-house continuing instructor training
B006. Participate in peer instructional evaluation
B007. Participate in vendor training
B008. Maintain currency with industry instructional guidelines

DUTY C: ASSESS TRAINING NEEDS (ANALYSIS/DESIGN)

C001. Conduct preassessment of trainee
C002. Evaluate training needs of plant
C003. Evaluate training needs of class
C004. Evaluate training needs of instructors
C005. Review job and task analyses data
C006. Evaluate training implications of industry and regulatory guidelines
C007. Conduct job analysis
C008. Develop a job analysis survey
C009. Conduct task analysis
C010. Obtain job- and task-related documentation (e.g., INPO, JTA)
C011. Write training development recommendations
C012. Evaluate need for vendor training
C013. Serve as subject matter expert for job and task analyses
C014. Revise existing job analysis
C015. Identify training resources
C016. Identify training constraints
C017. Analyze existing materials

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*Taken from Summary of Task Verification Data: 1987 Electric Utility Instructor Survey by Robert E. Norton, Consortium Manager, Columbus, OH: National Center for Research in Vocational Education, The Ohio State University, 1987.

DUTY D: DEVELOP/REVISE INSTRUCTIONAL MATERIAL (DESIGN/DEVELOP)

D001. Write program and course descriptions
D002. Formulate performance objectives based on job and task analyses
D006. Develop test items based on objective level
D007. Construct lesson plans
D008. Correlate lesson plan content with objectives
D009. Develop job performance measures
D010. Revise job performance measures
D011. Develop visual and graphic aids
D012. Develop learning activities
D013. Develop simulator exercise guides
D014. Develop lab exercises
D015. Develop text/manuals
D016. Develop trainee handouts
D017. Review instructional materials for format and technical accuracy
D018. Pilot test training materials
D019. Revise instructional materials to reflect industry, plant, and regulatory changes
D020. Modify existing training methods
D021. Modify existing audiovisual materials
D022. Develop simulator team training criteria
D023. Revise simulator team training criteria

DUTY E: PREPARE FOR INSTRUCTION (IMPLEMENTATION)

E001. Review trainee backgrounds
E002. Review course materials
E003. Select methods of instruction
E004. Personalize lesson plan
E005. Assemble training aids/equipment
E006. Set up training area (e.g., classroom, lab, shop)
E007. Identify personnel dosimetry/safety requirements

DUTY F: COORDINATE AND SCHEDULE TRAINING (IMPLEMENTATION)

F001. Establish training goals
F002. Develop a training matrix
F003. Schedule training activities
F004. Evaluate vendor training programs
F005. Select vendor training programs
F006. Arrange for off-site vendor training
F007. Arrange for off-site company training
F008. Arrange for on-site guest instructors
F009. Facilitate on-the-job training program
F010. Schedule reactor operator/senior reactor operator audit exams
F011. Schedule training program exams
F012. Arrange for availability of equipment and facilities

DUTY G: OPERATE AND MAINTAIN INSTRUCTIONAL EQUIPMENT (IMPLEMENTATION)

G001. Inventory training aids and equipment
G002. Inventory lab/simulator equipment

G003. Order needed equipment
G004. Operate lab equipment
G005. Make minor repairs to lab equipment
G006. Operate simulator
G007. Identify simulator problems
G008. Test simulator modifications
G009. Develop test procedures for simulator
G010. Run test procedures on simulator
G011. Process simulator modifications
G012. Select training equipment

DUTY H: DELIVER INSTRUCTION (IMPLEMENTATION)

H001. Present formal classroom instruction
H002. Conduct demonstrations
H003. Conduct seminars/workshops
H004. Conduct simulator training
H005. Conduct tours and walk-downs
H006. Conduct mock-up training
H007. Conduct on-the-job training sessions
H008. Conduct lab exercises
H009. Administer self-study materials

DUTY I: SUPERVISE TRAINEES (IMPLEMENTATION)

I001. Monitor lab activities
I002. Monitor simulator activities
I003. Tutor trainees
I004. Conduct performance reviews
I005. Counsel trainees
I006. Proctor exams
I007. Direct trainee presentations

DUTY J: EVALUATE TRAINEES (EVALUATION)

J001. Conduct written exams
J002. Conduct performance tests
J003. Conduct oral exams
J004. Conduct formative exams
J005. Conduct summative exams
J006. Conduct in-course assessment of individuals
J007. Review test results with trainees
J008. Conduct end-of-course assessment of individuals

DUTY K: EVALUATE TRAINING EFFECTIVENESS (EVALUATION)

K001. Perform informal oral surveys (trainees, supervisors)
K002. Conduct formal follow-up surveys
K003. Conduct course critiques
K004. Analyze test items
K005. Analyze exam results
K006. Make recommendations based on course evaluation

K007. Evaluate vendor training performance
K008. Conduct emergency drill critiques

DUTY L: PERFORM ADMINISTRATIVE ACTIVITIES (OTHER)

L001. Track trainees' progress
L002. Document trainee attendance
L003. Compile and review exams
L004. Grade exams
L005. Maintain course records
L006. Prepare special reports
L007. Respond to audits (e.g., QA, QC, INPO, NRC)
L008. Serve on committees
L009. Perform audit of course materials
L010. Prepare a budget
L011. Assist in procedure validation

Electric Utility Instructor Training Consortium

# WHAT DO ELECTRIC UTILITY INSTRUCTORS AND TRAINING MANAGERS SAY ABOUT THE MODULES?

The following statements were made by electric utility instructors and managers who provided field reviews of the modules.

- Truly excellent work. Reviewing work of this caliber is a joy!
- The whole electric utility industry needs these. The materials are beautiful!
- These modules will raise industry standards for instruction. They will save us time and provide for the consistent use of terminology.
- The case situations in this module (A-1) are excellent.
- The writer has done an excellent job in all respects (B-1). I am impressed with the completeness, clarity of explanations, and the considerations/questions during design phases. I'm already copying pages to use now.
- The section concerning adult learners is very well presented and provides a solid foundation for considering appropriate instructional techniques.
- Great format; your addressing the important things in a straightforward manner.
- These modules are effective self-study tools for individuals who teach periodically and for refresher training.
- With a few minor changes this module (D-1) is excellent. If the rest of the modules being developed are geared and focused on the electrical industry as this one is, we'll have some terrific material with which to work.
- Our review of module D-1 revealed that the content is accurate, comprehensive, and well organized.
- Found the modules very well written and informative. I found a great amount of useful information presented in a logical, easy to understand manner.
- These modules will blow some vendor materials out of the water.

ATTACHEMENT C

INDUSTRY INSTRUCTOR TRAINING MODULES

Category A: Analysis

- A-1 Determine Training Needs
- A-2 Conduct Job and Task Analyses

Category B: Design

- B-1 Design Instruction
- B-2 Develop Learning Objectives

Category C: Development

- C-1 Develop Lesson Plans
- C-2 Provide Print Instructional Materials
- C-3 Provide Visual and Audiovisual Aids

Category D: Implementation

- D-1 Present Formal Classroom Instruction
- D-2 Conduct Demonstrations
- D-3 Conduct Lab/Shop Exercises
- D-4 Conduct Mock-up Training
- D-5 Conduct Tours and Walk-Throughs
- D-6 Conduct On-the-Job Training Sessions
- D-7 Conduct Independent Instruction

Category E: Evaluation

- E-1 Evaluate Training Performance: Knowledge
- E-2 Evaluate Training Performance Using JPMs
- E-3 Determine Test Quality
- E-4 Evaluate Instructional Effectiveness

These modules are being developed cooperatively by the Center on Education and Training for Employment at The Ohio State University and the Electric Utility Instructor Training Consortium. Development work began in September 1987 and is scheduled for completion in 1989. For more information, contact Robert E. Norton, Consortium Manager, at the Center for Education and Training for Employment, The Ohio State University, 1900 Kenny Road, Columbus, Ohio 43210-1090, (800-848-4815 or 614-486-3655).

ATTACHMENT D

## Instructor Module Development
## Work Breakdown Structure

**Task 1.0 Identify the Tasks Performed by Instructors**

Activity 1.1 Analyze existing job analysis data

Activity 1.2 Select technical committee of experts

Activity 1.3 Conduct job analysis workshop

**Task 2.0 Verify the Tasks Performed by Instructors**

Activity 2.1 Develop a task inventory

Activity 2.2 Submit inventory to qualified instructors and immediate supervisors

Activity 2.3 Summarize and analyze task verification data

Activity 2.4 Select tasks for training

Activity 2.5 Cluster tasks for module development

Activity 2.6 Prepare job analysis report

**Task 3.0 Establish Module Format**

Activity 3.1 Review existing prototype module

Activity 3.2 Consider member-company module formats

Activity 3.3 Devise final module format and development specifications

**Task 4.0 Identify and Acquire Existing Resources**

Activity 4.1 Identify and acquire copies of all relevant member-company resources (print and media)

Activity 4.2 Conduct manual and computer search for other relevant references and media

Activity 4.3 Purchase needed references and media

**Task 5.0 Determine Extent of Development Needed per Module**

Activity 5.1 Assess usefulness of existing resources

Activity 5.2 Estimate amount of development/revision required

Activity 5.3 Recommend development/revision priorities to board

Task 6.0 Develop/Revise Instructor Modules

Activity 6.1 Develop revision specifications for modules to be revised

Activity 6.2 Develop outlines for new modules

Activity 6.3 Review and select from existing materials

Activity 6.4 Modify existing materials

Activity 6.5 Develop new module material

Activity 6.6 Modify/develop module graphics

Activity 6.7 Conduct internal review of module

Activity 6.8 Make necessary revisions based on reviews

Activity 6.9 Prepare module for field review

Task 7.0 Conduct Field Review of Modules

Activity 7.1 Develop field-review procedures and instruments

Activity 7.2 Select field reviewers (industry instructors)

Activity 7.3 Conduct field reviews

Activity 7.4 Summarize field-review feedback

Task 8.0 Revise Modules for Publication

Activity 8.1 Analyze data for revision implications

Activity 8.2 Revise module based on recommendations

Activity 8.3 Conduct final edit and format check

Activity 8.4 Prepare camera-ready copy

Activity 8.5 Duplicate sponsor copies

Activity 8.6 Arrange for commercial publication

ATTACHMENT E

# Integrating the Consortium Modules into Virginia Power's Instructor Training/ Certification Program

## Introduction

Virginia Power implemented its Instructor Training/Certification Program in late 1984 after analysis, design, and development work conducted by personnel in the corporate offices and training specialists working on-site at the nuclear training centers. Virginia Power using a tabletop job analysis and review of Cotrell's 384 tasks, identified 142 tasks needed by nuclear training instructors and designed a performance-based program on that basis.

The first seven-day Basic Training Course was offered in November 1984, with several classes following in January 1985. The Advanced Training Program was implemented in January 1985. Several on-site training specialists were hired to implement the program at both Virginia Power's nuclear training centers. Continuing training has consisted of specialized training workshops in areas such as interviewing techniques.

Throughout the program, on-site training specialists assist the instructors through the program and evaluate the instructors on their performance. Workshops accompany the Advanced Training Program. The Performance-Based Teacher Education (PBTE) modules, developed by the National Center for Research in Vocational Education at The Ohio State University (OSU) have been available as supplementary materials.

Very early on, it was determined that the PBTE modules, having been designed for vocational education teachers-in-training, were not well liked by the instructors. The instructors wanted utility-specific materials.

In mid-1986, Virginia Power participated in the formulation of a consortium, the Electric Utility Instructor Training Consortium, along with five other electric utilities. With the forming of the consortium, the utilities entered into Phase I: the research and curriculum design aspects of the project. The National Center at OSU became the research and development arm of the consortium.

In November 1986, a DACUM job analysis workshop was held, involving two representatives from each utility. The result of the four-day workshop was a Skills Inventory, which was distributed to 10 representative instructors from each member utility, plus representative instructors at seven other utilities as a means of obtaining national task verification data. Phase I ended with the conceptualization of 18 instructional modules based on the identified, verified, and clustered tasks.

Phase II development of an initial set of modules--began in September 1987. During 1987 and 1988, eleven modules were developed and made available to the member utilities. During late 1988, the National Center at OSU changed its name to the Center on Education and Training for Employment.

A word about the procedures used in the development phase is in order. All too often, the tendency is to hire a contractor and then, with minimal review of the work, wait for the final product. The training specialists and instructors at Virginia Power have played an integral part in the module development work. They, as well as other member utility reviewers, have provided substantial resource materials, as well as thorough reviews of the draft modules, including comments and recommendations for module enhancement.

Phase III began in January 1989 and involves the completion of the remaining seven modules. Training on simulator instructor skills is being provided by the utilities through the use of materials developed by subject-matter experts, the Southeastern States Nuclear Training Association .

Integration of the Modules into the Existing Training Program

The integration of the newly developed modules is already underway for Virginia Power instructors. Even prior to distribution of the final products, the drafts were being used to augment on-site instructor training, as well as the training of staff in the corporate offices.

The modules represent exceptionally fine work on the part of the Center staff and consequently lend themselves to a myriad of uses by the instructors and the training specialists. Although all of the uses have not been determined as yet, the modules can be and are being used in several ways, including:

- o Individualized, guided study materials
- o Primary training materials for the Advanced Training Program
- o Focal points for continuing training sessions or remediation

A brief description of the intended use of the modules, as well as a curriculum model, follow.

Individualized, guided study materials. The modules lend themselves to guided self-study for instructors needing specific, immediate information about a particular topic. In cases such as these, the instructor and training specialist will work out a plan to address a particular skill or set of skills. The instructor will then work on his/her own, completing review exercises and self-checks. The instructor is able to meet with the training specialist at any time for guidance and assistance.

Advanced Training Program. One note about the overall integration of the modules into the program. Instructors cannot and do not develop or perfect instructional skills in isolation by simply reading a book and doing exercises. Instructional skills are developed by performing the task and by watching other skilled instructors conducting training. The modules are not intended to replace the interaction and contact of the instructor with the training specialist. Each instructor always has the training specialist available to answer questions, give direction, and assist him/her in progressing through the program.

When beginning the Advanced Training Program (ATP), the instructor works with the training specialist to develop a training plan. The plan outlines when the instructor will complete different ATP units. The modules will be the primary instructional resource for each unit. The modules will provide instructional content about a particular skill or set of skills, such as developing performance objectives. Check-offs, self-checks, and related exercises are part of the completion of a given module.

These check-offs, self-checks, related exercises, and final Instructor Performance Measures (IPMs) replace Virginia Power's existing evaluation instruments for determining instructor proficiency.

When the instructor is prepared for the final evaluation--the IPM checkoff--a knowledge evaluation relating to the module is first conducted. If the instructor responds correctly to the cognitive evaluation, the training specialist then has the instructor demonstrate his or her proficiency on the identified skills, using the IPM as a guide. If the instructor does not complete the IPM successfully, the training specialist uses the module as a guide in developing an individual educational plan, which details areas in the module that the instructor needs to study again. The IPM that is used is the one developed for that particular module, making the development of an individual educational plan more compatible with the materials the instructor has readily available.

The program is performance-based. Using the modules, completing the self-checks, and demonstrating proficiency on the module tasks are steps to mastery. The modules support ATP units. A curriculum model indicates the point at which each module will be a fundamental part in the process for the instructors (see model which follows).

Continuing training. In continuing training, the modules will provide the focal point for special training sessions. If, after classroom observations and trainee feedback, several instructors are clearly weak in the performance of a given instructional skill, the training specialist can hold a mini-workshop to address the weakness. The module then becomes the focal point for the special training and provides the foundation for reinforcing instructional skills.

## Summary

The modules developed through the consortium effort will provide the fundamental resources to assist instructors through the instructor training program. They replace existing supplementary materials and give more depth of instruction to the instructors on all phases of training, from the design of a program, to the development of materials, to the conduct of training classes, and to the evaluation of instructor performance. Finally, the module content can be easily modified to meet Virginia Power's needs to redesign or update the materials as time goes on.



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Proposed Curriculum Model - Advanced Training Program

ITCP 1 Conduct Job and Task Analysis (Module A-2) [1]
ITCP 2 Determine Training Needs (Module A-1) [1]
ITCP 3 Design Instruction (Module B-1) [1]
ITCP 4 Develop Learning Objectives (Module B-1) [1]
ITCP 5 Develop Lesson Plans (Module C-1) [1]

Instructional Development Workshop

Implementation of Instruction

ITCP 6 Present Formal Classroom Instruction (Module D-1) [1]

Instructional Techniques Workshop

ITCP 7 Conduct Lab/Shop Exercises (Module D-3) [1]
ITCP 8 Simulator Training [3]

Simulator Instructor Training Workshop

ITCP 9 On-the-Job Training (Module D-6) [2]

On-the-Job Workshop

ITCP 10 Conduct Demonstrations (Module D-2) [1]
ITCP 11 Conduct Tours and Walk-Throughs (Module D-5) [2]
ITCP 12 Conduct Independent Instruction (Module D-7) [2]

Instructional Media

ITCP 13 Provide Print Instructional Materials (Module C-1) [2]
ITCP 14 Provide Visual and Audiovisual Aids (Module C-3) [2]

Instructional Media Workshop

Evaluation

ITCP 15 Evaluate Trainee Performance: Knowledge (Module E-1) [1]
ITCP 16 Evaluate Trainee Performance: Skills (Module E-2) [1]
ITCP 17 Determine Test Quality (Module E-3) [1]

Testing Workshop

ITCP 18 Evaluate Instructional Effectiveness (Module E-4) [2]

1 Modules that have been completed in Phase II
2 Modules to be completed in Phase III. Additionally, a module on conducting mock-ups will be developed.
3 Instructor Guide for 40 hour course completed by SESNTA
4 ITCP - Instructor Training and Certification Program

ATTACHMENT F

Florida Power Corporation
Nuclear Operations Training
8200 West Seven Rivers Drive
Crystal River, FL 32629
January 18, 1989

Dr. Robert E. Norton
Ohio State University
1960 Kenny Road
Columbus, OH 43210-1090

Dear Bob:

This past November we began incorporating the modules developed by the Consortium into our Instructor Training Program. We started with Module D-1, Present Formal Classroom Instruction. The delivery method we selected for this module combined lecture with self-paced instruction and was well received by our instructors. Our future plans for the modules developed by the Consortium are to make them the core of our instructor training program. Combined with our procedures, these modules satisfy all of the INPO guidelines and cover the topics our instructors need in order to become well-versed in the performance-based training methodology. Over the next two-year period, our instructors will complete the entire eighteen modules. This will be done mostly by self-paced instruction, combined with lecture.

The flexibility afforded by these modules has allowed us to design a program that meets the instructional training needs of our staff, without adversely affecting their other training duties. This flexibility is further accentuated by our capability of modifying the material to make it as site-specific as we desire. We have converted the SAMNA disks, which you sent us with each module, to Word Perfect. This conversion was relatively clean and enables us to easily modify the material to meet our own specific needs.

The essence of this letter is to let you and your staff know that we are completely satisfied with the modules we have received and that we look forward to receiving future ones. This has been a team effort from the beginning, and I think that fact is evident in the quality of the material.

Sincerely,

David L. Watson
Academic Specialist
Florida Power Corporation

# MANAGEMENT OF TRAINING
# "COUNTING BEANS OR DEMONSTRATING RESULTS"

W. L. Mooney III

ABSTRACT

A well-planned, well-staffed and well-housed training program may not function effectively. Program evaluators commissioned to assess the quality of a training program will inquire into its day-to-day performance only, with no bottom line assessment. Businesses evaluate their performance by counting cash receipts at the end of the day and by taking inventory of stock at regular intervals. Training Managers need measures of activity similar to commercial firms. The problem, of course, is that the ultimate product of training programs, safe, effective and efficient job incumbents, is not nearly as objectively measured or as concrete as store inventories.

With the onset of a new DOE order on training design and development methodology, a new audience for a relatively old process will inevitably fall victim to the "slam-bang" effect. Training personnel are generally enthusiastic and confident about the potential effects of their program. Because they are enthusiastic and put forth a maximum effort, they and their management expect the new program to have dramatic results - a "slam-bang" effect. As a result, the management of training programs is likely to become an arduous and disappointing task if the manager has no way of showing results. Currently, most of the focus at DOE contractor facilities is on preparation for and ultimate compliance with the DOE order on accreditation with little concern for the method or methods by which we will determine its ultimate success or failure. Methods such as program evaluation, goal attainment scaling and multi-attribute utility (MAUT) analysis may provide training management the information to make decisions to improve training quality and demonstrate results.

These methods will be discussed in detail and presented as a management tool to complement the accreditation activities at DOE contractor facilities.

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Under Contract No. DE-AC05-840R21400

Training Systems Development (TSD), and all other approaches to systematic development of training programs are often received reluctantly only later to become the object of management's great expectations. Quite often, these expectations are beyond the scope of the TSD process and the training department's mission. The formal adoption of a training development process is often undertaken solely for the purpose of compliance or to satisfy a directive, with little consideration or planning to establ criteria, goals or units of measure to gauge program success.

The well-known models of TSD, ISD, and SAT clearly call for distinct phases by which to analyze program requirements, design program content, develop program material, implement the program and evaluate program results. The focus of this paper is evaluation and the methods by which program evaluation can be used by management to demonstrate results. There are many reasons for conducting program evaluations. Among these reasons are:

1. Fulfillment of accreditation requirements
2. Accounting for funds
3. Answering requests for information
4. Making administrative decisions
5. Assisting staff in program development
6. Learning about unintended effects

Since training and the requirement of accreditation are costly propositions, it is imperative that management show results for the expenditure of funds. The objectives and criteria by which quality accredited training programs are judged are quite often interpreted to be only physical evidence, such as task lists, lesson plans, instructor certificates, and student records. Numbers of such items soon become the focal point of a training department's activities and each staff member assumes the role of bean counter to assure an adequate quantity of each item required for accreditation. Faced with a myriad of program components, the manager may have difficulty segregating these elements and establishing priorities to accomplish program goals.

A technique derived from decision theory, Multi-Attribute Utility (MAUT) Method (Edwards, Guttentag 1975), may be useful to management for program planning and establishing program goals/evaluation criteria.

The basic purpose of the MAUT method is to disaggregate a decision or to separate the elements of a complicated decision and evaluate each element separately. Such an approach will, in many cases, narrow the focus to the exact area of program weakness and more clearly delineate specific results to be accomplished for a particular program.

A simplified version of the MAUT Method might be described as follows:

1. Decide on the appropriate criteria on which to base a decision. (With respect to accreditation these criteria are already identified in the DOE Training Accreditation Program Manual under each major objective.)

2. Assign a weight to each criterion to reflect its relative importance. (Weighting of specific criteria for a particular program may differ according to the state of the program with regard to accreditation.)

3. Evaluate each program on the basis of each criterion. (This step equates to the self-evaluation process.)

4. Combine the evaluations made on the basis of individual criteria into an overall judgment. (Programs should be prioritized according to those needing the most work to attain accreditation.)

The use of the MAUT Method can best be shown in the development of a training program accreditation plan. As shown in slide #1 (Weighted Attribute System), each program is individually compared to each major accreditation objective and its subsequent criteria. Such comparison should normally be performed by a panel of individuals - usually managers responsible for the training function. Each member of the panel should assign a weight to each program attribute required for accreditation based on the program's present state. The weight of the program attribute should reflect strength or weakness of the program with respect to that particular characteristic. The sum of all rating for each attribute should then be averaged and an overall score assigned to the attribute.

After all attributes have been rated, program characteristics should be prioritized according to program weaknesses and plans put into place to rectify problem areas within given constraints such as manpower, budget and time.

Once work plans and goals have been established, tracking mechanisms and documentation of goal attainment should be utilized by management to monitor and aduet work plans. Goal Attainment Scaling (GAS) (Lund/and Kiresuk 1979), goes beyond the planning stage to permit measurement of the degree of attainment of the outcomes desired for a certain program. After program goals have been established, GAS requires that each goal be weighted by its relative importance. This weighting process is identical to the method suggested for assigning weights for use with the MAUT model and essentially establishes goal prioritization. The use of a weighting system to identify the relative importance of training goals allows the manager to assess the degree of goal attainment based on well-defined criteria for each goal/objective. Scaling methods may be used to assign numerical values to levels of accomplishment for each goal. For instance, a particular training program may require twenty lesson plans to be developed within a six-month period. If material development goes as planned, the training manager can expect twenty lesson plans, conversely, the most unfavorable outcome would be the total lack of lesson plans. The description of the most favorable and most unfavorable outcomes for each goal then become the basis of a Goal Attainment Grid, as shown in slide #2. The focus of goal attainment scaling should be the properties or observable aspects of the training system and not the system itself. With goals established and criteria in place to scale the level of goal attainment, the manager has a mechanism for tracking the training system's overall adequacy. The degree of goal attainment should be tracked on a periodic basis and documented with objective evidence such as milestone accomplishments which lead to the next level of program readiness for accreditation. Milestone accomplishments or failure to meet a milestone, may prompt reprioritization and/or rescheduling of the manager's work plan until all goals are accomplished for each particular program or budget and time restraints require reprioritization.

The final step in demonstrating training programs results should be that of summative evaluation. Summative evaluation should be performed on a regular basis (usually at the end of a program) and reflect the accomplishment of goals established at the onset of the program. Those goals which were not attained should also be noted and revisited to identify constraints on goal attainment. In addition to goals established for the training program itself, feedback information collected from various sources should be compiled and analyzed to determine necessary modifications to program content, delivery methods, and general impact on the trainee's job performance.

Data collected during program evaluation should reflect factual information based on documented occurrences. This information may be statistical in nature or subjective opinions submitted from program participants, supervisors and management. However, any inferences or conclusions made should be substantiated and documented. Items such as accidents, safety violations, unusual occurrences, production data, performance appraisals, etc. are excellent sources of information from which to draw conclusions regarding overall training program effectiveness. These items should be monitored continuously by the training manager as part of the program management process. Tracking these measures of training activity is analogous to the businessman performing activities such as counting cash receipts or taking inventories of stock. Over a period of time, such planning, documentation of achievement and evaluation will yield a history of training activity to which a dollar figure may be attached. As in Training System Development methodology, consistency of approach and the use of well-defined criteria are the key factors to consider when attempting to demonstrate training results.

For a more detailed discussion of Multi-Attribute Utility Analysis, Goal Attainment Scaling, as well as an excellent overview of program evaluation methodologies, the following texts are recommended:

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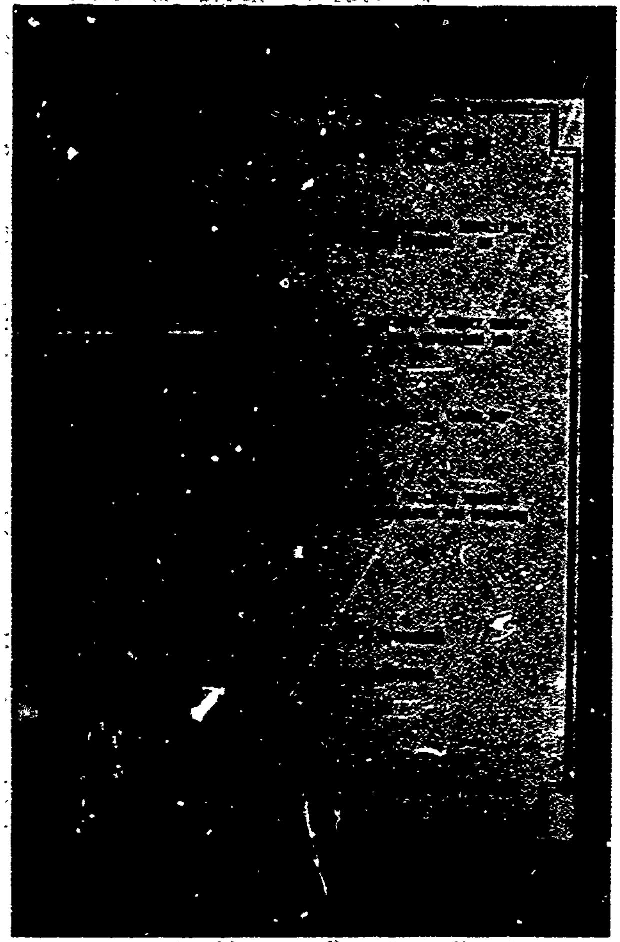
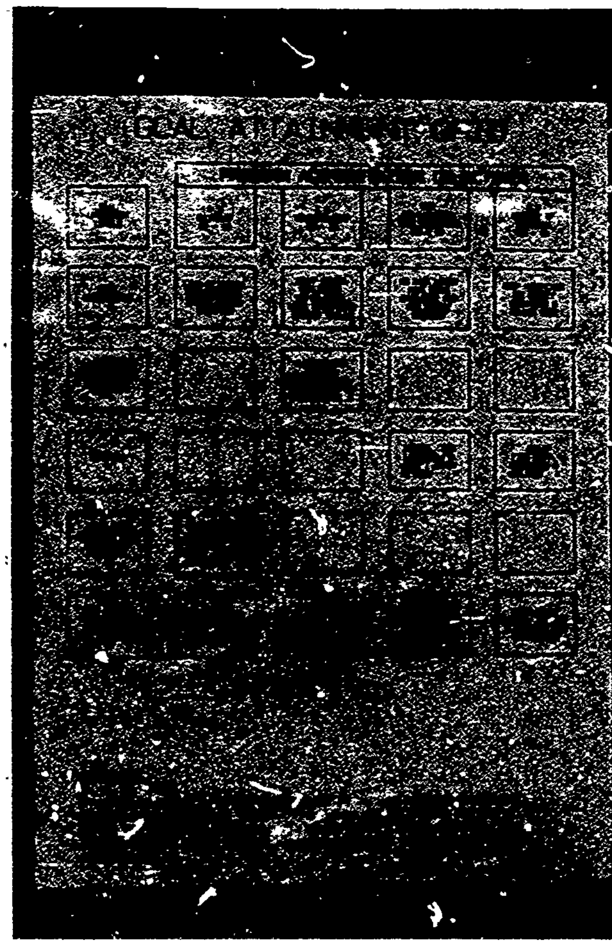


*Slide 1*



*Slide 2*

# USE OF STATISTICS TO MONITOR QUALITY IN TRAINING

Francis J. Helin
Roberta F. Gardner

ABSTRACT

The present method of examining quality in nuclear training is primarily through the use of periodic audits, usually externally done. But, we can control and monitor the quality of our training programs at a much lower cost and with greater efficiency by using other methods. By initiating Statistical Quality Control (SQC) methods, the data from individual exams can be used to identify strengths/weaknesses in each exam item and in the exam as a whole as well as generic weaknesses in the knowledge level of the population being examined. As an example, a brief review of a regression analysis performed at Vermont Yankee will be presented. This analysis was performed in order to examine how well our licensed operator training program actually prepared our license candidates for the NRC exam. In order for the results of such a statistical analysis to actually be useful, a commitment to act on these results must come from the highest level of management. This upper level of management must realize that quality is quantitative and that statistics is only a means to that end (of improving quality). Many companies have instituted slogans as a means of improving quality. Slogans do not increase quality; only an on-going commitment to constant improvement will.

## INTRODUCTION

Quality. It is understood that quality is a measure of excellence. To achieve high quality a well-defined standard must be used as the yardstick to measure the level of quality that one has achieved. In order for quality to mean something, it must be quantifiable. This is where statistics come into the picture. A statistic or set of statistics can provide a quantifiable measure of quality. Statistical Quality Control (SQC), introduced by W. Edwards Deming to Japan following World War II, is a major reason Japanese business has been so successful. American manufacturing companies began using SQC in the 1970's. Florida Power and Light has recently applied for the Deming Award, the most prestigious quality award given, as a result of their total quality control efforts. The nuclear industry must come to the realization that quality is quantifiable, not the latest management buzz word. To ensure training programs are of the highest quality, statistics must be used and upper management must make a commitment to respond appropriately to the statistical results. As we have seen in many companies, lip service and slogans do not increase quality.

The present method of examining quality in nuclear training is periodic audits. Although these audits certainly have a function in ensuring that objectives are covered in lesson plans, NRC regulations and INPO recommendations are met; they only scratch the surface in determining if quality in training exists. The most picture perfect training program that fails to get people licensed or fails to adequately prepare them for their job in the Control Room cannot be considered quality training.

At Vermont Yankee, we have attempted to identify some statistics and to determine how well our initial licensed candidates are prepared for their NRC examination. In our study, both RO and SRO candidates were grouped together. This was done to increase the sample size and to decrease the standard deviation. Separate SRO and RO candidates could have just as easily been looked at, as well as other statistics such as post-training survey results, etc.

The study consisted of looking at two separate statistics: the weekly quiz average of the license candidates and the results of an independent audit exam. The audit exam is an independently prepared trial NRC-type exam: the exam format and content is designed to be similar to the NRC licensing exam. At Vermont Yankee the minimum passing grade on a quiz is 80%. The minimum acceptable grade for the audit exam is 70% in each of the four sections with an 80% overall average. These are the same standards used for the NRC written exam.

A simple regression analysis was done comparing these two statistics with actual NRC exam results. The basic question being asked was, "If a student gets an 80% in Vermont Yankee's program, how well prepared is he for the NRC exam?". When the results were examined, the data yielded many interesting insights into our licensed operator training program.

## COMPILING THE DATA

When the data from Table 1 was plotted on histograms, the results indicated that the scores from the NRC exams generally followed a somewhat normal distribution (Figure 1). The histogram of Vermont Yankee's weekly exams (Figure 2) showed the distribution to be skewed from normal with a clear peak at 87.

This posed many interesting questions that are still being discussed. One question which resulted from this analysis was whether instructors were tailoring the exams to the abilities of the students. If instructors were writing exams, even subconciously, that would result in a average grade in the mid-eighties, is this really consistent with what is best for the students and the program. These questions have not been resolved; however, this analysis did serve to increase the awareness of the instructors in relation to preparing test items. In addition, the instructors were given some specialized training in test item development and test types.

Instructors must be made aware that exams, of the type given to license candidates, are designed to test a minimum competency level. Nice distributions with peaks in the mid-eighties are not what we should be striving for; those types of distributions are the aim of aptitude tests. If no one in the class possesses the required minimum competencies, then the test results must show this.

## THE ANALYSIS

A simple linear regression was conducted (Figure 3) with the following objective: If a student has a weekly test average of 80%, what is he expected to score on his NRC exam, based on past history. Using a 95% confidence interval, the results showed that with a weekly test average of 80%, the student should receive a mean score of 81% on the NRC exam. The 95% confidence interval ranges are 75% and 85%. This showed that the level of difficulty of our test items was about equal to that of the NRC examination. More simply, if a student passes Vermont Yankee's license program with an 80% average, he has about a 50-50 chance of success on the NRC exam. This is clearly not the result one would want.

Ideally, a person who is successful in the license program should be assured of passing the NRC exam. But, in order for this to occur in reality, we must shift the confidence interval upward such that a person who averages 80% on his weekly exams will have a higher probability of passing the NRC exam. This is the problem Vermont Yankee is now attempting to solve. One suggestion that has been made is to raise the minimum acceptable standard on weekly tests to 85%. This would significantly raise the expectancy that the students will pass the NRC exam. However, this is not the ideal solution in the minds of many of the instructors who recommend that we raise the difficulty level of the test items while ensuring that these items remain within the scope of the student objectives as well as the NRC's knowledge and abilities catalog. As you can imagine, identifying and implementing the best solution for this problem is not an easy task!

## CONCLUSION

Although the license training program at Vermont Yankee has a strong reputation and has received high grades from both the NRC and INPO, one can see from a simple statistical analysis that there is still room for improvement. This is the true benefit in the use of Statistical Quality Control.

Vermont Yankee has identified an area in which we can improve, and as a result, can now take steps to improve the quality of the training programs. This information would not be available if audits were the sole means of program evaluation and effectiveness.

The people who can best recognize the need and take the necessary steps to increase the quality of the training program are those who are most closely associated with that program. These people, armed with the right statistical information and management commitment, will be able to continually improve the quality of the training materials. Thus, it becomes clear that quantitative measures of quality provide concrete data which, in turn, provides a means to maintain and improve program quality; whereas, slogans, being more abstract and open to individual interpretation, do not identify specific areas where improvement can be beneficial.

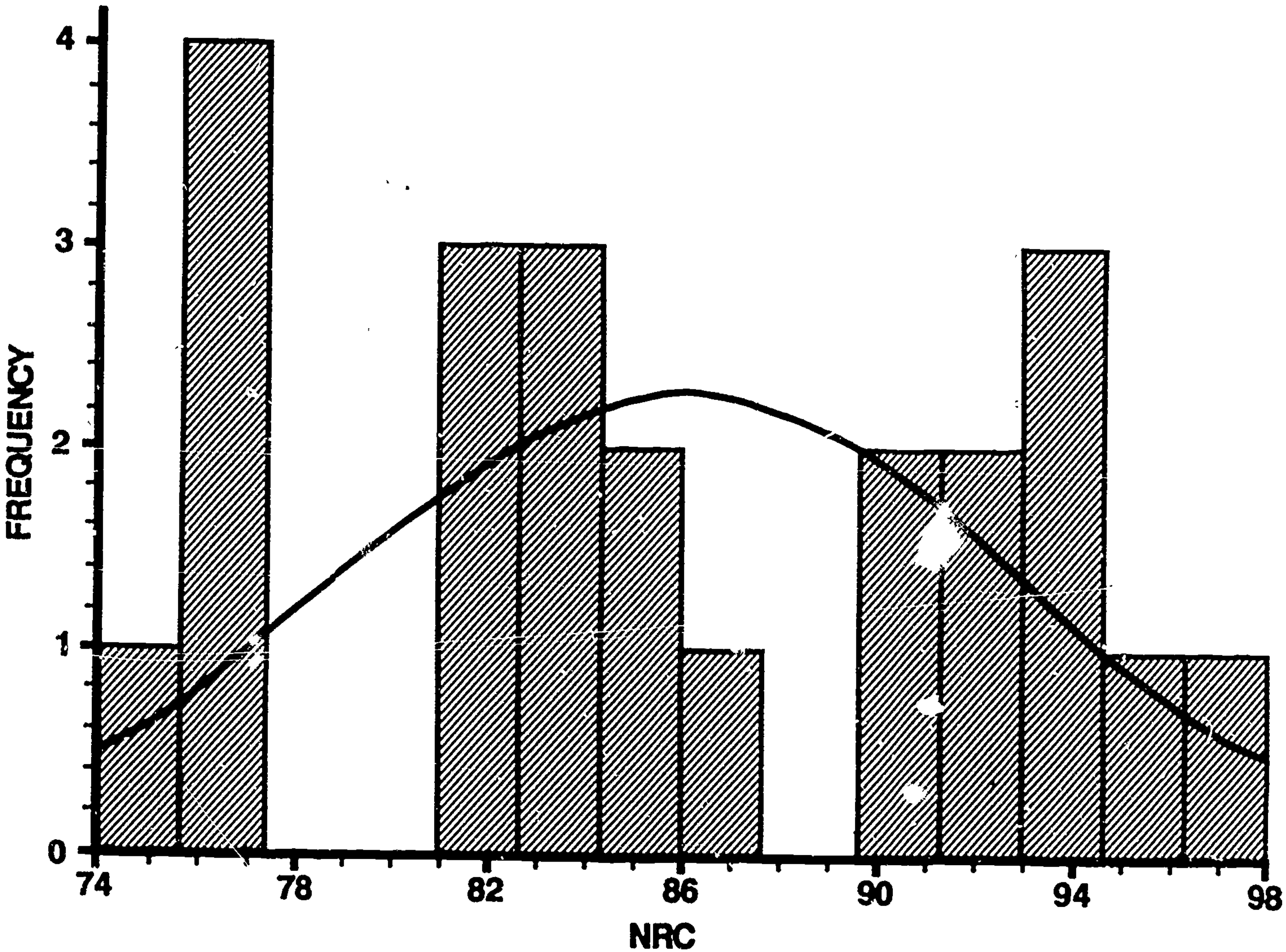
Table 1, Data Collection

| $i$ | $X_i$ | $Y_i$ | $(X_i-\bar{X})^2$ | $(Y_i-\bar{Y})$ | $(Y_i-\bar{Y})^2$ | $(X_i-\bar{X})$ | $\lvert X_i Y_i \rvert$ | $\hat{X}_i^2$ | $\hat{Y}_i$ | $(Y_i-\hat{Y})$ |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 87.4 | 90.6 | 0.81 | 3.20 | 10.24 | 0.90 | 7918.44 | 7638.76 | 88.3 | 5.29 |
| 2 | 88.1 | 93.1 | 2.56 | 5.70 | 32.49 | 1.60 | 8202.11 | 7761.61 | 89.9 | 17.64 |
| 3 | 87.8 | 92.5 | 1.69 | 5.10 | 26.01 | 1.30 | 8121.50 | 7708.84 | 88.6 | 15.21 |
| 4 | 88.0 | 91.7 | 2.25 | 4.30 | 18.49 | 1.50 | 8069.60 | 7744.00 | 88.8 | 8.41 |
| 5 | 87.4 | 90.6 | 0.81 | 3.20 | 10.24 | 0.90 | 7918.44 | 7638.76 | 88.3 | 5.29 |
| 6 | 84.2 | 93.4 | 5.29 | 6.00 | 36.00 | -2.30 | 7864.28 | 7089.64 | 85.2 | 67.24 |
| 7 | 87.7 | 93.7 | 1.44 | 6.30 | 39.69 | 1.20 | 8217.49 | 7691.29 | 88.6 | 26.01 |
| 8 | 88.3 | 87.6 | 3.24 | 0.20 | 0.04 | 1.80 | 7735.08 | 7796.89 | 89.1 | 2.25 |
| 9 | 91.6 | 97.1 | 26.01 | 9.70 | 94.09 | 5.10 | 8894.36 | 8390.56 | 92.3 | 23.04 |
| 10 | 81.7 | 81.8 | 23.04 | - 5.60 | 31.36 | -4.80 | 6683.06 | 6674.89 | 82.8 | 1.00 |
| 11 | 79.5 | 76.9 | 49.00 | -10.50 | 110.25 | -6.90 | 6113.55 | 6320.25 | 80.7 | 14.44 |
| 12 | 86.7 | 95.0 | 0.04 | - 7.60 | 57.76 | 0.20 | 8236.50 | 7516.89 | 87.6 | 54.76 |
| 13 | 85.6 | 85.4 | 0.81 | - 2.00 | 4.00 | -0.90 | 7310.24 | 7327.36 | 86.5 | 1.21 |
| 14 | 83.7 | 81.5 | 3.96 | - 5.90 | 34.81 | -2.80 | 6821.55 | 7005.69 | 84.7 | 10.24 |
| 15 | 86.3 | 74.5 | 0.04 | -12.90 | 166.41 | -0.20 | 6429.35 | 7447.69 | 87.2 | 161.29 |
| 16 | 85.5 | 83.7 | 1.00 | - 3.70 | 13.69 | -1.00 | 7156.35 | 7310.25 | 86.4 | 7.29 |
| 17 | 91.5 | 76.9 | 25.00 | -10.50 | 110.25 | 5.00 | 7036.35 | 8372.25 | 92.2 | 234.09 |
| SUM | 1471 | 1486 | 146.99 | | 795.82 | | 128728.25 | 127435.62 | | 654.70 |
| MEAN | 86.5 | 87.4 | | | | | | | | |

$X_i$ = Average of Weekly Exam Scores

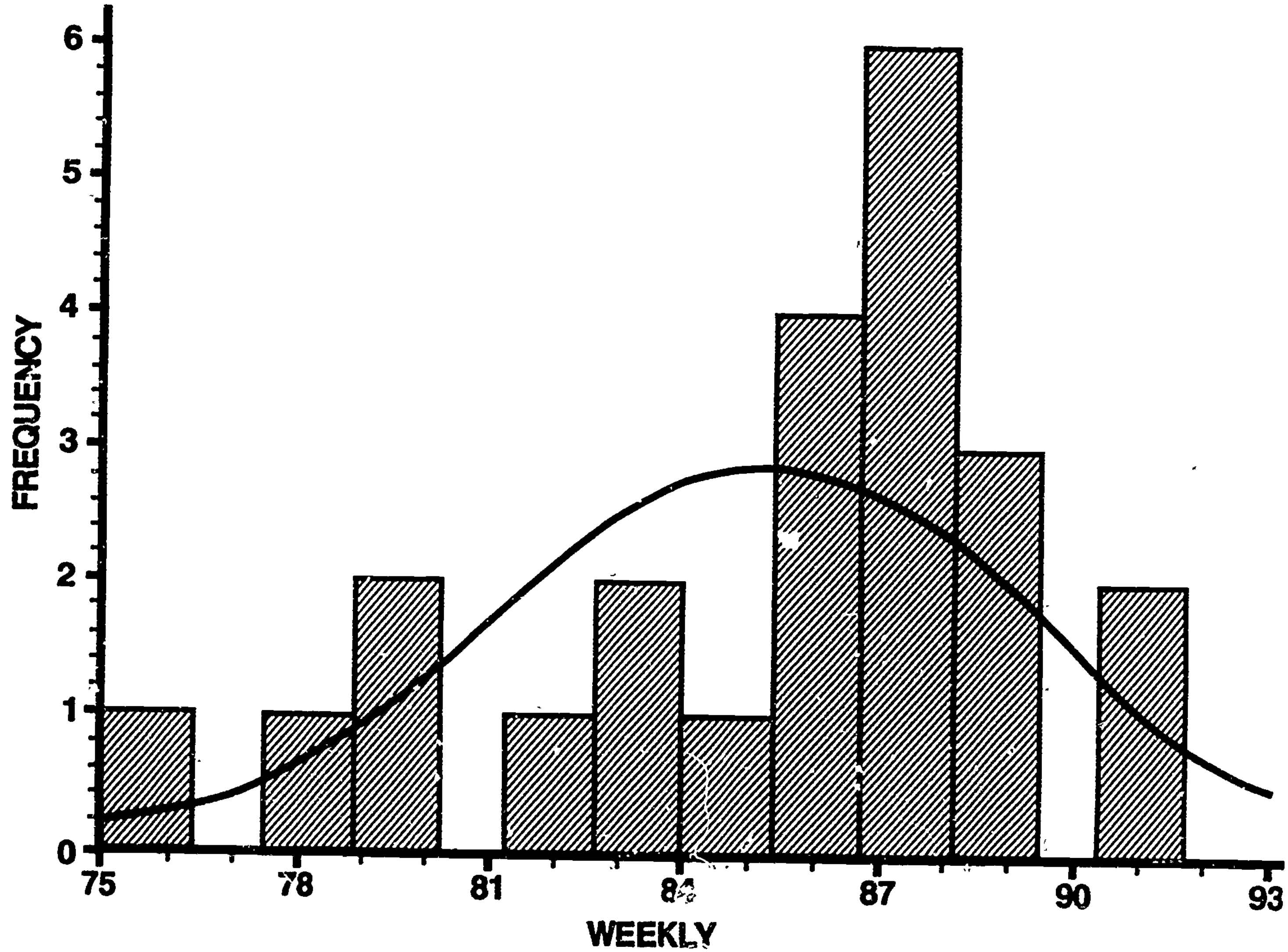
$Y_i$ = NRC Exam Score

FIGURE LIST



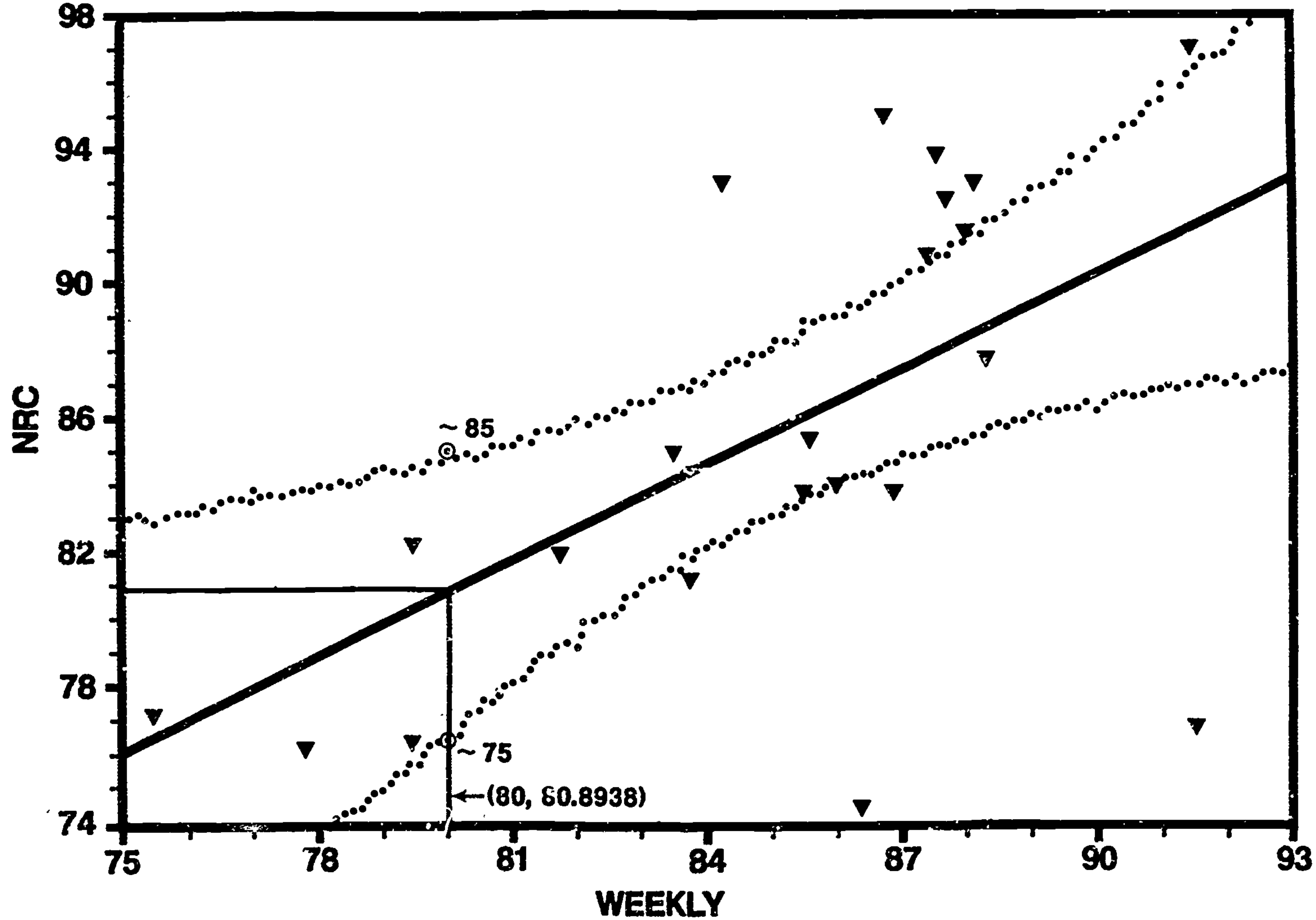

Frequency Histogram: NRC Exam
FIGURE 1

V-A.4.10




Frequency Histogram: Weekly Quizzes
FIGURE 2

V-A.4.12




Regression of NRC Exam on Weekly Quizzes
FIGURE 3

# FEASIBILITY OF QUANTITATIVE PERFORMANCE MEASURES FOR EVALUATING NUCLEAR POWER PLANT OPERATORS*

Richard J. Carter
Edward M. Connelly
Paul A. Krois

## ABSTRACT

A more valid measure of team performance in nuclear power plants is needed. A study is described which was oriented towards evaluating the feasibility of synthesizing performance measures by deriving measures for crews responding to an off-normal event in a full-scope simulator. The thesis was that performance assessment is based on the subjective judgment of training instructors. The procedure used to synthesize the performance measure consisted of: identification of the factors believed to be important to performance assessment, development of example crew performances and ratings on each be instructors, and derivation of the measure by capturing the instructors' assessment rules. A performance measure was derived which explains nearly all of the variance of the instructors' team performance assessments. There is reason to believe that this method of synthesizing measures can be applied to other events.

## INTRODUCTION

The assessment of crew performance in nuclear power plant (NPP) operations usually is accomplished by examining team performance on individual tasks, as well as on the overall exercise. For task performance assessments, relatively global team criteria such as task performance time or number of errors generally are compared to a

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checklist of previously established reference tasks. Such comparisons lead to the specification of the adequacy or inadequacy of crew performance at the task level. With respect to the assessment of team performance on the overall exercise level, specific aggregates of the task criteria typically are utilized. These, in turn, lead to a specification of adequacy or inadequacy of crew performance on the exercise level. Several concerns/problems exist with respect to such performance evaluation attempts. First, there is the concern that the task performance criteria and exercise performance criteria are not valid measures of team performance. Second, there seems to be no evidence in the literature that supports the aggregation of task performance criteria to obtain overall exercise performance criteria. Third, requirements to specify either adequate or inadequate performance dichotomizes the crew performance assessment procedure. Such a treatment tends to ignore important crew performance information concerning the degree to which adequacy or inadequacy are achieved. Because of these and other concerns related to the adequacy of current team performance evaluation methods, there appears to exist a need to define a more val. l measure of crew performance.

Oak Ridge National Laboratory (ORNL) conducted a study to evaluate the feasibility of synthesizing performance measures for NPP teams by deriving measures for crews responding to a test problem in a NPP simulator. This paper describes the study and the results therefrom.

## METHOD OF SYNTHESIZING PERFORMANCE MEASURES

CRNL defines a team performance measure as a mathematical function of system variables that permits the quantitative evaluation of overall system (team and plant) performance as the crew responds to an off-normal event. The term performance measure is not used to mean data collection (i.e., the recording of values for plant or crew variables); it is not used to denote the performance scores obtained when assessing team performance; and it is not used to refer to any decisions made after obtaining crew performance scores. Rather, a team performance measure is an analytical statement that incorporates the tradeoffs among the system variables that must be considered in order to assess total crew performance.

What is the source of performance assessment information on team performance; that is, what is the source one can rely on in evaluating crew performance? The study's thesis was that performance assessment is ultimately based on the subjective judgment of the person (or persons) who is accepted as the authority/expert for team performance assessment. This person is assumed to be a training instructor evaluating crew performance when the team is operating the plant (or NPP simulator) in an important exercise such as a certification exam.

The subjective form of an instructor's performance assessment is effectively applied when the instructor evaluates observed performance. To make the performance assessment, the instructor typically makes explicit judgments regarding the relative importance of various crew and system factors to team performance. While making these judgments, the instructor may use quantified variables describing system states, such as: water level, flow rates, and temperatures, and also factors that are not easily quantified, such as: the appropriateness of crew communication, te efficiency in monitoring system parameters, and crew ability to diagnose plant conditions. Thus, training instructors may use their judgment at two levels during the performance assessment process. At one level, the instructors may estimate the value of the factors that are not readily quantified. Then, at the second level, the instructors may use those estimated values along with the values of quantified variables to assess overall crew performance.

While the subjective form of the instructors' performance assessment judgment may serve the instructors well for the evaluation of team activity that the instructors can personally observe, its subjective form makes it difficult for anyone else to similarly evaluate crew performance. Since the problem is the subjective form of the assessment, not the performance assessment itself, it may be beneficial to consider synthesizing a quantitative equivalent to the instructors' performance judgment.

Since instructors are the source of team performance information, the question of how to extract that information must be addressed. The issue is: Should the instructors be asked to write the rules they use to evaluate crew performance or should the instructor's performance preferences be captured as the instructor evaluates observed crew performances? Research on the extraction of information from experts indicates that while experts can successfully demonstrate their judgement ability when working with observed performances, they may not be fully aware of all the factors and tradeoffs they use to produce their judgments. Consequently, the rules that instructors say they use to assess performances should not be relied on as definitive. However, one can ask instructors to provide the rules they use to assess team performance and employ them as a baseline for the performance measure synthesis.

According to the study's thesis, reliable information on crew performance assessment may be obtained by asking instructors to observe and assess team performance. The instructor can be relied on to compare observed performances and indicate a preference for one over another. If one can present descriptions of performances to instructors and have the instructors score them, or at least order them according to performance preference, then the ordering must imply a rule. If that rule can be captured in a quantified form, the mathematical equivalent of the instructor's subjective judgment would be available.

When considering performance assessment of any system, there may be a number of existing measures that one can suggest as candidate performance measures. The question then is: Do these existing performance measures provide the correct assessment of performance? There is a reliable way of comparing any existing measure to the correct measure even though one does not know the correct measure. The key idea is to recognize that the basis for assessment of performance quality is the subjective judgment of an individual (or group of individuals) who is accepted as an authority in assessing performance. The individual or group examines descriptions of possible performances (called performance demonstrations) and concludes that one performance demonstration is preferred over another which, in turn, is preferred over a third, and so forth. This ordering, according to performance preference, defines the performance discrimination task of the correct performance measure. Thus, if an existing measure discriminates performance demonstrations the same way as the experts, there is no reason to reject the measure. On the other hand, if the measure does not discriminate performance as did the experts, it must be rejected and a correct measure synthesized.

## PROCEDURE FOR SYNTHESIZING THE PERFORMANCE MEASURE

The procedure used for synthesizing the performance measure in the feasibility study was comprised of the following steps:

1. Identify the factors believed to be important to performance assessment.

2. Develop examples of crew performances and have instructors rate performance on each.

3. Derive the performance measure by capturing the instructors' assessment rules.

### Identification of Factors Believed to Be Important to Performance Assessment

Method

Ten Tennessee Valley Authority (TVA) training instructors provided opinions as to what factors should be considered in assessing crew performance. This information was obtained through the use of a questionnaire. The questionnaire consisted of four items, three open-ended and one closed-ended. Question #1 asked for a rating, on a seven-point scale, of the crew as a whole. The instructor also rated the individual crew members, i.e, senior reactor operator, reactor operator, balance-of-plant operator, and shift technical advisor, if applicable. Question #2 was directed at obtaining the factors the instructor believed to be important when assessing crew performance. Question #3 asked for the specific crew actions or behaviors that were assessed as especially good and significantly influenced the instructor performance assessment. Question #4 requested the instructor to provide for the crew those actions or behaviors that could have been improved.

The questionnaires were completed while the training instructors were evaluating twenty-one Watts Bar and Sequoyah NPP crews operating in the TVA simulator located in Chattanooga, Tennessee. The crews were participating in certification and requalification training classes. The situations which were being simulated consisted of five off-normal events (turbine loading, turbine trip, loss of all feedwater, steam generator tube rupture (SGTR), and main steam line break/SGTR/loss of a refuel water storage tank.

Each instructor evaluated at least one exercise (and completed one questionnaire). Training instructor assignment was not a controlled part of the study, so there was variation in the number of exercises evaluated by each instructor. One instructor evaluated twenty training exercises, while others only three or four. The median number of exercises evaluated (and questionnaire forms completed) by an instructor was eight.

Results

A major difficulty was encountered during the data analysis. It dealt with the instructors use of a variety of different, but apparently synonymous, words to describe the same thing. To limit the effects of an analysis judgment when interpreting (possibly erroneously) the intended meaning of a term, the first data analysis of the completed questionnaires was a sorting of the responses by: crew plant (Watts Bar and Sequoyah), off-normal event (A - E), question, and crew rating (crew rating was classified into three levels - 3.5 points or less, 3.5 to 5.5 points, and 5.5 or more points). An example is presented in Table 1.

The second analysis consisted of investigating the responses to question #2 (factors believed to be important when assessing crew

Table 1. An Example Sorting of the Questionnaire Responses

Plant: Sequoyah, Event: Turbine Loading, Rating: 3.5 to 5.5

| Question #3<br>Task Performed<br>Well | Question #4<br>Task Needing<br>Improvement | Question #1<br>Crew/Average<br>Rating |
|---|---|---|
| SRO - exceptional knowledge of electric, RO - continuously viewed board | Even though SRO knew all about it, procedures (GOI) should have been used more in putting generator on line | 5.0/5.4 |
| Use of instructions very good, communication of crew good, start-up accomplished with a minimum of problems, such as no low level alarms on S/G's | Some things were done by crew members and were not known by others in group, such as transferred station service | 5.0/5.0 |
| Communication of group very good | Instructions could have followed more closely, some actions were out of step | 5.0/5.0 |
| Good communication in all areas, smooth operation | None - good job done by all | 5.0/5.0 |
| RO demonstrated exceptional ability in working with BOP | Supervisor should have communicated more crisply with the operators, BOP should have maintained better control of S/G levels | 4.0/4.25 |
| Normal start-up, use of GOI | Getting S/G level control in automatic | 4.0/4.2 |
| Crew followed instructions | S/G level control could have been better but problem was simulator, if BOP had practiced on simulator before his performance would have been better. The problem is the speed of the MFP when in automatic | 4.0/3.8 |

performance). The most frequently occurring terms (or more accurately, the most frequently occurring factors as the analyst perceived them) were: quality of actions, observation/awareness, communication, use of procedures, identification of problem, timely execution, and teamwork. Table 2 gives the results of an analysis of these seven terms. While the answers to question #2 were used to identify the major factors, the data shown in the table were taken from the responses to questions #2, #3, and #4. The percentages (%) shown are the percentages of all answers to the questions that used the factor typed in bold letters.

Discussion

The data generated in this part of the study was sufficient for the purpose of the analysis; however, the analysis was hard to perform and somewhat subjective due to the fact that the: instructors do not use a common set of well-defined terms to describe performance and an individual instructor uses various terms to refer to the same factor. In addition, a specific vocabulary for discriminating the level of quality for important crew responses does not exist. For instance, the term "communication" was frequently cited as an important crew function. Yet there are many types of information to be communicated including: statements by crew members of plant problems as they perceive them, statements of hypothesis about the plant problem, announcements of an intended plan of action, announcement of completion of a set of actions, statements identifying an alarm, and asking for advise and information. Also, there are both spoken and unspoken communications among crew members.

For the above reasons, it appears as though a standardized assessment language should be developed. The language should be defined

Table 2. Results from the Analysis of the Seven Terms

| % QUESTION #2 | % QUESTION #3 | % QUESTION #4 | EVENT |
|---|---|---|---|
| | QUALITY OF ACTIONS | | |
| 10.5 | 3.4 | 25.0 | A |
| 16.7 | 28.6 | 47.4 | B |
| 13.5 | 16.0 | 25.0 | C |
| 8.3 | 26.5 | 17.4 | D |
| 16.1 | 17.4 | 37.9 | E |
| | OBSERVATION/AWARENESS | | |
| 15.8 | 20.7 | 6.7 | A |
| 0.0 | 0.0 | 0.0 | B |
| 0.0 | 16.0 | 0.0 | C |
| 0.0 | 0.0 | 4.2 | D |
| 0.0 | 0.0 | 3.2 | E |
| | COMMUNICATION | | |
| [illegible]3.9 | 37.9 | 21.4 | A |
| 25.0 | 21.4 | 21.1 | B |
| 16.2 | 20.0 | 11.1 | C |
| 18.8 | 14.7 | 9.5 | D |
| 16.1 | 17.4 | 7.1 | E |
| | USE OF PROCEDURES | | |
| 23.7 | 17.2 | 14.3 | A |
| 16.7 | 7.1 | 10.5 | B |
| 8.1 | 8.0 | 0.0 | C |
| 8.3 | 23.5 | 8.7 | D |
| 9.7 | 8.7 | 3.4 | E |
| | IDENTIFICATION OF PROBLEM | | |
| 2.6 | 0.0 | 32.1 | A |
| 8.3 | 14.3 | 0.0 | B |
| 21.6 | 20.0 | 19.4 | C |
| 18.8 | 11.8 | 8.7 | D |
| 38.7 | 34.8 | 31.0 | E |
| | TIMELY EXECUTION | | |
| 10.5 | 6.9 | 17.9 | A |
| 0.0 | 0.0 | 0.0 | B |
| 10.8 | 12.0 | 11.1 | C |
| 12.5 | 5.9 | 8.7 | D |
| 0.0 | 4.2 | 18.9 | E |
| | TEAMWORK | | |
| 2.6 | 13.8 | 0.0 | A |
| 8.3 | 0.0 | 0.0 | B |
| 10.8 | 0.0 | 0.0 | C |
| 8.3 | 11.1 | 0.0 | D |
| 9.7 | 8.7 | 0.0 | E |

so that it allows instructors to identify particular crew actions and responses. The language should also permit precise descriptions of many levels of response quality that exist between the superior and need-to-be improved performance levels.

Collection of Scored Performance Demonstrations

The purpose of this part of the study was to determine what measurable data (independent variables) will predict instructors' performance assessment scores (dependent variables). It investigated the use of measurements of crew responses which are only available by observation of the crew. According to the study's theory, prediction of the instructor's crew assessment score from independent variables provides the basis for the determination of the quantitative rule for scoring crew performances, i.e., the performance measure sought.

Method

Two experienced NPP training instructors from ORNL evaluated fifteen crew performance demonstrations. They also completed a ten-item questionnaire which was designed to elicit observational, rather than judgmental, information describing each crew's functioning. The questionnaire consisted of closed-ended items, each having a five-point rating scale; Table 3 presents the ten questions. After the instructors had finished responding to the observational questions, they again rated the crew's performance. The two assessments were collected to determine if the training instructor's thought process of systematically thinking about specific crew responses affects his overall crew assessment. A difference between the first and second assessment scores would indicate the existence of such an effect.

Table 3. Observational Questions

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#1. To What Extent Was the Quantity of Communications Proportional to the Rate of Automatic Actions and/or Changes in Important Parameters?

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Less Than | | | Greater Than | |

#2. To What Extent Was the Content of Communications Related to Pertinent Information?

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Unrelated | | | | Related |

#3. To What Extent Was the Style/Quality of Communications Instructions Clear?

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Unclear | | | | Clear |

#4. To What Extent Did the Crew Demonstrate Knowledge of Immediate Actions in Procedures?

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Few Actions Accomplished | | | All Action Accomplished | |

#5. To What Extent Did the Crew Make Efficient Use of Time Available as a Reflection of Their Knowledge of the Tolerance of the Plant?

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Delayed Response | | | Rapid Response | |

#6. To What Extent Did the Crew Continuously Monitor Parameters?

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Infrequent | | | | Frequent |

#7. To What Extent Did the Crew Continuously Monitor Alarms?

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Infrequent | | | | Frequent |

#8. To What Extent Did the Crew Members Perform Within Their Job Assignments?

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Not All The Time | | | All The Time | |

#9. To What Extent Did the Crew Correctly Diagnose Plant Conditions?

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| No Diagnosis | | | Complete Diagnosis | |

#10. To What Extent Was the Crew Continuously Aware of the Plant State?

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Seldom | | | Continuously | |

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The performance demonstrations consisted of video recordings of the loss of feedwater off-normal event which were taken in concert with the first part of the study. (As crews operated in the simulator, two video cameras recorded their actions and communications.) The video tapes of the NPP crews operating in the TVA simulator contain information on crew interactions, monitoring of the control panel, and crew hypothesis formulation and testing. Each instructor viewed and evaluated fifteen sets of tapes.

Results

It was determined through review of the data that the first and second performance assessments were not always consistent. Instructor 1 changed his assessment four times with two increasing and two decreasing in value. Instructor 2 changed his assessment six times with only one decreasing. While there does not seem to be a pattern to the changes, responding to the observational questionnaire did cause the instructors to reflect on the crew's performance, and in some cases, provide a different assessment.

Consistency between the instructors' scores or the relative ranking of the crews' performance is the first consideration because those judgments are the basi for the measures to be developed. Table 4 shows the instructors' scores for each crew, ordered according to score value. As an aid to understanding consistency of instructor scoring, the rankings were divided into quarters, as shown in the fifth column in the table. Seven of the fifteen crews were consistently scored within quarters.

The rank differences of each crew are exhibited in the second column of Table 5. Crews with the largest rank differences were #8 and

Table 4. Relationship Between Performance Scores

| Instructor 1 Average Score | Crew | Instructor 2 Average Score | Crew | Consistent In Quarter |
|---|---|---|---|---|
| 95 | 6 | 90 | 6 | 6 |
| 86 | 3 | 85 | 14 | 14 |
| 86 | 14 | 82.5 | 1 | |
| 84 | 8 | 82.5 | 3 | 3 |
| 82 | 15 | 82.5 | 13 | 13 |
| 78.5 | 1 | 80 | 2 | |
| 77.5 | 5 | 80 | 12 | |
| 77 | 13 | 77.5 | 15 | 15 |
| 76.25 | 2 | 75 | 5 | |
| 75.5 | 11 | 75 | 8 | |
| 73 | 7 | 70 | 9 | |
| 65 | 4 | 70 | 4 | 4 |
| 61 | 10 | 65 | 11 | |
| 60 | 12 | 60 | 7 | |
| 59.5 | 9 | 60 | 10 | 10 |

Table 5. Differences in Performance Orderings

| Crew | Difference in Ordering of Scores | Number of Observation Questions with Values Different by More Than One Point |
|---|---|---|
| 12 | 6 | 1 |
| 8 | 6 | 1 |
| 9 | 4 | 2 |
| 7 | 3 | 1 |
| 11 | 3 | 0 |
| 2 | 3 | 1 |
| 13 | 3 | 2 |
| 1 | 3 | 1 |
| 15 | 3 | 1 |
| 3 | 2 | 2 |
| 10 | 2 | 0 |
| 5 | 2 | 2 |
| 14 | 1 | 1 |
| 6 | 0 | 1 |
| 4 | 0 | 2 |

#12 with a difference of six ranks, while crew #9 had a difference of four ranks. The remaining crew ranking differences were less than four ranks.

In addition to the differences in crew score rankings, differences between the instructors' observations of crew responses, as indicated by the responses to the observational questions, must be considered. A comparison of the instructor observations is provided in the third column of Table 5. It shows for each crew the number of questions with answers different by more than one point. Crews #8 and #12, the crews with the largest differences in performance score rankings, are found to have only one question (question #9) with answers different by more than the tolerance of one.

1 ble 6 exhibits, for each observation ~ estion, the number of crews for which the values of the answers were different by more than one point. The third column of the table indicates the relative prediction power of the questions, which is explained shortly. Examination of Table 6 reveals that ques on #9 resulted in four crews having answers differing by more than one point. This suggests that question #9 may be poorly stated, resulting in different interpretations by the individual instructors. Perhaps the subject of the question requires a multi-dimensional description, requiring multiple questions. Similar problems may exist, but to a lesser extent, with questions #3 through #7.

A step-wise, multivariate regr ssion analysis was conducted on the data; results are given in Table 7. The dependent variable was the second crew assessment. The independent variables were the responses to the observation questions. Regression results are listed in the order

Table 6. Differences in Answers to Observation Questions

| Question | Number of Crews with Different Answers * | Relative Score Prediction Value |
|---|---|---|
| 1 | 0 | - |
| 2 | 0 | - |
| 3 | 2 | 2 |
| 4 | 2 | - |
| 5 | 2 | 3 |
| 6 | 2 | 4 |
| 7 | 3 | - |
| 8 | 1 | - |
| 9 | 4 | 1 |
| 10 | 1 | - |

*Number of answers that were different by more than one point.

Table 7. Prediction of Crew Performance

| | Mean | Standard Deviation |
|---|---|---|
| Dependent Variable: Second Assessment | 75.6 | 9.61 |
| Independent Variable: Question #9 | 3.7 | 1.16 |
| Independent Variable: Question #3 | 3.2 | 0.83 |
| Independent Variable: Question #5 | 3.4 | 0.82 |
| Independent Variable: Question #6 | 3.5 | 0.69 |

Multivariate Regression Analysis

| Independent Variable | Regression Coefficient | t-Value | p |
|---|---|---|---|
| Question #9 | 2.96 | 4.17 | .0001 |
| Question #3 | 4.94 | 5.52 | .0001 |
| Question #5 | 3.75 | 4.23 | .0001 |
| Question #6 | 2.79 | 2.95 | .01 |

Intercept = 25.57
Variance Explained = 89.4%

of the variance each explained in a univariate regression analysis. Thus, question #9 explained the most variance and question #6 the least (but still statistically significant). This ordering of the independent variables according to variance explained is indicated in the "relative score prediction value" column of Table 6.

Discussion

Since the variance explained by the regression, which uses only answers to observational questions for independent variables, is very high, strong evidence is available to support the claim that instructors use observations of crew activity, as opposed to simulated power plant data, to formulate their team performance assessments. This might be translated into the conclusion that it is the process the crew employs rather than the results of the crew actions that is of primary importance to instructors when assessing team performance -- but at this point, this is merely conjecture.

Since, according to the regression analysis, question #9 is important to crew performance prediction and since, in answering that question, the instructors differed as to the crews' ability to diagnose the plant conditions, ORNL must conclude that it is the difference in the instructors' interpretation of question #9 that produced the difference in the crew performance scores. Consequently, the adequacy of the question should be challenged -- instructors should be asked to state their interpretation of the question and expound on their preferences of plant diagnostic strategies. When the different interpretations of the instructors are understood, the question (or perhaps questions) can be rewritten and the relevant part of the performance assessment questionnaires completed again by the training instructors.

## CONCLUSIONS

A crew performance measure was developed which uses, as independent variables, instructor observations of specific crew behavior. Because the measure explains nearly all of the variance of the training instructors' team performance assessments for the loss of feedwater off-normal event, there is strong evidence that the performance measure is functionally equivalent to the subjective assessment rules used by instructors. There is also reason to believe that the method of synthesizing this measure can be successfully applied to other types of off-normal events.

The measure synthesis method permits comparison of differences among instructors as to the relative importance of the affect of crew behaviors on overall system (crew and equipment) performance. Examination of the mathematical function provides a means for identifying the crew behaviors that instructors apparently use in making performance assessments.

## RECOMMENDATIONS

Recommendations for future research include the following:

1. The data collection questionnaire should be refined, based on interviews with instructors, to more precisely define the observation variables found to be critical to crew performance assessment.

2. Behavioral examples for each level of each of the observational questions should be developed, so that crew performance corresponding to each level can be more easily understood by other instructors.

3. The performance measurement synthesis should be applied to similar system problems using additional instructors to develop a larger data base of instructor performance assessment judgments.

4. The performance measure synthesis should be applied to additional types of system problems to determine the measurement factors common to all plant problems and those specific to each problem.

5. A standardized performance assessment language and a specific vocabulary for discriminating the level of performance quality should be developed for use by training instructors.

6. Computer programs which can be installed in each NPP facility to automatically synthesize performance measures for any new system problem should be developed.

COMPARATIVE ANALYSES OF APPRENTICESHIP PROGRAMS BETWEEN NUCLEAR AND NON-NUCLEAR POWER PLANTS

John Naegle
Salt River Project
Coronado Generating Station

PAPER WAS NOT RECEIVED AT TIME OF PUBLICATION

# ADULT LEARNING TECHNIQUES IN MAINTENANCE TRAINING

Kenneth M. Roush

## ABSTRACT

The increased emphasis on the training of power plant personnel has provided the trainer with the resources and the opportunity to develop and implement quality training programs. Trainers must continually focus on how to present these quality programs in the most efficient and effective manner possible. Applied Adult Learning Techniques will increase the probability that training programs will be effective and efficient.

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Most of you have taught adults and many of you have used one or more of the techniques I will be discussing today. Some of you may find this information new and useful and others may find this information a good review. Whatever the case, please feel free to ask questions at the end of the presentation or during the remainder of the conference.

We have been using Adult Learning Techniques at Susquehanna since 1978. In our early days we didn't call it Adult Learning, I'm not sure we knew the difference between pedagogy and andragogy. We did know that it was the way we wanted to do business and it made us feel right about the way we taught and treated our customers; the student. These techniques are the major reason we have experienced success and the reason we continue to evaluate and improve our sound learning system.

What do I mean when I say Adult Learning Techniques?* The term andragogy has been used to describe the different techniques used to teach adults verses pedagogy which describes the science of teaching children. The techniques that I will be covering are as follows:

- Adults want to be involved with deciding what their training program should contain.

- They need to see immediate use for the information and/or skill.

- They want to share their knowledge and experiences.

- They learn better if you tie new information and skills to existing information and skills.

- They need to practice newly acquired knowledge and skills to ensure they have formed new habits.

- They want to know how well they are learning with out fear of being embarrassed when they do not know something.

The above list is not all inclusive. I have selected these items to elaborate upon and could have easily added others.

*References are listed at the end of the paper.

## Involvement

The incumbents in all of our Maintenance Groups are involved in the continued verification of the task lists that our training programs are based on. The incumbent, along with the supervisor, is also a member of the respective Curriculum Committee. Curriculum Committees meet as often as necessary but at least once a year to review the training program and evaluate it effectiveness as well as review the evaluation feedback to determine what action, if any, is needed to change the training program. These two methods ensure the workers have input into the content of the training program.

All students in the class are provided an opportunity to provide immediate feedback as to the content of the program. This evaluation also provides the student with the option to request a meeting with a training supervisor or work group supervisor to discuss the course. Students are randomly selected for follow-up feedback on courses three to six months after the course was conducted. These two methods of evaluation are part of the information reviewed by the Curriculum Committee during their scheduled meetings. The whole process ensures the adult learner has input into the program before it is presented and after it has been presented to provide assurance that the student is receiving what he or she needs to do the job.

## Application

Adults need to understand where they are going, how they are going to get there, how the training applies to their job, and why they should learn the information. This is accomplished by providing the students with an introduction to the course. This includes: what the instructor is going to do, how it is going to be done, the purpose of the course, and the relativity of the course to their job. This is in addition to the objectives. This sets the stage as to why the student should learn the information and/or skill.

## Sharing

Adult students are a treasure. These people come to class with a wealth of knowledge and experience. Adults want to share these experiences with others. The knowledge and experience an adult has can be used to teach them needed knowledges and skills by relating the new to the existing. The instructor must be a facilitator of knowledge. This can be done by: knowing the topic; being prepared to teach the topic; knowing the students' background; and by allowing the student to help teach the class. The physical and psychological settings are important because they help the students feel comfortable enough to allow them to participate. We limit the number of students in all laboratory settings to encourage participation by all. We use u-shaped or board room layouts to encourage face to face communication with the students as well as the instructor. We provide positive reinforcement of questions and answers by students. We maintain a constructive learning environment which can include the use of humor since learning should be fun. We hire instructors who want to teach and have technical knowledge in the area to be taught. Instructors are trained to treat all students with respect and to include adult learning techniques in their teaching settings. Not all experiences are in line with the way you may be training them. If that is the case, the instructor must use an approach that will correct the misinformation and not embarrass the student.

## Association

During the teaching/learning process, the adult learner will retain the information better if you tie the new information and skills to existing knowledge or skill. The students will be able to retain the information better if you use the procedures, tools, and equipment with which they are accustomed. Besides showing relevancy, it also ensures the probability the person will be able to transfer the knowledge and skill to the job. Sequence of training is important to ensure the student has the necessary prerequisite knowledge prior to moving on to more complex information.

## Practice

The use of mockups for adult learning is an excellent way to ensure the student gets involved in learning. Maintenance personnel are hands-on people. With that in mind, our program has always used mockups to train Maintenance people how to apply the skills that we are teaching.

## Progress

The success of training is proven when the student can perform the skill or use the knowledge that was taught. Adults want to know how they are doing. It is important to check during the training session to ensure the student is learning. Do not wait until the examination to find out the student has not learned. Nobody wants to be examined and not know the results. The examination must be fair and valid. The use of practical examinations is an excellent way to demonstrate skill. As with any learning, the more you practice something the better your chances are to retain it. Therefore, repetition of the new knowledge or skill is essential during the program. The examination provides an opportunity for the student to prove competency.

## Summary

In summary, if you use these adult learning techniques in the development and implementation of your training programs, as we have, you will be able to have more effective and efficient training programs. All our Maintenance programs, Electrical, Instrument and Controls, and Mechanical apply the techniques.

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# THE ROLE OF ENVIRONMENTAL QUALIFICATION TRAINING IN NUCLEAR PLANT MAINTENANCE

Gary W. Krantz

## INTRODUCTION

Over the past decade and a half the nuclear utility industry in the United States has undergone a dramatic metamorphosis. The early years of our industry have born witness to the massive construction effort required to complete commercial nuclear plants. Design of the complex nuclear plant alone requires 50%-80% more time than conventional power plants. Three hundred thousand cubic feet of concrete and hundreds of thousands of tons of structural steel are laced with tens of thousands of feet of large diameter high quality piping, supported by up to 30,000 hangers. Electrical cable in quantities exceeding 5-6 million feet are supported in trays anchored in the concrete or supported on massive steel members.

For the next two and one-half decades, the operation of the 111 completed and the nearly completed or near-term operating license(NTOL) plants will predominate. We are now in the thrust of this phase of our nuclear industry cycle. Already, however, we are beginning to witness a rush on extension of life, Nuplex (Nuclear Plant life Extension), of our newly operational plants. Maintenance proficiency, expertise, and effective maintenance, preventive maintenance and surveillance program implementation will characterize those nuclear plants who succeed in the operations phase and make it to plant life extension. The NRC has admonished the nuclear industry that plants with a poor track record of maintenance need not apply for license extensions beyond the 40 years permitted in the current two-stage licensing process. We must therefore develop, train and manage our plant organizations involved in primary side maintenance, secondary side maintenance and in power generation, control and distribution maintenance.

Since nuclear safety is paramount, however, we can neither dismiss nor omit the need for the very highest caliber maintenance of that segment of our nuclear plants involved in shutting down the plant and in maintaining safe shutdown in the case of a serious design basis accident (DBA). Although the redundant, safety-related, shutdown equipment receives no fanfare for megawatts generated or revenue produced, the equipment must receive the limelight of our attention in the ongoing maintenance program throughout the life of the plant.

DBAs primarily include loss of coolant accidents (LOCAs), high energy line breaks (HELBs) and main steam line breaks (MSLBs). The nuclear plant equipment and systems involved in a DBA shutdown effort, the peripheral equipment which must function to support the shutdown capability, and the equipment which provides "post-accident" monitoring capability are the vital "safety" organs of the nuclear plant. The equipment is required by the NRC to receive special attention from design, through manufacturing, procurement, storage, installation, operation, testing and most importantly - maintenance.

To pay casual attention to this very, very special safety-related "shutdown" equipment is like building a 500 miles-per-hour race car and leaving off the brakes. This paper will deal with the required installation of this equipment in harsh plant environments, the importance placed on maintenance of the equipment, and of the role of training in the maintenance activities.

## EQ REGULATORY HISTORY AND BACKGROUND

In 1956, as the Atomic Energy Commission was preparing to license the very first commercial U.S. nuclear power plant, Shippingport, their initial publication of the Code of Federal Regulations had to address a very serious safety concern. The safety concern was later to become an "unresolved safety issue" (USI-A24). Simply stated, the concern asks, "In the event of a serious postulated design basis accident, would the nuclear plant safety-related shutdown equipment be able to live through the harsh environmental conditions of the accident and survive to bring the plant to a safe shutdown?" In the early 1970s, the Code of Federal Regulations, Title 10, "Energy", made special provisions for the safety concern when a general design criterion (GDC) was developed to specifically address the consideration of environmental conditions in the design of the safety-related equipment. The regulatory mandate, 10CFR50 Appendix A, general design criterion Number 4, was entitled "Environmental and Missle Design Bases". It required that:

> "Structures, systems, and components important to safety shall be designed to accommodate the effects of and to be compatible with the environmental conditions associated with normal operation, maintenance, testing, and postulated accidents, including loss-of-coolant accidents . . . "

During this same time period, the 10CFR50 Appendix B Quality Assurance (QA) criteria were also being developed and incorporated into the Federal regulations. Criterion Number 3 of Appendix B, "Design Control", required that;

> "where a test program is used to verify the adequacy of a specific design feature, it must include suitable qualification testing of a prototype unit under the most adverse design conditions. . ."

These two regulatory requirements, which ushered in the acronym "EQ" or environmental qualification, were not easily interpreted since they set forth only the basic minimum requirements and not the detailed means to accomplish the equipment qualification objective. Regulatory requirements of this nature left the burden on the licensee to demonstrate by test, analysis or experience that the equipment was qualified to meet the vigorous environmental conditions of a DBA, and to "take a licking and keep on ticking" as a commercial of the time conveyed. Some postulated harsh environmental conditions had been extrapolated for DBAs. Temperatures and pressures were initially predicted to ramp up to approximately 280°F and 45 PSIG under saturated humidity conditions for the initial ten minutes of an accident and then to steadily decrease to ambient within an hour or so. However, when attempting to qualify the safety-related equipment, the specific time-based qualification parameters had to be approximated. Very little published criteria was available, either from the regulatory agency or the nuclear industry. In the early years of EQ, there were no regulatory guides or national standards available to amplify the Appendix A and B requirements and qualification methodology.

In 1971, a trial-use national standard was developed by the Institute of Electrical and Electronics Engineers. It was published to give direction and guidance on qualifying the nuclear plant safety-related electrical equipment to the conditions it would be required to live through in an accident. IEEE-323, as it came to be known, was revised in 1974 to include equipment aging, margins (engineering conservatisms) in the qualification process, and documentation of the qualification testing performed. In 1975, the fledgling Nuclear Regulatory Commission (NRC) endorsed the IEEE-323 national standard in a regulatory guide (Reg. Guide 1.89).

Environmental qualification received national attention in the mid 1970s as an organization known as the Union of Concerned Scientists (UCS) voiced their concerns regarding the adequacy of the environmental qualification of nuclear plant safety-related equipment. On November 4, 1977, the UCS filed a petition with the NRC requesting shutdown of all operating reactors and the suspension of construction on construction permit plants until EQ deficiencies were resolved.

Although the NRC denied the UCS petition, they launched a vigorous effort to develop EQ verification in the nuclear utility industry. The effort resulted in a barrage of NRC guidelines, information notices, and bulletins. A published Nureg was later made mandatory by an NRC "order", requiring major improvements in EQ.

The initial nuclear industry benefit from the EQ effort was realized at Three Mile Island Unit 2 on March 28, 1979. Environmentally qualified electrical devices and components helped bring this country's first serious LOCA in a commercial nuclear plant to a safe shutdown without significant radioactivity releases to the environment. The accident and lessons learned from the experience helped pave the way for an EQ ruling and regulatory requirement. On January 21, 1983, the EQ ruling was published in the Code of Federal Regulations in Title 10 part 50.49. Nuclear plant equipment designated as requiring environmental qualification under 10CFR50.49, became known as "50.49" equipment and included the following:

- Safety-related class "1E" electrical equipment located in a harsh environment that must remain functional during and following certain DBAs.

- Non-"1E" electrical equipment in a harsh environment whose failure could inhibit safety functions performed by the "1E" equipment.

- Certain postaccident monitoring (PAM) equipment located in a harsh environment (covered under Reg. Guide 1.97, Rev. 2).

Class "1E" equipment is identified in IEEE-323 as electric equipment relied upon to remain functional during and following a DBA to ensure;

- Integrity of the reactor coolant pressure boundary (RCPB)

- Capability to shutdown and maintain safe shutdown

- Capability to prevent or mitigate the consequences of an accident

The 1983 EQ ruling established a specific schedule for EQ compliance. It specified a deadline for compliance by:

- Completion of the second refueling outage after March, 1982, or

- March 31, 1985, whichever is sooner.

- Additionally, the NRC could grant requests for extension, for specific pieces of equipment, to a date no later than November 30, 1985.

The term "harsh environment" used in the ruling is not a well defined term but, in general, references those spaces in the nuclear plant where the environmental conditions created by a postulated accident are significantly greater than the abnormal environmental conditions. Abnormal conditions are considered to exist for up to eight hours per excursion and occur less than 1% of the plant life.

The EQ ruling identified nine specific criteria which the "50.49" equipment must be qualified to if it may be subjected to them during a Design Basis Accident. Through training of our nuclear plant personnel of the severity of these prospective DBA environmental criteria, a realization of the pertinence of quality maintenance can be affected. This paper will address the fundamental aspects of the nine EQ criteria, particularly as they relate to the training of maintenance personnel for awareness and for providing a basis for the importance of their maintenance on 10CFR50.49 equipment.

10CFR50.49 ENVIRONMENTAL QUALIFICATION CRITERIA

1. <u>Temperature</u>

"Mild" environment nuclear plant equipment normally experiences temperatures ranging from 50-104°F. Much higher temperatures are projected to occur in "harsh" environmental areas, however, during a loss of coolant accident, main steamline break or high energy line break. Figure 1 shows the typical projected LOCA/HELB temperature curves for a PWR with ice condenser containment design. Temperatures of up to 327°F are projected. Even higher temperatures of up to 450°F have been projected to occur in other nuclear plant containment designs.

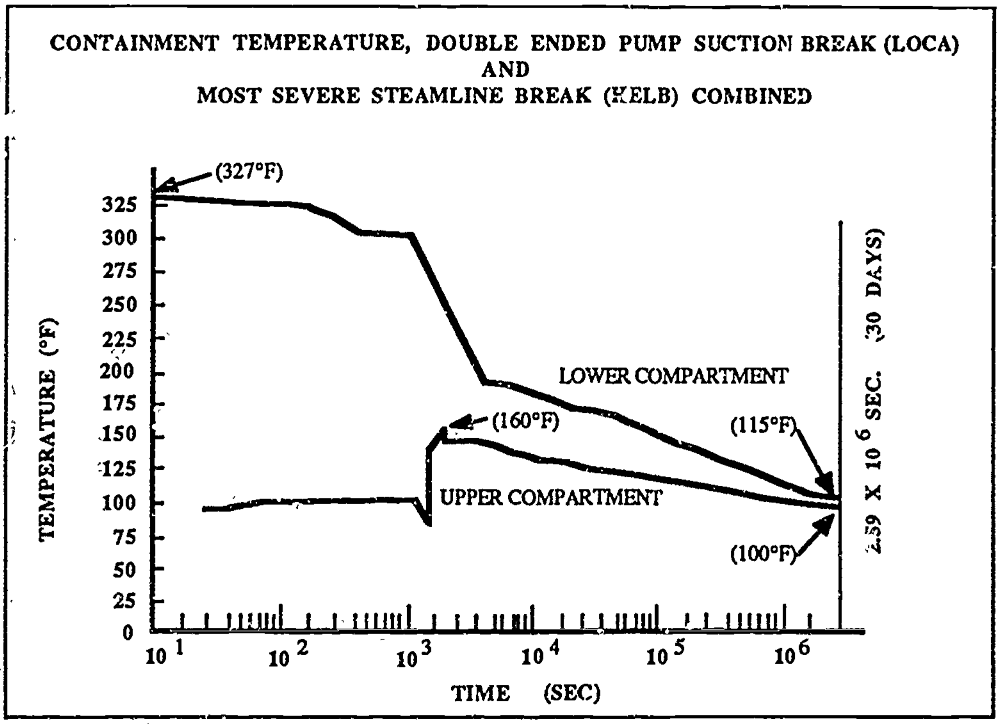



Figure 1. LOCA/HELB Temperature Curves

## 2. Pressure

In a design basis accident LOCA, Ice Condenser - type containments with spray down capability are projected to experience pressure peaks of up to 12.3 pounds per square inch as shown in figure 2. Other nuclear plant containment designs may experience pressure peaks of up to 65-70 psig. The driving force of this pressure can force the high humidity environment, radioactive byproducts and chemicals through poorly maintained, carelessly torqued seals, gaskets and o-rings on cover plates and other sealed, protected equipment. Once inside, the harsh environment can wreak havoc on motor internals, electrical system components, solid state devices, wiring, instrumentation sensors and control systems. Our nuclear plant maintenance personnel must be trained to be aware of the end-result of aberrant seal/gasket maintenance and why seal/gasket integrity is critical to equipment survival in a DBA.

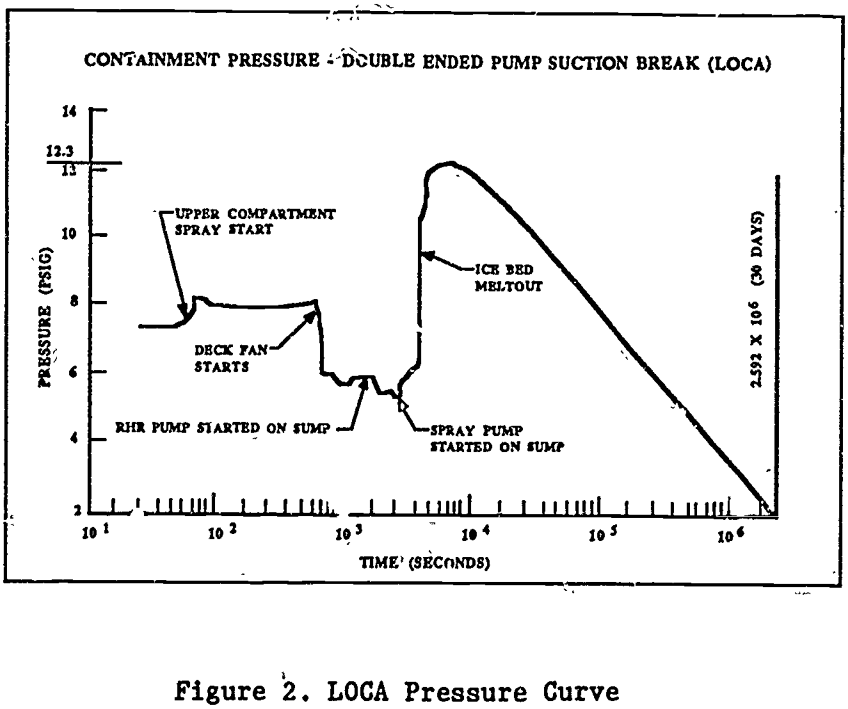



Figure 2. LOCA Pressure Curve

3. Humidity

The humidity in a LOCA, MSLB or HELB is projected to increase to 100% during the first few seconds and remain at 100% for greater than 24 hours. This occurs as the isenthalpic release of the RCS inventory contained in a 2200 psi atmosphere at greater than 600°F is released into the near-ambient pressure of slightly less than one atmosphere inside containment. In addition to LOCA steam, the containment spraydown system dumps in excess of 9,000 gpm, or 0.92 gpm/square foot of containment cross section, of 2000 ppm borated water from a ring spray system high in the top of containment. All of the containment equipment, including the safety-related 50.49 equipment is subjected to the spraydown. Nuclear plant maintenance personnel must be trained to realize that "50.49" safety-related shutdown equipment must be protected from the high humidity and spraydown conditions of a DBA.

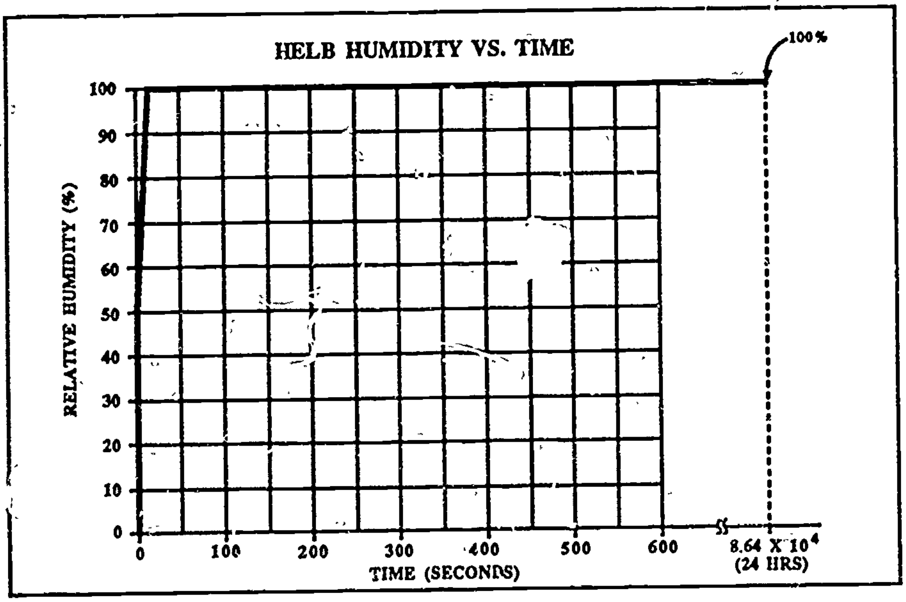



Figure 3. LOCA/HELB Relative Humidity Curve

4. Chemicals

Our nuclear power plants are not strangers to chemicals. In fact, a cadre of caustic, corrosive, oxygen scavenging, pH balancing reagents are employed in all nuclear plants in the United States. Table 1 provides a listing of some of the chemicals used directly in various applications in the nuclear plants.

Table 1. Chemicals Used in Nuclear Plants

| Chemical | Nuclear Plant Use |
|---|---|
| $Na_2B_4O_7$ | Ice Condenser PWR - Ice Baskets |
| $Na_2B_5O_8$ | BWR Standby Liquid Control |
| $H_3BO_3$ | PWR Reactivity Control & Chemical Shim |
| $Na_2S_2O_3$ | Radioactive Iodine "Getters" |
| NaOH | Radioactive Iodine "Getters" |
| $N_2H_4$ | Oxygen Scavenging |
| LiOH | pH Adjustment |
| NaOCL | Microbe/Clam Control |

Sodium Tetraborate ($Na_2B_4O_7$) employed in ice condenser containments, sodium hydroxide (NaOH) and sodium thiosulfate ($Na_2S_2O_3$) are chemicals employed to, drip down or spray down and capture radioactive Iodine-131 released as a gaseous fission byproduct in a LOCA. Lithium Hydroxide

(LiOH) is a chemical used to resolve RCS pH imbalances during startup of the nuclear plant. Sodium hypochlorite (NaOCL) is used to remove clams and other marine organisms from service water systems.

Boric acid ($H_3BO_3$) is used for chemical shim and reactivity control in PWR plants. There are no serious environmental consequences of boric acid in dilute 1000-2000 ppm (Boron) concentrations. However, when leakage occurs in flanges, instrument lines, steam generator manholes/handholes, reactor coolant pump flanges and in the vessel head area, serious degradation can occur to pressure boundary components and fasteners as the hot metal surfaces evaporate the water, thereby concentrating the boric acid up to 25,000 ppm (Boron). Rampant corrosion and mass wastage occurs on reactor coolant pressure boundary components and fasteners at these concentrations under favorable conditions. An even more serious problem may result in the "50.49" electrical equipment if the seals, gaskets, o-rings or penetrations are breached in a LOCA, MSLB, or HELB and the electronic circuitry is subjected to chemical degradation. Through training, our maintenance personnel and engineers can be made aware of the necessity for conc n over the environmental consequences of boric acid and other chemicals on our safety-related equipment, especially "50.49" equipment used in shutdown during a DBA.

5. Radiation

The radiation exposure inside containment after a design basis accident LOCA is calculated based on a release to the containment atmosphere of 100 percent of the core inventory of radioactive noble gas, 25 percent of the core inventory of radioactive iodine and 1 percent of the core inventory of solid fission products. The normal integrated radiation dose in a nuclear plant, during a 40 year license of operation ranges from $10^3$ Rads outside of containment up to $10^7$ Rads or so for spaces inside containment. The 40 year normal integrated dose plus the postulated DBA accident dose used in equipment environmental qualification ranges from $10^4$ rads up to $2x10^8$ rads or higher depending on the specific application, location, and actual radiation dose expected. Fuel handling devices and primary coolant pumps/blowers are constructed to take radiation dose rates of up to $2x10^9$ rads.

Table 2 provides general information relating to the effects radiation has on various materials.

Table 2. Radiation Effects on Materials

| Rads | Material |
|---|---|
| $10^{12}$ | Aluminum Alloys and Stainless Steel Ductility is Reduced. Stainless Steel Strength Triples |
| $10^{11}$ | Carbon Steel Loses Ductility |
| $10^{10}$ | All Lubricants Gel/Solidify |
| $10^9$ | Asbestos/Carbon-based Material Damage Threshold<br>Some Metals Increase Yield Strength |
| | All Lubricant Thickens |
| $10^8$ | |
| $10^7$ | Lubricant Damage Threshold |
| $10^6$ | All Lubricants Evolve Gas |
| $10^5$ | Organic Material Damage Threshold |
| $10^5$ | Organic Material Damage Threshold<br>Metallic Semiconductors Dysfunction<br>Glass Changes Colors |
| $10^4$ | Teflon Damage Threshold |

During normal operation, some "50.49", environmentally qualified equipment is subjected to long term exposure to low dose-rates of radiation and must be designed to withstand it. During a DBA, the "50.49" equipment may be subjected to high levels of radiation for extended periods of time. The primary defense against the intrusion of radioactive byproducts into the electrical equipment is the organic seal, gasket, bushing, and o-ring. They normally contain organic materials like rubber or neoprene - delicate from a radiation standpoint. As the potential weak link in the defense against radiation intrusion and other harsh elements, the loss of integrity of one o-ring may render a particularly critical 50.49 "whole device" useless in the LOCA defense and in safe shutdown. The nuclear plant maintenance personnel must be informed, through training, of the importance of these fragile, radiation sensitive piece parts and of the criticality of their scheduled periodic replacement before the end of their installed qualified life.

Lubricants, both in liquid (oils) and solid (greases) forms are seriously affected by high temperature/radiation effects. Turbine oils and gear lubricants have an operating range of 140-200°F and radiation tolerance up to $10^7$-$10^8$ rads. The temperature threshold for accelerated oxidation occurs in oils exposed to $10^9$ rads at 285°F. The lubricants perform multiple functions, on safety-related equipment, including:

- lubrication
- coolant
- contaminant removal
- wear reduction
- corrosion protection
- resist foaming/aeration
- serve as hydraulic medium

Radiation-induced scission and crosslinking of the organic lubricant molecule can alter the viscosity of lubricating oils. If lubricant cosslinking and its inherent thickening occurs, it may cause gear drive loading, pump flow rate decrease, motor overheating/burnout and a myriad of maintenance nightmares. Lubricants used on mechanical equipment moving parts subjected to high radiation, like control rod drives ($10^8$-$10^9$ rads), must have special lubricants which are carefully monitored. Normal grease subjected to high radiation of $5x10^9$-$10^{10}$ rads is transformed into a dark, amber-colored glassy substance that cracks into pieces when smashed with a hammer. Nuclear plant maintenance personnel must be trained to recognize the symptoms of lubricant radiolysis. They must also understand the problems that can result from casual mixing of lubricants in gear drive cases like limitorque valve operators. When the lube level must be increased, lubricant type and chemistry must be verified, otherwise, careless mixing of two incompatible lubricants can cause foaming, gelling, or breakdown, resulting in loss of the "50.49" equipment.

6. Submergence

Submergence is another "50.49" environmental criterion that must be considered in a DBA. In the recirculation mode of operation required in some accident scenarios when the 330,000 gallon Refueling Water Storage Tank (RWST) is expended into the RCPB - hence into containment, the surge flood line may be approximately 20-22 feet deep. "50.49" equipment, including cables, motors, and sensors located below the floodline must either be environmentally qualified to submergence or protected by other means. Otherwise, it must be moved above the floodline. Qualification to submergence must consider reactor coolant chemistry, temperature, radioactivity concentration, and the duration of submergence.

7. Synergistic Effects

This 10CFR50.49 EQ Criteria takes into consideration the cumulative effect of the various criteria in a design basis accident. The 50.49 equipment must be able to survive all of the harsh environmental criteria consequences synergistically or cumulatively. This makes the LOCA environment orders of magnitude more devastating on the equipment synergistically than when considering each criterion separately.

The last two of the nine 10CFR50.49 environmental criteria required to be included in the qualification process are Aging, a difficult topic to define, and Margins.

8. Aging

Although the scientists and technical personnel involved in "50.49" environmental qualification disagree on particular aging considerations and processes, it is nonetheless important for us to promote an awareness of the aging concepts in our maintenance personnel. "50.49 qualification testing of a whole device to the aforementioned EQ criteria in a laboratory setting is a meaningless and futile exercise unless the device has been dynamically taken to its end of installed life physical/electrical exposure conditions (aging) before testing.

9. Margins

The safety-related "50.49" environmental qualification testing levels, cycles or durations must have margins, or engineering conservatisms, built into the qualification specification. Frequently, "50.49" equipment is environmentally qualified by testing laboratories to an envelope of conditions which have an adequate margin built in to fit the needs of general procurement specifications.

In addition to the specific environmental qualification requirements, seismic qualification of both the electrical and mechanical safety-related equipment is required. Although seismic qualification is excluded from the EQ ruling, 10CFR50.49, it is required by 10CFR50 Appendix A GDC 2, and by Regulatory Guide 1.100 which endorses the national standard for seismic qualification, IEEE-344, 1971/1975. Seismic qualification has been a long term safety concern, much like EQ, and became an unresolved safety issue, USI-A46 for the nuclear industry to deal with as experience is gained.

The two fundamental objectives for environmental qualification are:

1. We <u>must</u> first uncover any prospective design deficiencies that may cause simultaneous failure (in rapid succession) of redundant (both train A and B), backup "50.49" equipment in the event of a design basis accident. Once we have proven the design to be safe and reliable, manufactured it, procured it, stored it, issued it, installed it and are operating it, we must then rely on the second EQ objective.

2. We <u>must</u> maintain it correctly and prevent maintenance and modification deficiencies from detracting from and disqualifying the equipment.

The long term maintenance of environmental qualification of whole devices into the future for the installed life of the component is contingent upon its receiving required scheduled maintenance, preventive maintenance and surveillance. The environmental qualification data packages or qualification file specifically identifies, by equipment type, the required maintenance. Plant procedures are required to formalize how the maintenance must be performed. The replacement of organic piece parts and lubricant maintenance frequency are also specified. Maintenance, therefore, is a key element in the future of EQ for the 111 operating nuclear plants in the United States.

The role of EQ training in the maintenance of the nuclear plant equipment is to ensure that our personnel know <u>why</u> it is important - critically necessary, and to be knowledgeable of the environmental conditions the equipment must face in a DBA.

By performing preventive, predictive, and scheduled maintenance right the first time, with knowledgeable maintenance personnel who understand why it is important, acquired through positive, professional training, we can reduce the nuclear plant downtime. We can increase plant availability. We can reduce unnecessary plant trips and the resultant outages, and we can reduce maintenance and operational costs.

By employing the familiar "defense-in-depth" strategy known to the nuclear utility industry, we design our nuclear plant to prevent accidents. If an accident occurs, however, we have automatic systems, including "50.49" equipment that takes over and shuts down the reactor. We have a third defense - containment - to prevent radiological releases to the public. The role of training, the fourth and last of the sequence in the "defense-in-depth" concept, is to ensure our maintenance personnel and other plant workers recognize the importance of their job, recognize why it is important, and know how to do it correctly. EQ training serves a pivotal role in a successful maintenance program on "50.49" equipment.

## TVA EQ TRAINING PROGRAM

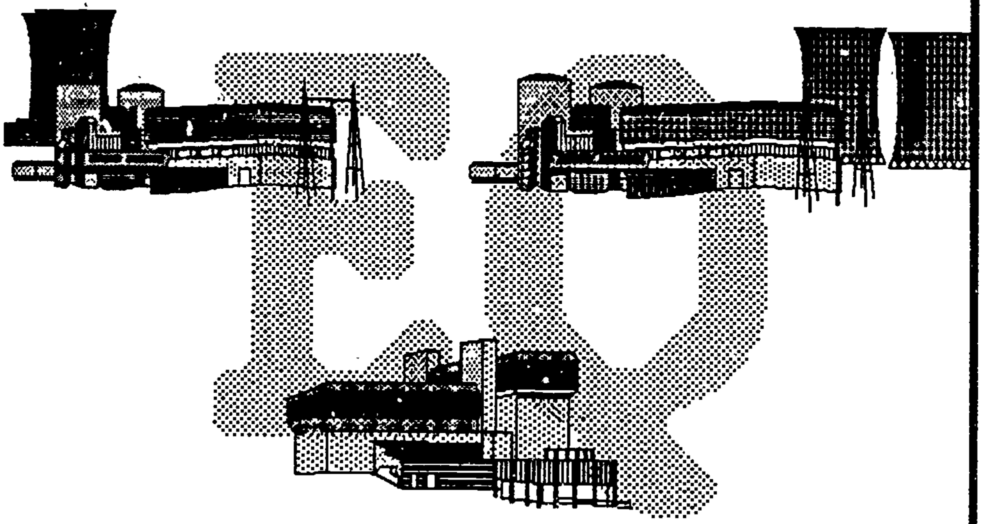
At the Tennessee Valley Authority, EQ training of nuclear plant personnel became a corporate Nuclear Power issue in 1988. Although formal EQ Orientation and EQ Procedures Training had been developed and implemented at TVA nuclear plants as early as 1985, TVA managers recognized the need for more in-depth training of plant personnel involved in EQ activities. Under TVA Corporate Nuclear direction, an EQ Task Force was established to review EQ training needs, assess any training deficiencies, and to make adjustments as required. Members of the EQ Task Force include the EQ Coordinators from Browns Ferry, Sequoyah, and Watts Bar Nuclear Plants plus representatives from Nuclear Engineering, Nuclear Maintenance, and Nuclear Training.

The nuclear plant EQ-related disciplines were considered, specific needed learning objectives analyzed and developed, and peripheral EQ background needs reviewed and documented. Each EQ course scope, content, and format was methodically determined. The target audience for each EQ Training Program course was carefully considered. Training program schedules also had to be coordinated with plant outage/maintenance priorities.

The eight EQ course content and target audience description sheets presented in figures 4 though 12, provide information on TVA's EQ Training Program. Some courses in the program are now in the design/development phase while others are under implementation. The INPO-structured Training Systems Development (TSD) format for performance-based training is employed throughout the EQ Training Program. Positive feedback is already being utilized to hone the courses to meet the training needs of the maintenance organization. TVA's EQ Training Program is already producing favorable results as the nuclear plant workers and support personnel acquire a broader understanding of the EQ requirements, concepts, and technical issues and apply the training in their jobs.

ENVIRONMENTAL QUALIFICATION
TRAINING PROGRAM

TENNESSEE VALLEY AUTHORITY



Nuclear Training
Quality and Management Systems
Training Department
Quality Standards Training
1988/1989

WHAT IS YOUR EQ IQ?

Figure 4. TVA EQ Training Program Description Cover Sheet

## Introduction to Environmental Qualification

### Course Content:

* EQ History, Regulations & Standards
* Present status of Qualification/Evolution
* Nuclear Plant Environments (Harsh-Mild)
* In-service Degradation - Aging
* Qualification "Process" Overview
* Replacements (Procurement Basics)
* End of Life Replacements
* Radiological Effects on Components (rubber, lubricants, organics, etc.)
* Other Topics

### Target Audience:

Nuclear Power Personnel

* Maintenance
* Engineers
* Supervisors
* General Foremen
* Electricians (all levels)
* Pipefitters (all levels)
* QA/QC
* Planners/Schedulers
* Other interested persons

Figure 5. Course Content, Introduction to Environmental Qualification

# Dedication, Replacement, and Procurement of 50.49 Items

## Course Content:

* Why Specialized Equipment Procurement
* Dedication of Commercial Grade Items
* Substitution Evaluations
* Unique Procurement Requirements
* Equipment upgrades, category II & I
* Vendor Vengeance (No QA!!)

## Target Audience:

Nuclear Power Personnel

* Engineers (Corporate)
* Engineers (Site)
* Engineers (Construction)
* QA/QC
* Site Materials
* Maintenance
* Other interested persons

Figure 6. Course Content, Dedication, Replacement, and Procurement

## Introduction to the Digital System 1000

### Course Content:

* How to Qualify Components
* Digital 1000 System
* Qualification Methods
* Aging Evaluation
* The Analysis Process
* System 1000 Inputs
* System 1000 Outputs
* Accuracy of Qualified Life Estimates

### Target Audience:

Nuclear Power Personnel

* Maintenance
* Engineers
* SRO's
* STA's
* Supervisors
* Electricians (all levels)
* Planners/Schedulers
* Other interested persons

Figure 7. Course Content, Introduction to the Digital System 1000

## EQ Data Packages (Binders)

### Course Content:

* NRC Binder Mandates
* 50.49 List
  - -parameters
  - -location
  - -revision process
  - -relationship to Binders
* EQ Binder

### Target Audience:

Nuclear Power Personnel

* Engineers (Corporate)
* Engineers (Site)
* Engineers (Construction)
* Planners
* Schedulers
* Supervisors
* Foremen
* Other interested persons

Figure 8. Course Content, EQ Data Packages (Binders)

## EQ for Maintenance Craftsmen and Engineers

### Course Content:

* Industry Experience update
* The Role of Preventative Maintenance in Environmental Qualification
* The Qualification Maintenance Data Sheets (QMDS)
* How to Recognize Environmental Degradation and What to do About It
* Recognition of the Effects of an Environmental Excursion
* Failure Under Accident Conditions
* EQ Spare Parts Acquisition
* Component Specific EQ Maintenance Requirements

### Target Audience:

Nuclear Power Personnel

* Engineers (I & C)
* Engineers (Electrical)
* Engineers (Mechanical)
* QA/QC
* Audit Personnel
* Craftsmen (I & C)
* Craftsmen (Electrical)
* Craftsmen (Mechanical)
* Other interested persons

Figure 9. Course Content, EQ for Maintenance Craftsmen and Engineers

## EQ for Planners and Schedulers

### Course Content:

* Importance of EQ planning & scheduling
* Planning & Scheduling as it relates to 50.49 maintenance/modifications
* The use of EQIS in EQ planning & scheduling
* The use of HEMS in EQ planning & scheduling
* The use of "50.49" Binder QMDS (tab G) in EQ planning & scheduling
* Preventative Maintenance - its' importance in maintaining "50.49" equipment

### Target Audience:

Nuclear Power Personnel

* Planners
* Schedulers
* System Engineers
* Component Engineers
* Procedure Engineers
* Craft Foremen
* Other interested persons

Figure 10. Course Content, EQ for Planners and Schedulers

## Introduction to Mechanical Equipment EQ

### Course Content:

- * IS another EQ "Ruling" coming for Mechanical?
- * Regulatory Requirements for Mechanical?
- * The Major Elements of Mechanical Qualification
- * Preventive Maintenance
- * Radiation Damage Thresholds for Materials
- * Lubricants and Lubricant Radiolysis
- * Mechanical Equipment "Aging"

EQ

### Target Audience:

Nuclear Power Personnel

- * Engineers/Managers
- * Modifications
- * QA/QC
- * Mechanical Maintenance
- * Other interested persons

Figure 11. Course Content, Introduction to Mechanical Equipment EQ

## Seismic Qualification (SQ) of Mechanical and Electrical Equipment

### Course Content:

* Defines Safe Shutdown Earthquake (SSE) and Operating Basis Earthquake (OBE)
* Defines Richter/Mercalli Earthquake Scales
* Provides Evolutionary Chronology of SQ
* The National Standard, IEEE-334 for SQ
* Regulatory Requirements for SQ
* Unresolved Safety Issue A-46, NRC
* Seismic Qualification Objectives
* Seismic Qualification Methods
* Acceptance Criteria for SQ
* Seismic Loads - Horizontal, Vertical, & Amplification
* "SQUG" Seismic Experience Data

### Target Audience:

Nuclear Power Personnel

* Engineers/Managers
* EQ Program Personnel
* QA/QC
* Maintenance Foremen
* Other interested persons

Figure 12. Course Content, Seismic Qualification of Mechanical and Electrical Equipment

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# EVOLUTION OF TECHNICIAN AND MAINTENANCE TRAINING

D. R. Clifton

Diablo Canyon

ABSTRACT

In the past five years Maintenance Training at Diablo Canyon Power Plant has evolved into a sophisticated and strongly supported organization. The key elements in the successful transition have been management support and plant specific "hands-on" training equipment.

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Although we may call our programs by different names, or arrange them differently under the Technician and Maintenance umbrella, those of us working in maintenance training areas face the same issues and challenges of the nuclear industry. I would like to share our experiences from the DCPP program and identify the goals and challenges we see ahead. In the process, I want to leave you with some suggestions which you can take and use to improve and gain more support for your maintenance training programs.

## HISTORY

My work in preparing this presentation has given me an opportunity to step back and gain perspective on where we've been in the past five years and where we still need to go. We've come a long way since training was either an "add-on" responsibility of someone with a full-time plant job, or a trainer who belonged to a line department in the plant spending the majority of time being a jack of all trades. We were assigned to do whatever needed to be done; procedure writing, conducting interviews, etc. We did conduct training, but it could be best described as reactionary, "knee jerk" training. We were eternally in the reaction mode responding to problems, but not organized or properly staffed to conduct the training which could help prevent these problems. You have probably faced the same, or similar, issues and may have made similar or even better decisions than we did. We can all learn from each other.

In November 1983, Diablo Canyon formed a formal Training Department with its own Department Manager. This was obviously a crucial step in our evolution. We now had an organization that could truly devote 100% of its efforts to training. The impetus behind the formation of the Training Department was the recognition by PG&E management that we had to make a total commitment to achieve INPO accreditation and improve our training programs.

At DCPP we placed the following programs under the Technician and Maintenance umbrella: Instrument and Controls (I&C), Mechanical Maintenance, Electrical Maintenance, Chemistry, and Radiation Protection.

Things were looking better all the time. We could now devote ourselves full-time to training. We were able to hire additional instructors and we developed and conducted formal training classes. Our programs became more defined and organized; we had lesson guides in the files and A/V materials on the shelves. Unfortunately, we also noted that while we were gaining enthusiasm and momentum, our students appeared in some cases to be burning out.

At that time our programs were 100% lecture based and covered general topics such as Systems and Administrative Procedures. We found that we couldn't hold the interest of our students and that they were reluctant to attend training. At the same time we noted the tremendous success that the Operations Training Section was having with their newly constructed Control Room Simulator. The Simulator was making a dramatic impact on the operator programs. We noticed training hardened Operators suddenly became involved, and even enthusiastic about training. Instructor and student involvement was impressive; results were excellent. The hands-on application/ simulation approach was so effective that we decided we would do something similar in Technician and Maintenance Training.

We stepped back and took a long look at our program. If we were going to do application/hands-on training in the training environment, we had to have corporate support for the facilities and equipment needed for this training.

Historically, the plant environment was used to accomplish hands-on training but the plant is not a training environment. Its use for training was severely limited because of the need for production. When a plant component is down for maintenance, one cannot afford to take the time to train on it. In addition, training on operating equipment not only interferes with the personnel trying to operate it, but there is a higher risk of a plant trip since a training evolution by its nature has a higher probability of error. You need a separate training environment, complete with the equipment, if you really expect to accomplish anything. Trainers need the freedom to let students "use" the equipment without holding them back for fear of an impending plant trip.

It was at this time that the concept of the T&M shops and labs was formed. The key point here is that we had the commitment from upper management that allowed us to move forward. We were also fortunate to get our lab equipment incorporated into our building budget. This eliminated the need for continual justifications that would have taken forever on a piecemeal approval process. If you're in the process of collecting and developing training aids, you need to have some broad blanket type purchasing agreements to get the programs up and going.

We went on to construct a second training building with approximately 30,000 square feet dedicated to Technician and Maintenance training. The labs and shops were designed around the equipment that we planned to use in them. We talked to other utilities to find out what was included in their labs and learned from their experience.

One of the first things we noted was that if the lab equipment allowed us to only address the basics, we would be severely restricting ourselves and the usefulness of the labs. With a static population of students there is only a finite amount of basic training one can do. Once that has been accomplished, there is nowhere else to go. Additionally, the journeymen always feel they understand the basics and want something more and even though that's not always the case, traineers need to be able to show them more. Using the concept of incorporating plant specific training equipment into our basic training equipment allowed us to go beyond just the basics. The concept of plant specific hands-on equipment for training was the most significant decision that we made. It is what has made the T&M programs work and allowed us to gain the plant's full support for training.

## PLANT SPECIFIC EQUIPMENT AND HANDS-ON TRAINING

I don't want to mislead you, we do have some standard "baseline" training equipment. We have Lab Volt equipment that supports basic electricity and electronics, AC/DC electricity, motors, motor controllers, etc. although they are valuable, they are not enough. Students can learn basic principles on generic equipment, but the more immediate benefits to the plant are the skills and knowledges one can gain from training on actual plant componentry.

The best example of this philosophy involves one of our first purchases; our Reactor Coolant Pump (RCP) mockup. When we first looked at purchasing training aids, my Department Manager asked our Maintenance General Foreman which he preferred for training: a 1/3-scale acrylic model of a Reactor Coolant Pump or a full weight, full sized mockup. Without hesitation, the General Foreman said he would like to see the full weight, full sized mockup. Prior to that I had already written off the full weight, full size mockup as being unattainable because of cost. That acquisition made me realize what we were tasked with accomplishing and what resources we would need to do it. If you're going to commit to effective maintenance training, you cannot skirt the issues and avoid the commitment to buy the necessary resources. Equipment acquisitions must have the same priority given to Operations training; they need to be able to work on and practice with plant type componentry and equipment.

The full scale, full weight RCP mockup has been one of the best investments we've made. The plant maintenance people recognized the value of the mockup from day one. We didn't have to try and sell them on its value. They wanted to get their hands on it; they could immediately see the benefits of training on it. The RCP mockup also has the additional benefit (as do many of the mockups) of serving to address our ALARA (as low as reasonably attainable) concerns for radiation exposure control. We use the RCP mockup prior to each outage to qualify our crews. Its use has resulted in not only exposure savings for the plant, but also increased productivity of the workers and better reliability of the Reactor Coolant Pumps in the plant.

With plant specific equipment we can do what it takes for effective and meaningful "hands-on training" in our Maintenance training programs. Lecture based training is not enough. You must provide your students with the opportunity to take equipment apart and put it back together if you want to hold their interest and build their skills. They need to be able to make a direct connection between their work and training. If they view training as useful and something that will help them do their job, they will be self-motivated to participate. The students we deal with do not want to talk about abstract theories. They relate best to what they can get their hands on, so it only makes sense to provide them with what works best for them. We even go so far as to construct work packages for many of our hands-on activities. This accomplishes two things: it makes the training activity more realistic, and steps the workers through the administrative portion of the work activity. In our business, as you well know, the paperwork is just as important as the repair itself.

## FACILITIES

I've talked about the concept behind the labs and our training philosophy for Technician and Maintenance Training. Perhaps what would work best now is to briefly go through each of the labs and tell you a little about them.

### Chemistry Lab

For our chemistry and radiochemistry people, we duplicated and sized our labs for the existing plant equipment. In addition to the basic chem lab facilities, we have a one for one relationship with the plant in terms of the chem and radiochem lab equipment. Examples of some of the equipment are:

Atomic Absorption Spectrophotometer (AA) - Used to analyze liquid samples for dissolved metal content

Boron Titrator - Gives automatic analysis of boron concentration

Ion Chromatograph - Gives automatic analysis of liquid samples for ions in a complex solution (single sample broken down into its elements and concentrations of same)

Gas Chromatograph - Identifies and quantifies gases

Spectrophotometer (UV) - Sophisticated color comparitor used to analyze impurities in liquid samples

TOC Analyzer - Analyzes total organic carbon content of a liquid sample (used in corrosion analysis)

Radiochemistry Lab

Canberra Counter and Detector System - Used to analyze samples for radioactive makeup and concentrations (use for both liquid and gaseous effluent analysis)

Liquid Scintillator Counter - Used to analyze and quantify low energy Beta radiation

Tennelec Counter - Used to analyze air samples and removable contamination smears

An example of what plant specific training equipment can do is demonstrated by our Canberra Radiochemistry Counting System. When the plant made the decision to upgrade to a new counting system, Training was the first to get the new equipment. We set it up and tested it. The plant department engineers came out and used it to develop procedures, and then the Training group used the new procedures to train the technicians. When the plant changed over to the new system, there was little or no confusion, everything was tested and proven and everyone was fully trained to operate the new equipment prior to installation. It allowed for a smooth transition in the plant.

## Radiation Protection Labs

The Radiation Protection lab facilities were designed with a slightly different approach. The plant equipment was still duplicated one for one, with the portable radiation instrumentation used by the plant. But in general, we felt that we just needed training space to meet their needs. Two labs were dedicated to Radiation Protection area. The first is a small lab built to conduct training and experimentation with the hand held, portable equipment. A second, larger lab was also built for multi-purpose activities without dedicating it to any one specific piece of equipment. This large, clear area may be used for training on contaminated area work practices, suit up for Steam Generator entry, etc.

## Electrical Lab

For our electricians we actually utilize two labs. One of them they share with the Instrument and Controls (I&C) Group, but the one I want to talk about now is what we call our Electrical Rotating Machinery Shop. It contains several basic Lab Volt Training Systems that deal with AC and DC motors, power transmission, troubleshooting, wiring, and basic power modules. In truth, we haven't utilized the majority of this equipment to any extent. A great deal of our time in this lab has been spent on power operated valves and breakers. Again, I am talking of plant specific equipment; limitorque and rotorque valve operators, electrical breakers, and relays.

## Mechanical Shop

Our Mechanical Maintenance Training Shop is a fully equipped maintenance shop, complete with milling machine, lathes, and drill presses. Yet again, the majority of our training has been on equipment components or mockups. Examples of these are:

Reactor Coolant Pump (RCP)

Lower Portion of Steam Generator

Pumps

Valves

Turbines

Snubbers

Freeze Seal Mockup

Here again, we went for plant specific equipment whenever possible. We acquired a good number of valves and snubbers from the plant scrap piles, but for our larger pumps and turbines we went to salvage yards. It was strictly a cash and carry operation with traveler checks and a u-haul truck, but it's the only way to get what is needed at a reasonable cost. To pull it off, your people must be able to recognize what they need and where it will fit into their training programs.

I'm quite proud of what our mechanical trainers have accomplished. To give you an example of what I mean and how far we'll go, our latest acquisition is a full sized 16 cylinder ALCO diesel engine. It served as a locomotive engine and is in running condition; we got it for about a dollar a pound.

## I&C Labs

The next three labs I want to talk about are labs that were developed for our Instrument and Controls technicians. The first lab is a multi-purpose one called the Basic Electricity/ Electronics Lab. It has a Lab Volt System for training on AC and DC electricity, digital electronics, and microprocessors. We also use the lab as a general classroom for test equipment and soldering training.

The second I&C lab is what we call our Process Lab. In our Process Lab we took the standard Lab Volt process training stations (temperature, pressure, and level) and redesigned them to allow us to do advanced training using plant specific equipment. Doing this enabled us to set up or mimic all the various plant processes. This lab, because of its design, has unlimited capabilities. We can replace, relocate and modify the process stations to incorporate, test, and train on new equipment. We have the ability to continually revise and update the system. Recently we added an in-line pH and conductivity system similar to that installed in the plant.

Once again we procured the plant's process controller, a Westinghouse 7100 Process System, allowing us to duplicate the plant process loops in the lab.

I've saved what we call our Integrated Plant Systems Lab (IPS) until last. This lab contains plant specific componentry such as NIS (Nuclear Instrumentation System), SSPS (Solid State Protection System), Rod Control, DRPI (Digital Rod Position Indication) System and DEH (Digital-Electrical-Hydraulic) Turbine Controls, and an actual control rod drive mechanism. All of this equipment is operable with simulators to simulate redundant trains found in the plant. This allows the I&C technicians to get their hands into the heart and soul of plant equipment which is virtually unavailable to them in the plant. It also represents the most critical equipment they work on. And if you haven't noticed, I&C activities cause a good number of our plant trips.

A quick example of what can be accomplished in this lab is demonstrated by a DRPI lab session we conducted early on. It was one of the first courses we taught in the IPS lab. As part of that course we inserted an error in the system similar to one the plant had previously experienced. In the plant the DRPI system has componentry located both in and outside of containment. The actual plant incident took several hours and three containment entries to locate and fix the problem. Following the hands-on DRPI training, the students were given the identical situation experienced in the plant. They were able to determine and fix the problem within fifteen minutes. They did this without accessing equipment that would have required a containment entry in the plant.

The IPS Lab conceptually started with the idea of selected static Westinghouse components that could be powered up for training. About the same time we were designing our labs, equipment from Marble Hill became available. We were fortunate because much of this equipment was virtually identical to our own plant equipment. Instead of a few drawers of equipment, we were able to acquire entire and complete systems. While we were fortunate to get the equipment relatively inexpensively at that time, I would still push for it today even at a higher cost. I believe it can pay for itself by providing meaningful training for the technicians which relates to less down time for the plant and fewer trips.

Now that I've gone through the labs and told you of all their virtues and possibilities, let me temper it with a word of caution. While I honestly can't think of anything better to train with, the labs will eat you alive in terms of instructor time. As one might imagine, it takes a good deal of effort to track and make appropriate modifications with plant specific equipment to maintain its currency. It also takes a great deal of time to simply maintain the lab equipment. There are parts to be ordered and functional tests to be made. There is also a good deal of lab preparation necessary prior to a class. The equipment has to be configured properly and a dry run of the exercise made. It takes a great deal of time and effort to make the labs effective but they're worth every minute that it takes.

## PROGRAMS

We did everything when it came to the development of our programs; an in depth task analysis, extensive design and development, implementation and evaluation. I don't want to get into those areas today, but will suffice it by saying, "Don't lose the big picture by getting too involved and detailed in the analysis and design areas." No matter how much up front work you do, it's the implementation and evaluation that makes or breaks the programs.

## QUALIFICATIONS

When we started out in 1983, we were happy to have instructors, lesson plans, and students. Considering where we came from, what more could we have asked? But as we went forward, it became apparent that the process was still incomplete. We needed something more. What we needed to close the loop was a "Qualification System." We developed and incorporated qualification systems for all of our training groups but we have had varying degrees of success with their implementation in the plant. Some of it has to do with how people are assigned work in the plant and some of it has to do with a too complicated tracking system on our part. A good deal of the difficulty has to deal with the sheer size of our programs and the effort it takes to keep everything aligned within it. If a worker were to take everything available for each program, and qualify on all tasks, it would involve very substantial amounts of classroom training and lab training.

| | |
|---|---|
| Chemistry and Radiation Protection | 1470 hrs |
| Electrical Maintenance | 1600 hrs |
| Mechanical Maintenance | 1400 hrs |
| Instrumentation & Controls | 2000 hrs |

The qualification program is an area we need to continue look at. We must make our qualification programs easier to maintain and, at the same time, work at developing a better method of qualifying people for the majority of the tasks.

## SUMMARY

I have given you a brief picture of what we do at DCPP for Technician and Maintenance Training and why we feel it's necessary to conduct our programs the way we do. But what does that do for you today and what can you take with you that will help in your programs?

The number one thing you need is a true and full commitment of your management. Without that commitment, you'll just be beating your head against a wall. So, how can you convince them to buy into Technician and Maintenance Training? Here are some points you might want to use.

1. Maintenance training is every bit as important to the safe and efficient operation of the plant as Operations training.

    a. If plant equipment malfunctions during an emergency situation, it compounds the problems.

We've all seen too many instances where this has happened. Recovery actions are no good if the equipment used in them fails to perform.

b. Equipment down time is money. You can't expect a worker to gain a high level of proficiency on something they've never been properly trained on. The work place can be an extremely costly place to do such training.

2. Increased knowledges and skills of workers have an upward cascading effect. When a worker is more competent and efficient in his work, it is easier for the foreman to assign and supervise the work. Departments are more productive and there is less rework. Ultimately the plant benefits in higher availability.

3. The NRC is taking an increasingly in-depth look at maintenance activities in regard to qualified workers. When something goes wrong with equipment, one of the first things they want to know is if the previous work on the equipment was accomplished by a qualified worker. The NRC does not tolerate the old philosophy of learning by your mistakes when it comes to

maintenance activities.

4. There are other uses for plant specific training equipment and labs other than Technician and Maintenance training. Here are some valuable arguing points one may use to further justify the cost of plant specific equipment.

   a. Operations Training covers all aspects of the power plant from basic theory to complex manipulation of safety systems. The T&M labs are directly applicable to such training. They can use the Integrated Plant Systems Lab to train on items such as reactor trip breakers, safeguards test cabinet, and rod control. The Electrical Rotating Lab can be used to teach basic electricity and electric motors, or we could go to the Process Shop and cover the fundamentals of level control. The possibilities are endless.

   b. The ability to troubleshoot plant problems in the training facilities.

c. Trying out and testing new equipment prior to putting it in the plant.

d. Development of procedures for equipment with the ability to test out and verify that the procedure works before implementing it in the plant.

e. Engineering research by the on-site engineering groups.

f. Implementation of ALARA principles. Reduction of stay time by increased efficiency and practice.

Once you receive management support for your maintenance programs, you have a start. You still must convince the departments for whom you are doing the training that it's worthwhile. Notice I didn't say the department head or manager; I said the department. Unless and until the department organization as a whole feels there is a benefit in training, you won't be completely successful. You must conduct training that they will truly see as a benefit to them, not just something that meets a requirement.

## RADIATION MONITORING TRAINING SYSTEM - AN AID TO PERFORMANCE-BASED TRAINING

C. L. Boudreaux

ABSTRACT

This paper covers the use of plant-specific equipment used for hands-on training of plant personnel. Specifically, we will discuss the Radiation Monitoring Training System; however, the application applies to any component or system utilized to support a performance-based training program.

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### INTRODUCTION

To be effective, a true performance-based training program must encompass more than one phase, or setting. A supervisor measures the success of a training program by determining if his personnel are more effective during the performance of their job once these employees leave the training environment. If the employee gains knowledge but cannot actually perform the task, training is not effective. Conversely, if the employee can perform the task but does not understand what he is doing, training again is not effective. To be effectively trained, the employee must have the knowledge required to understand what he is doing and why, and he must be capable of performing the task.

Most power plants try to accomplish this training in two steps - classroom training and on-the-job training. This is fine, but what do we do when the plant equipment is unavailable for on-the-job training? The answer is either to purchase equipment for training or provide vendor training for these employees.

This is the basis for my talk today.

## WATERFORD-3's QUALIFICATION PROCESS

The qualification process for Louisiana Power and Light's Waterford-3 maintenance personnel is quite extensive. For each area of qualification, the employee is required to possess the prerequisite knowledge and training, satisfactorily complete classroom training for that area, complete the OJT Checklist for that area, and satisfactorily demonstrate his knowledge during an oral examination.

We have observed that the OJT process for some areas requires an extensive amount of time to complete. Upon further investigation, it was discovered that tasks could not be performed because the equipment was unavailable for training due to plant constraints. Additionally, Maintenance personnel could not develop their troubleshooting skills because they might not be available when the equipment malfunctioned.

Because of the extensive time required to complete the OJT process, the maintenance backlog increased on the Radiation Monitoring System due to the inadequate number of personnel qualified.

## THE DECISION - Vendor Training or Plant Training System

When plant systems are unavailable for training, what do you do? Typically, the choices are vendor training (offsite or onsite) or procuring a plant specific trainer or mock-up. Both are expensiv propositions.

In the final analysis, offsite vendor training is a quick fix at best. Plants can usually afford to send only a few people at a time, and, unless specified, employee training is not plant-specific, but generic to all facilities.

Onsite vendor training can accommodate more personnel and can be plant-specific. However, unless the vendor can provide plant- specific training aids (usually very expensive), the employees receive no hands-on-training.

The other choice, procurement of plant-specific training mock-ups, provides many long-term benefits: immediate reinforcement of classroom training, full control of malfunctions for troubleshooting skills training, availability of training mock-ups for continuing training, minimizing impact on plant staff because of the ability to conduct multiple training sessions onsite and the capability to provide discipline cross-training specific to each discipline's needs.

## Radiation Monitoring Training System

Waterford-3 used a combination of the training choices for RMS training. For immediate needs, selected personnel were sent to the vendor's facility to participate in site specific classroom and hands-on training. For long-term requirements, a site-specific Radiation Monitoring Training System (Figure 1) was purchased. The system was installed in the LP&L Skills Training Center in October, 1988 and contains each type of Plant Radiation Monitor as well as an operator's console. System operating characteristics are similar to the plant's Radiation Monitoring System including full loop communications. Components of the system are: RM-11 Operator's Console with Bantam-11 computer (Figure 2), Portable Area Radiation Monitor (Figure 3), Liquid Radiation Monitor (Figure 4), Particulate, Iodine, & Gas Radiation Monitor (Figure 5), Wide Range Gas Radiation Monitor Conditioning Skid and Wide Range Gas Radiation Monitor Detector Skid (Figure 6), RM-80/Customer Interface Junction Box (Figure 7), and Portable RM-23 (Figure 8).

Modularized training courses were developed to facilitate classroom, hands-on-training, and troubleshooting skills training for each type of monitor. Each training setting is evaluated before proceeding to the next module. The course final exam covers complete system diagnostic troubleshooting of instructor-controlled malfunctions.

The first course, which spans six weeks, was completed December 16, 1988. Participants included personnel from I&C, Health Physics, Engineering, and Quality Control. While the course is specifically designed for I&C technicians, diverse input from other disciplines really enhanced the course.

An additional feature of the RMS Training System is the ability to test printed circuit cards after they have been repaired prior to installation in the field or storage in the warehouse to ensure full operational capability. This allows onsite repair, testing and engineering evaluation instead of sending cards to a vendor for repair.

Additionally, because the course if modularized, it can be used for requalification training of operators and other disciplines.

## CONCLUSION

Although initial capital costs may be quite expensive, the advantages offered by a plant-specific training mock-up make up for this expenditure over the long term. While we talked about one particular training system, I hope that you can see how this could apply to other hands-on training systems or components in completing the cycle of a good performance-based training program.

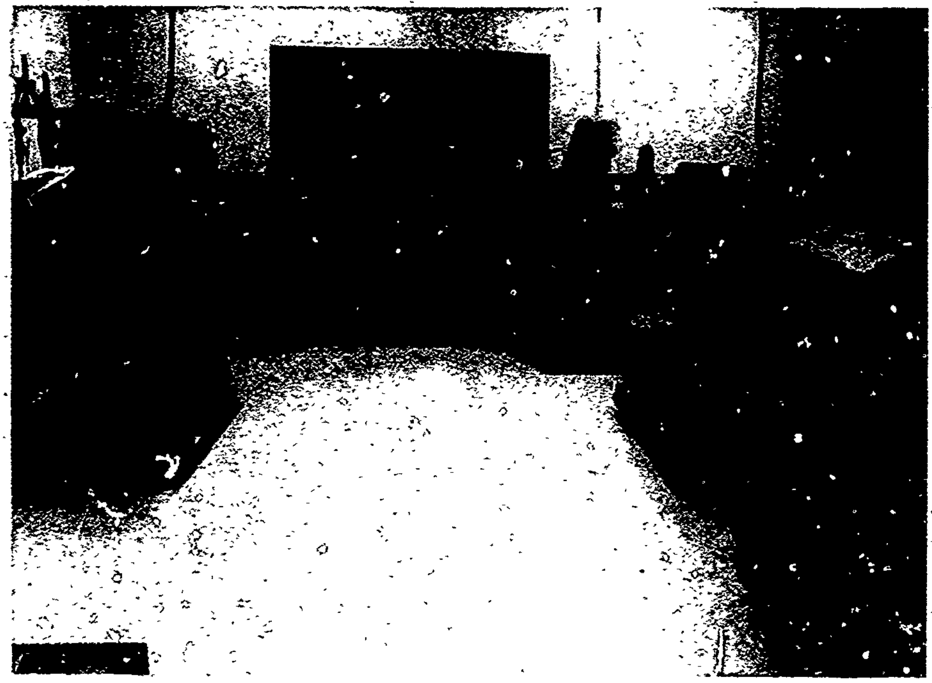

FIGURE 1 RADIATION MONITORING TRAINING SYSTEM

This room is used to house the Waterford-3 Radiation Monitoring System Trainer. Trainees receives hands on training using plant-specific procedures with an emphasis on using proper maintenance techniques.

This room contains each of the following: an RM-11 Operator's Console, a Portable Area Radiation Monitor, a Liquid Radiation Monitor, a Particulate, Iodine and Gas Radiation Monitor, a Wide Range Gas Radiation Monitor, an RM-80/Customer Interface Junction Box, and a Portable RM-23.

FIGURE 2 RM-11 OPERATOR'S CONSOLE

Right Cabinet

RM-11 Operator's console with a Aydin Display CRT at the top, associated keyboard in the middle, and a Bantam-11 computer in the bottom.

Left Cabinet

Contains three RM-23 modules which are used to interrogate radiation monitors for information and status, one WRGM Timer Panel which is used to time the Grab Samples taken remotely from the WRGM Sample Skid, and five chart recorders for the different monitors. This panel simulates the panel that would be found in the Control Room.

FIGURE 3 PORTABLE RADIATION MONITOR

This unit monitors gamma radiation and provides local indication and alarms. It has an RM-80 for signal conditioning and communication with the RM-11 Operator's Console.

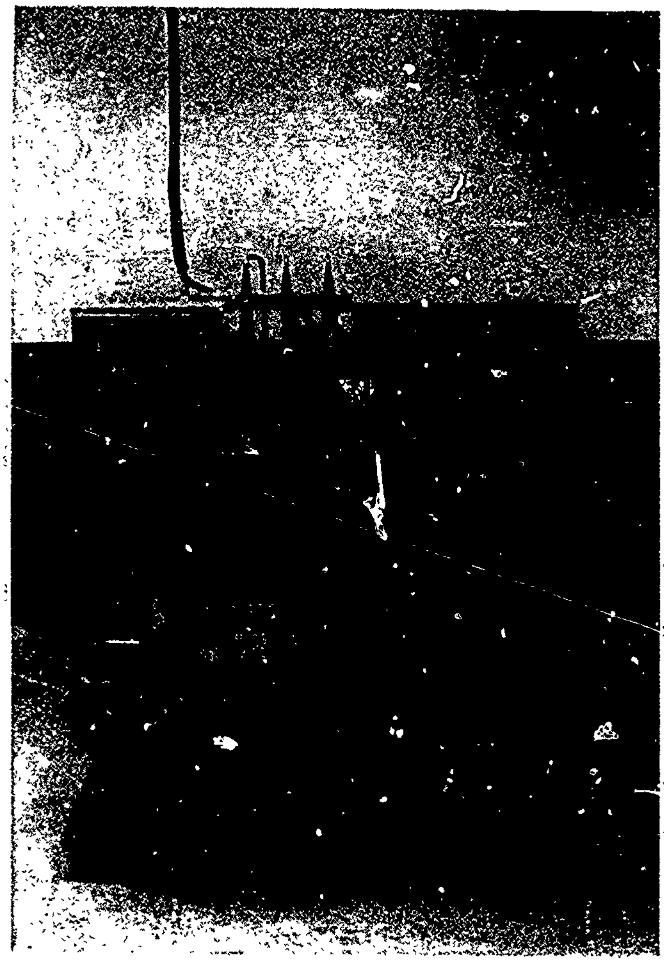

FIGURE 4 LIQUID RADIATION MONITOR

The Liquid Radiation Monitor measures gross radioactivity concentrations of plant liquids from a sample stream.

This unit contains an RM-80 microprocessor, sample flow heat exchanger, detector and detector chamber, and a power control center.

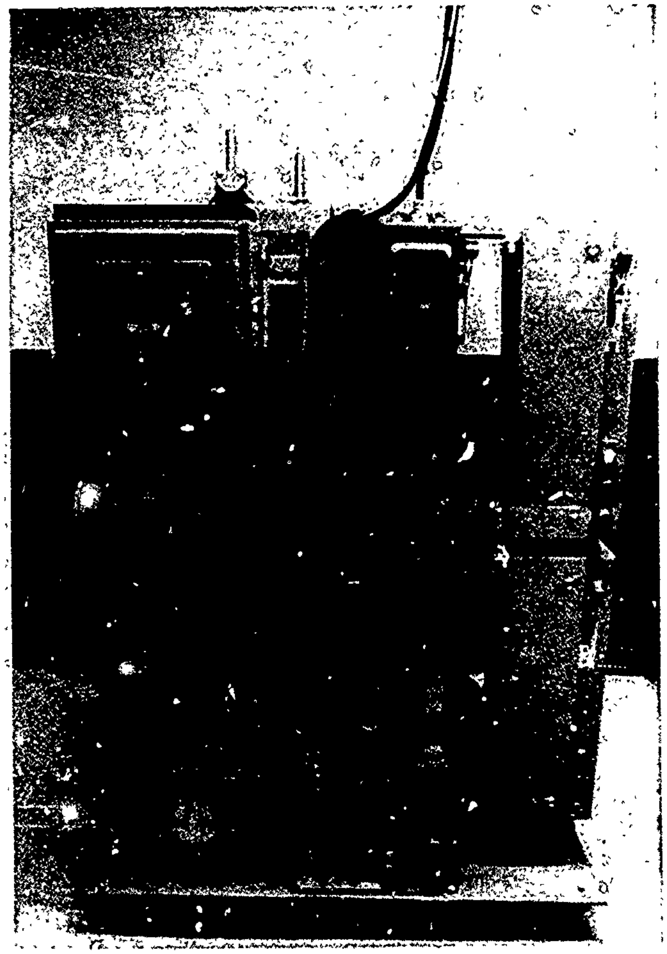

FIGURE 5 PARTICULATE, IODINE
AND GAS RADIATION MONITOR (P.I.G.)

This unit measures particulate, radioiodine and noble gas concentrations from a single extracted sample distributed into separate sample streams.

The skid contains a RM-80, sample pumps, detectors, and various power control panels.

FIGURE 6 WIDE RANGE GAS MONITOR (WRGM)

On the left, the Sample Condition Skid provides particulate and iodine grab samples for laboratory analysis. It also filters out large concentrations of radioiodine and particulate in order to prevent detector skid contamination.

On the right, the Sample Detector Skid Assembly extracts from the effluent stream a gas sample that is representative of the conditions that are present.

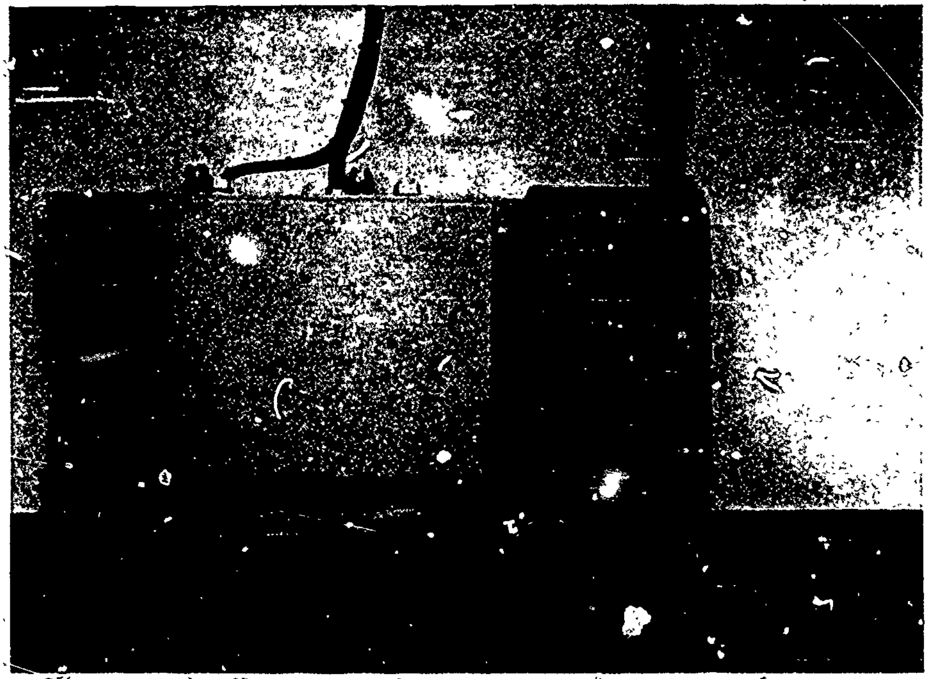

FIGURE 7 RM-80/CUSTOMER INTERFACE JUNCTION BOX (CIJB)

Wall mounted unit which contains RM-80 enclosure on the right, a CIJB in the middle and a power safety switch on the left used only with Wide Range Gas/Monitors (WRGM).

The RM-80 is the central processor and control unit which provides detector and process transducer data collection and reduction, data analysis and display, data storage and history files, alarm generation and process control.

The CIJB provides terminal blocks for customer connections and system interface, high current contact relays, sample flow amplifiers and optically isolated converters (voltage to current).

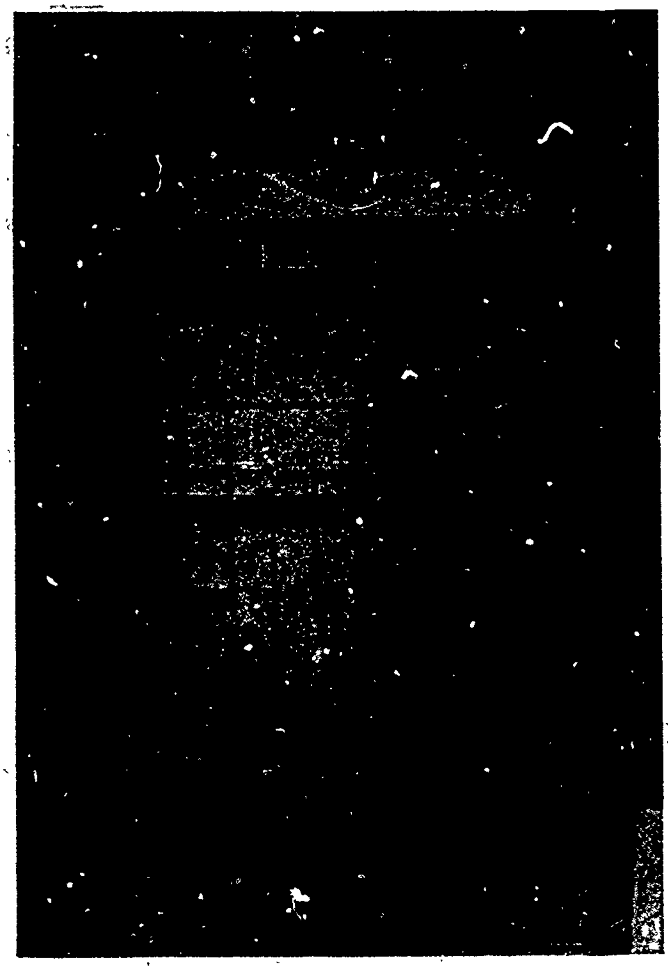

FIGURE 8 RM-23P

The RM-23P is a portable unit that contains a standard RM-23 module and a power supply mounted in a portable carrying case.

This unit is used in daily operations of testing and troubleshooting. It connects directly to the RM-80 and allows the technicians to gather data and make data base changes.

# MOTIVATION IS AN ATTITUDE

Dennis E. Mannering

Motivation is a very popular topic these days. When our company is called by an organization to provide training, most often the topic we're asked to address is "motivation." Our first question is usually "How many people do you have working for you?" The typical answer is very close to "Oh, about half of them," or "Well, Joe's been working ever since we threatened to fire him." The sad truth is that many people quit looking for work the minute they find a job.

Why is this? What has happened to the work ethic in America? The youth of today, when asked to use five descriptive words for work, use words like "hard," "boring," "dull," "dirty," "tedious." Why do so many parents subject their children to listening to their complaints about their work?

One teenager I was interviewing observed, "I get home from school before either Mom or Dad do. Then Mom gets home and warns not to talk to her because she had a 'bad' day at her 'awful' job because of her 'terrible' boss. Then Dad gets home. And if you think Mom has a terrible job, you should hear Dad! His is even worse. Sometimes he and Mom actually get into arguments over who has the worst job!" Believe it or not, they both want to win the argument!

Is it any wonder that many young people today dread the prospect of going to work, and that once they get there they are not highly motivated in their jobs? What are their role models telling them?

I am not really pointing fingers, but I **am** searching for the reason why so many workers today are unmotivated and provide the type of role models just described by this teenager.

Obviously, something is missing in the jobs of these dissatisfied, unmotivated people. Too many are waiting for their bosses to do something to motivate them to work.

There are numerous ideas on what motivates people. Labor unions would have us believe higher wages and fringe benefits will do the trick. Employers would love to believe their workers really want to help them make a big profit. Every once in a while, a company gives its workers a raise or a new fringe, and everyone is happy. . .for a while. But, in a matter of time, the same problems arise. Discontent returns. Motivated people become harder and harder to find. Why?

### Motivation vs. Movement

I believe there are several reasons. One is that many employers really don't want motivated workers. They confuse the word "motivation" with the word "movement." They want people who do **what** they want, **when** they want, and **how** they want it done. Now, a motivated person may not necessarily do just that. He may be looking for new and better ways to do things. He may rock the boat by suggesting innovative ideas for a company content to do things **the way they've always been done.** So the motivated employee may find his ideas squelched and, along with his ideas, his motivation.

To further illustrate the difference between motivation and movement, I like to use the example of the little dog I used to have when I was a boy. Every morning he would lay in front of our gate to wait for his last bit of attention before I left for school. Now, there were two ways I could get him to move so that I could get through the gate. I could firmly plant my foot in the center of his behind and he would move. Or, holding up a biscuit, I could call the dog and he would come running. In the first method, the dog moved because **I** wanted him to move. That is movement. With the second method, the dog moved because **he** wanted to move. That's **motivation.** He had an inner directed desire to move. . .for his reasons, not mine.

### Four Statements on Motivation

That brings us to some other statements about motivation. **Number one, you can't motivate other people!** As you can see from the examples I've used, you may move people but you can't motivate them. That's got to be an inside job. What you **can** do is create an environment in which an individual will be positively motivated. I'll explain more on this point later.

**Second,** and you may find this hard to believe, **all people are already motivated.** The catch is, it's not necessarily positive motivation. That student or worker who is habitually late for school or work is motivated to sleep late or, perhaps, to party too late into the night. The salesman who spends more time in the coffee shop than out with his clients is motivated to socialize or relax rather than work.

**Third,** and one of the hardest principles of motivation to understand, is that **people do things for their reasons and not your reasons.** In other words, trying to convince or motivate someone to do something by showing them how you'll benefit is futile. You would be much more effective by recognizing the needs of the individual and showing them how **they** stand to benefit. To tell a worker that it will benefit you, the supervisor, will not motivate the worker. But if you can illustrate to the worker that a certain action will make the job more interesting for him - there's motivation. He'll be doing something because he wants to do it.

The ability to recognize individual needs is a skill which must be developed to apply my **fourth** basic statement on motivation, as well. That statement (admittedly said in many ways before) is this: **If you treat all people the same, you are mistreating half the people.** "Now wait a minute," some might respond. "Is that what you're saying? Haven't **you** ever prided yourself on being 'fair' with your employees, your students, your children by dealing with each one in exactly the same way?" I would, in turn, ask this question: Did you find the effectiveness of your "fair treatment" was equal in each situation, or were you more successful with one individual than another?

I am assuming the answer to the second part of that question is "yes" simply because I have found that no two individuals respond to the same stimuli or treatment in the same way. Why? Every person has different needs for every facet of his or her life, from job challenges to recognition to social needs.

Vince Lombardi was a master at recognizing individual needs. One story told about him involves Paul Hornung and Jerry Kramer. Lombardi knew that what motivated Paul Hornung to play his heart out for the Green Bay Packers was different from what motivated Jerry Kramer to do the same.

Paul Hornung was a player with average talent in several positions on the field. Lombardi recognized this, decided to make Hornung "Mr. Versatile," and proceeded to convince Hornung he was just that . . . "Mr. Versatile." Lombardi would put his arm around Paul and say, "Paul, you're the greatest. Now get out there and show the crowd how terrific you are." And Hornung did.

Now, Jerry Kramer was a man blessed with a great deal of talent but he was just a little on the lazy side. Lombardi recognized both traits and knew just what he had to do. When Kramer would come off the field and say, "How'd I do, Coach?" Lombardi would hold his nose and say, "You stunk up the field! Now get back out there and get to work!" Along with those seething words often came a swift kick in Kramer's behind. How did Kramer respond? He went out there and performed even better than before.

Years later, when asked why he didn't kick Hornung like he kicked Kramer, Lombardi roared, "Because he probably would have kicked me back!" Whether this part of the story is exaggerated is not really of importance to me. What Lombardi was really saying was that he knew each player responded to a different type of recognition and reward, and he was willing to do what he had to do to meet those individual needs. Did this philosophy work for him? I believe his record of success speaks for itself.

### The Unquenchable Thirst

There was another fellow by the name of Abraham Maslow, a noted psychologist, who studied the nature of man in depth and developed the theory that all human beings follow a sort of step-by-step progression of needs as they go through life. As our needs are met, according to Maslow, we move up the ladder to the next level of need which motivates us to work and strive to attain satisfaction. I believe his theory helps us to understand those needs which motivate people and it also helps employers and supervisors practice appropriate motivational techniques with each individual.

To illustrate Maslow's "Hierarchy of Needs," I'd like to use the story of Charlie, a poor soul who is out of work, tired, cold and hungry. This illustration takes place at the turn of the century when there was no such thing as welfare, so Charlie is desperately seeking employment.

Picture Charlie walking along a dirt road. He comes upon a sign which simply states "Ditch Diggers Wanted - Apply Within." Being hungry and tired, he rushes in to the office and eagerly asks the manager for a job. The manager replies, "Well, Charlie, we don't pay much in wages here, but see those uniforms over there? We'll provide you with five of those woolen shirts and five pair of woolen pants plus two pair of warm boots. Also, my wife is a terrific cook and we'll provide you with three warm meals each day. And out behind our house are the workers' barracks. You can sleep there free of charge."

Needless to say, Charlie took the job and for the first time in weeks he was warm, full of good food and had a good night's rest. His **physical needs** were met. And was he motivated? You bet! He dug ditches like ditches had never been dug before. . .for two weeks.

Then, one day, the manager came by and saw Charlie leaning on his shovel. "What's wrong, Charlie. Why aren't you working?" the manager asked.

"Well, boss, you know that **one** night off you give us? Well, I went down to the local tavern and I was talking with some guys from the ABC Ditch Digging Company. And you know, they've got Blue Cross/Blue Shield. We don't have that. What if I drop a shovel on my toe? Who's going to pay for that? And they have a retirement plan. I mean, they have **security!** I want the same!"

"Well, Charlie," the boss replied, "that's asking for quite a lot. I'm sure we can do that for you. But my wife's my partner. I'll talk it over with her and we'll see what we can provide."

A couple of days later, Charlie is informed that he now has all the insurance he needs plus a healthy pension plan. Wow! Was he motivated! He felt secure in his job and was again the best ditch digger around. . .for three weeks.

Then, one day, the boss came walking by and there was Charlie leaning on his shovel. To be honest, the boss was perplexed. How could Charlie be dissatisfied? He had good food, warm clothes, a warm place to sleep, health insurance, dental insurance and a terrific pension plan. What more did he need? When questioned, Charlie replied, "Well, boss, I had a chance to get into town on one of the **two** nights off you've given us, and I was talking to the guys from ABC Ditch Digging Company. You know, boss, they have a bowling team. Every Christmas they have a party. And besides that, I'm tired of working next to Harry. He has bad breath! I want to work over there, next to. . .Arlene! You see, boss, I have some **social needs!** I want to feel like I belong somewhere."

This all made sense to the boss and his wife. So to please Charlie, they organized a bowling team, had a big banquet and party at Christmas, threw in a summer softball team and yes, moved Charlie so that he could work next to Arlene.

Did that motivate Charlie? You bet! For about. . .six weeks. Then, you guessed it, the boss came walking past and there was Charlie, leaning on his shovel.

"How could this be?" the boss wondered, and he confronted Charlie. "What **is** the problem? We've provided you with good food, warm clothing and a nice pleasant place to sleep. You have health insurance, life insurance, dental insurance and even a profit-sharing plan. You're the captain of the bowling team, chairman of the Christmas party, manager of the softball team and you've **married** Arlene! For what more could you ask?"

Charlie, leaning on his shovel, scratched his head and said, "You're right, boss, you've been very good to me, but I'll bet I'm the best darn ditch digger you've ever had. As a matter of fact, I believe I'm the best ditch digger in this county. But, does anyone ever say so? Does anyone ever give me a pat on the back? No! I'd like some **recognition,** you know. Why the other night, I was talking to the fellows down at ABC Ditch Digging Company and they get recognition banquets. They get plaques and sometimes even a gold watch in appreciation of their good work. I never get any gold watches!"

The boss thought it over and after discussing it with his wife, he decided that this was a pretty inexpensive request. So to keep Charlie happy he initiated a recognition plan complete with pats on the back, plaques and gold watches. Surely Charlie would be satisfied now. Surely he would be motivated to do the best job he could!

And surely he was. . . for about eight weeks, when the boss again found Charlie leaning on his shovel looking bored and dissatisfied. The boss was stunned.

He questioned Charlie, desperate for an explanation. "Charlie, what's wrong now? You have everything a man could possibly want: good food, warm clothing, shelter, insurance plans, pension plans, a bowling team, softball team. Christmas parties, summer picnics and a beautiful wife. You've had your name in the paper every week as

'Ditch Digger of the Week.' You haven't room on your wall for any more plaques. Your arm is covered with gold watches. What do you want now, Charlie? **My** job?"

"Well, boss," Charlie replied, "that's basically right! You see, I don't feel challenged anymore. I'm the best ditch digger there is and I'm ready for a job where I can find self-fulfillment. I want to be **self-actualized.** I don't know what that means, but I want it!"

And so we have it: A frustrated worker and an even more frustrated boss. Both are looking for an outside stimulus to create the inner motivation needed for a hard working, conscientious employee. As the story of Charlie illustrates, however, human beings have an **unquenchable thirst** for more and better things, so that "things" and "rewards" and fulfillment of needs are not permanent motivators, but rather temporary movers.

## What is Motivation?

When all is said and done, motivation is an inside job. If a person is truly motivated to accomplish a goal, to be the best in his or her profession, to be a productive and responsible member of society, it is because of a desire that comes from within the person, a desire that remains there even when rewards or recognition are removed. In essence then, a positive, motivated person has a particular **thought process** which manifests itself in the way he **feels** which manifests itself in the way he **acts.**

Thinking. Feeling. Acting. These three words are primary in defining another word which is basic to the rest of this book . . . **ATTITUDE.** In my research and experience I have come to the conclusion that **MOTIVATION IS AN ATTITUDE,** and in the following chapters I will explore the attitudes needed to be a truly motivated and, consequently, successful person.

Excerpt from Dennis E. Mannering's book Attitudes Are Contagious... Are Yours Worth Catching?

# EVALUATING LEARNING STRATEGIES IN OPERATOR TRAINING PROGRAMS

Nan Quinlan

Abstract

Effective and efficient operator training depends, to a large degree, on the learning strategies planned and implemented by the instructor. An understanding of recent related instructional design theories and the learning strategies that emerge from them can provide instructors with powerful tools to help operator trainees achieve success with their learning. An overview of three theories is provided. The depth of knowledge available in these theories can also be used to develop evaluation criteria to determine the effectiveness of selected learning strategies before and during lesson delivery.

A challenge to the operator training instructional design process is the planning of learning strategies to meet the diverse learning characteristics of trainees. As nuclear training moves forward in its mission to "fine tune" training programs there is a need to address these diverse learning characteristics in order to enhance learning effectiveness in high risk training environments.

Learning strategies are external events planned and implemented to activate and support the internal process of learning. The internal learning process cannot be observed nor can it be taught. It can only be influenced through external events supplied by the instructor. Learning strategies cannot be specified in general, but must be designed for each objective. Content delivered with the support of meaningful and relevant learning strategies assists each trainee's encoding process committing new learning to long term memory where it can be retrieved on the job for safe and efficient operation of nuclear plants.

How do instructional designers and operator training personnel responsible for the review and approval of instruction ensure that selected learning strategies are appropriate for stimulating the internal process of learning? First, through instructor tr . ng programs all training personnel must acquire a thorough know .dge of instructional design and learning processes. Acquisition of this knowledge requires study, selection and practice of learning theories and models that go beyond traditional linear approaches to instructional design or adult learning theory. Secondly, an evaluation structure needs to be developed to review planned learning strategies before and during training delivery. The purpose is to ensure that appropriate opportunity is being provided for trainee success. Yes, success! Learning strategies support the internal learning process and the instructor, to a large degree, controls trainee success by implementing learning strategies. To "a large degree" is stated because of the need to consider the human variables involved. Some trainees are more self-directed in the process to internalize new learning. They will develop and use their own cognitive strategies to organize, rehearse, store, remember and retrieve information.

The remainder of this paper will focus on presenting a brief overview of three instructional theories that provide recent knowledge with respect to selection and planning of learning strategies. Each theory has its own language and contains a high level of detailed information that is too expansive to be covered here. Readers should refer to the texts listed in the Reference section for a complete explanation of the theories. The theories were selected because they address micro-level learning strategies. Micro-level strategy design focuses on teaching single ideas or performances specified in objectives.

The purpose of presenting these three theories is to show how learning strategies emerged and were expanded in the last decade. In order to design learning strategies and criteria by which to review them training personnel must have an understanding of the theories and the learning processes they address.

## Learning Strategies: An Overview

The instructional design theory of Robert Gagne of Florida State University and Leslie Briggs is the first theory that brought together research on micro-level strategies. Their instructional design theory focuses on learning outcomes and the conditions that must be present in order for various types of learning to occur. Gagne classified learning outcomes into f e categories; verbal information, intellectual skills, cognitive strategies, attitudes and motor skills. His work contains research on information processing and v idly describes how communicated information is registered and passes through a series of steps into long term memory. What has been learned (learned capability) can be retrieved into working memory (conscious memory) and observed as planned outcomes specified in performance objectives or combined with other information for new learning.

Learning strategies in Gagne's design for instruction gained importance in the model prescribed for intellectual skills. Gagne calls learning strategies "events of instruction" and proposes that the internal process of learning can be assisted by externally activated events during instruction. Gagne developed nine events to support and stimulate the internal process of learning. Learning strategies are designed during the development of instruction after content is selected and sequenced. Selection of learning strategies requires consideration for learner characteristics, type of instruction (learning category) and the training environment. Some may not be needed because they are obvious to some trainees who may be self-directed enough to use learning strategies to manage their own learning. Research has grown in the area of "cognitive strategies." Recent literature contains suggested strategies to help trainees process information. This research appears to create a dual function for instructors; 1) planning and implementing strategies to help trainees internally process the content that needs to be learned and 2) planning and implementing strategies to help trainees "learn how to learn."

Gagne's Nine Instructional Events

The examples provided for each of the nine events is not conclusive. Several additional learning strategies can be found in the literature.

1. Gaining Trainee Attention.

Gaining attention is a fundamental task that must be executed first so that other instructional events can follow. The purpose is to immediately get the trainee involved and participating in the learning through rapid stimulus changes. This may be accomplished through visuals, analogies, presentation of puzzling events, covert thinking strategies, rhetorical questions, hypothetical situations and demonstrations or may simply require that the instructor make adjustments to the environment or his voice level.

2. Informing the Trainee of the Objective.

Trainees will know they have learned only when they know the required performance. Providing objectives at the start of a lesson lets trainees know what they are accountable for while in training. If complex, multi-level objectives exist for a lesson the objectives should be classified and the trainees provided with a list of behaviors they are responsible for demonstrating.

3. Stimulating Recall of Prerequisite Learned Capabilities.

Trainees come to courses with certain capabilities already present. Through formal review or simple questions prerequisite knowledge is recalled to support new learning. Strategies must relate the new and the old learning if trainees are to make appropriate associations to fill knowledge gaps. This strategy is particularly important for operator training where trainees are responsible for linking (chaining) the learning from one course to another. This strategy also gives the instructor the opportunity to make sure that prerequisite learning has been learned to mastery.

4. Presenting the Stimulus Material.

The stimuli used to present training content flow from the performance requirements. Thus if trainees need to learn the facts, concepts and principles for a system these facts, concepts and principles must be communicated. Stimuli can be enhanced through the use of media. Stimuli must also relate to what is to be learned. Relevant stimuli will directly impact trainee motivation by showing task value and connection to a larger goal. With the motivating factor in mind stimuli may include trainee involvement in activities that provide opportunities for choice or cooperative interaction such as role playing with a variety of examples.

5. Providing Learning Guidance

Questions or prompts help to keep trainees on track in a lesson by directing their thoughts to arrive at the correct answer or solve a problem. The amount of guidance to provide depends on the learning characteristics of the trainees.

6. Eliciting the Performance.

The key to this strategy is practice. Relating the required performances to life experiences, modeling the correct response and monitoring practice to ensure accuracy will make learning permanent. Varied practice with repetition promotes acquisition and transfer. Small intense practice sets massed at the start of new learning will result in faster learning. Repetition of the required performance will increase automaticity (performing a skill without interfering with a second simultaneous task) leaving time to work on solving problems.

7. Providing Feedback.

Feedback is provided on the correctness of trainee performance. Opportunities to give feedback need to be planned into instruction to let trainees know how they are doing with the new learning. Positive reinforcement will strengthen the response it immediately follows and make that response more likely re-occur.

8. Assessing Performance.

Trainees may be asked to demonstrate the required performance by applying what has been learned to several examples. In testing it is imperative that the test items and skill demonstrations are congruent with the objectives.

9. Enhancing Retention and Transfer.

The implementation of carefully spaced, relevant and varied practice sets will increase retention and transfer.

Guided by performance requirements in the objectives learning strategies are planned and organized within a lesson in a flexible manner. Often instructors have only an estimate of the capabilities and entering competencies of trainees and have to monitor and adjust learning strategies during delivery of a lesson. The main question that needs to be asked throughout lesson planning and delivery is: Do trainees need support at this stage for this learning task?

## Extensions of Gagne-Briggs Theory and Learning Strategies

As comprehensive as it is the Gagne-Briggs theory did not provide specific guidance on activities that could be used for each of the nine learning strategies for any given type of objective. Recognizing that different models of instruction were needed for different learning situations researchers extended the knowledge base provided by Gagne and Briggs.

The following two theories focus on micro-level strategies. Built on the Gagne-Briggs instructional design framework these theories extend the research to a level of detail that has direct application to operator training. They are applicable because they contain prescriptions for learning in which multi-level objectives must be mastered and the content that supports these objectives is complex and highly detailed.

Researcher Dr. David Merrill offers a Component Display Theory (CDT) that provides more depth to Gagne's three learning outcome categories of verbal information, intellectual skills and cognitive strategies. Although this theory does not address all of Gagne's nine learning strategies it is rich in the guidance it provides. Selection of learning strategies is derived from the CDT's unique prescriptive relationships among three structures. These structures are; 1) a two-dimensional performance-content classification system, 2) a taxonomy of presentation forms, and 3) a set of prescriptions relating the classification system to the presentation forms.

Determining appropriate learning strategies requires stepping through a process to categorize content and capabilities to be learned within a two-dimensional classification of performance and content type. Categories of performance are find, use and remember. Content types are fact, concept, procedure and principle. The theory assumes that for each performance-content type there are primary and secondary presentation forms (learning strategies). Primary presentation forms focus on what is to be learned. Secondary presentation forms add to and enhance the primary presentation forms. The suggested learning activities that come from the CDT includes specific uses for examples and practice. Elaborations for prerequisites, mnemonics, attention devices, feedback and descriptive events are designed to enhance the learning process especially when multi-level complex objectives are the rule.

The CDT is also concerned with trainee control and cognitive processing. Trainee control includes the strategies trainees select to help internalize new learning as they interact with training content. The CDT provides suggestions for planning strategies to foster conscious cognitive processing. Activities may include suggestions to trainees to explain "in their own words" or to ask them to relate how they stored information or procedural steps in their memory.

Like Gagne and Merrill, Dr. George Gropper of Digital Equipment Corporation designed an instructional theory that prescribes learning activities for objectives. His behavioral approach to the design of instruction contains different instructional models for five types of objectives to include: recalling facts, defining concepts and principles, giving and applying explanations, following procedural rules and solving problems. The model for each type of objective requires consideration for the mix of skills specified in the objectives and the possible problems that may effect stimulus-response characteristics.

Each of the models contains three components; 1) routine treatments, applicable to all types of objectives, 2) shaping progressions linking component skills into a complete performance and 3) specialized treatments to assist with learning difficulties. Learning strategies emerge from these components to help trainees achieve the required performance.

At the heart of this behavior theory is the requirement for trainee practice. Reinforcement follows demonstration of the behavior to confirm accuracy. During the learning of a task trainees must be able to discriminate stimuli, generalize, associate and chain. When discriminating a trainee is able to tell one stimulus from another. Generalization means being able to respond to any stimulus belonging to the same class of stimuli. Association is the ability to associate an appropriate response with a class of stimuli and chaining is the ability to combine stimulus-response associations into a complete chain or end performance. Practice helps trainees master all these stimulus-response skills. Selecting learning strategies requires a thorough analysis of the subject matter and the objectives. The analysis assists in determining the stimulus-response characteristics and the treatments to help elicit responses and remedy learning problems. For example, an objective that requires following procedural rules to stabilize a situation necessitates that a trainee learn a long chain of stimulus-response units. Thus a flashing indicator light on a control panel may become the occasion for an operator to close a valve; the closing of the valve becomes the occasion to call a maintenance technician and so on... If the end required performance is to stabilize a situation the operator will have to demonstrate many component skills (recognizing the meaning of the flashing light, closing the valve, calling a technician). Treatments are designed so that at the end of instruction trainees will be able to exhibit all the component skill requirements of the objectives, under the conditions that effect them and to the prescribed performance standard.

Gropper provides six treatment tools instructional designers can use to develop learning strategies for practice tasks. These are; 1, degree of cueing, 2) size of the unit of behavior, 3) the mode of required stimulus-response, 4) example variety, 5) content practice and 6) frequency of practice. All are used in various combinations throughout the practice task. During initial practice strong cues may be required. As mastery increases cues can be faded and finally eliminated as trainees demonstrate the required performance. Cues can be any learning strategy that provides guidance to trainees such as demonstrations, checklists, flowcharts, single words or symbols.

Units of behavior for practice tasks depend on the size and complexity of the behavior to be mastered. Smaller units of practice are designed when many stimulus-response associations or procedural decisions are required. Consideration for the stimulus-response mode may make it desirable to begin practice of new learning by first practicing easier earlier learned performances. This aids in moving practice progressively towards more difficult performances. Early practice of already mastered performances strengthen response recognition, decision and generalization skills plus builds confidence to begin new learning.

Varied practice examples promote generalization and transfer and helps trainees classify new instances of a class of objects, ideas, symbols or situations. Practice content includes practice of the required performance for mastery. Gropper includes additional cues for the practice of content to help trainees make distinctions among closely related stimuli or responses, learn how to prevent errors, learn procedures made up of a long chain of steps and learn principles associated with the performance of procedures. The key to frequency of practice is repetition. Important to transfer, repetition increases response strength. When combined with practice variety repetition enhances acquisition, retention and transfer of behaviors. Decisions must be made before and during the lesson regarding the number of practice tasks needed to progressively move trainees to more difficult practice sets. The culmination is practice of an entire series of tasks. It appears that decisions regarding practice can best be made during training delivery because of the various stimulus-control skill requirements that need to be activated and monitored by the instructor. However, practice sets (part task and cumulative series) need to be carefully planned to ensure trainees experience all component stimulus-response associations that lead to the required performance. Gropper's suggestions for practice sets focuses not only on the use of treatment tools but their organization within a lesson so that the appropriate direct route to instructional efficiency will be reached. Gropper's work provides a level of detail and a variety of behavioral design principles that have direct application to the design of simulator training. Careful consideration and incorporation of Gropper's behavioral principles into simulator training can lead to effective training and maximize the use of simulators.

Implications and Evaluation Criteria

The three theories discussed support the need to make learning strategies part of the instructional design plan. Though there are similarities between the prescriptions each theory provides a depth of guidance and strategy examples that give Gagne's nine events new applications for the complex multi-level objectives found in operator training programs. Classifying objectives according to Merrill's two-dimensional performance-content classification system will assist in prescribing optimal learning strategies to help trainees with their learning. Incorporating and enhancing Gagne's nine events with Gropper's treatment tools will increase retention and transfer.

Operator training personnel responsible for the review and approval of instruction need to evaluate learning strategies as part of the review process. The theories discussed provide the knowledge for evaluation criteria. Below are suggested criteria that begin with Gagne's question for learning strategy planning and delivery.

1. Do trainees need support at this stage for this learning task?
2. Are learning strategies planned to facilitate acquisition of the training content?
3. Are learning strategies planned for retention and transfer?
4. Do learning strategies contain suggestions for trainee cognitive processing?
5. Do learning strategies support the stimulus-response associations for component skill acquisition?
6. Are varied practice sets planned?
7. Is the content to be practiced broken into manageable units of behavior?
8. Are learning strategies appropriate to elicit the required performance in the objective?
9. Are opportunities provided to review earlier learning before new learning is introduced?

Instructors need to evaluate learning strategies when the monitoring of student performance in training reveals that a planned strategy needs changing. At the next convenient break the instructor reviews the content piece and the strategy change. The review helps to ensure that the strategy was appropriate for the performance requirement, presented an appropriate stimulus that resulted in correct trainee response or increased cognitive processing. Trainee actions expressed through questions, confused statements or body language can clue the instructor to make strategy adjustments. The evaluation criteria helps the instructor to decide whether additional instruction, review or practice needs to be implemented before moving on to new learning or administration of the final examination. Ultimately, evaluating learning strategies before training and the adjustments made to them during training will ensure that trainees are provided with several appropriate opportunities to achieve success with their learning.

In conclusion, operator training personnel need to study recent theories in order to prescribe optimal methods for trainee success. In parallel with this study personnel need to examine the curr highly structured linear approach to nuclear training and cons r how the new theories can be an effective and efficient departure to multiple paths focused on learning. There is no question that in operator training the high risk environment needs state-of-the art technology. This state-of-the art technology must be complimented with state-of-the art learning processes.

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SRO SUPERVISORY SKILLS

James W. Holt

## ABSTRACT

Over the past four years, St. Lucie Nuclear Plant has had 64 unplanned shutdowns of which 35 were automatic trips. Eight of these 35 automatic trips were associated with operator error. Analysis has shown that the three top causes of operator error were poor communication, poor supervisory practice, and imposed stress.

Operations Training at St. Lucie has developed a countermeasure that addresses these causes and provides the supervisory skills necessary for the SRO to be the hub of an operations crew. These skills not only apply when all operations are normal but also apply when off-normal and emergency events are in progress. St. Lucie Operations Training Department developed an approach that integrates (∫) Questioning, Intervention, Observation, and Coaching into a task called ∫QIOC (pronounced "sky-ock"). This task is based upon an understanding of Human Information Processing theory and represents the core of SRO Supervisory skills. A classroom setting is used to describe the task and the theory upon which it is built.

After being taught the theory behind ∫QIOC, the students see practical application of its use. Through the media of video the students see control room crews in a variety of situations, from surveillance testing to emergency operations. They view the SRO's proper use of the ∫QIOC task. The instructor will point out missed opportunities to apply this task as well. This helps the student to see how well this task can work to achieve the desired crew performance when properly applied.

The final phase of SRO Supervisory Skills training is done on the Simulator. The student practices the individual skills of ∫QIOC through the use of Simulator Exercise Guides. These guides provide the scenarios that put the student in a variety of situations, allowing him to practice the integration (∫) of Questioning, Intervention, Observation, and Coaching.

## INTRODUCTION

In the post Three-Mile Island era, the Nuclear Industry has focused considerable amounts of attention on the role of the SRO as a supervisor and his transition to management. The SRO is responsible for overall plant operation. In order to meet this responsibility, he needs to possess skills which enable him to interface with his crew. It is his crew that actually operate the plant; therefore, if he is to have influence on plant operation it must be through them.

For years Senior Reactor Operators have asked, "When are we going to get a course that will teach us supervisory skills to help us be the hub of an operations crew?" We tried the typical leadership skills type courses, and they filled a small part of the void, but a large space still existed.

As a result of the Simulator Instructor Job and Task analysis conducted at St. Lucie Plant, we identified a Simulator Instructor task. This task Integrates (∫) Questioning (Q) Intervention (I) Observation (O) and Coaching (C) and is called ∫QIOC (pronounced sky-ock)[1]. This interactive process allows the Simulator Instructor to assess operator performance and correct any deficiencies. It was after the development of this Simulator Instructor task that we began to see a glimpse of what would be our SRO Supervisory Skills course.

During the same period of time that the Operations Training department was developing ∫QIOC, the Operations department was analyzing the cause of unplanned shutdowns due to operator error. The analysis concluded that operator errors were a result of poor communication, poor **supervisory practice**, and imposed stress.

The Operations Training department made the decision to develop the SRO Supervisory Skills course as a counter-measure for poor supervisory practice.

## SRO SUPERVISORY SKILLS

### Human Information Processing

In order for the SRO to interface with his crew, he first needs to understand what makes them "tick." How does an operator decide on a particular "response execution?" Why is it that he appears under stress at times?

Because it is important for a SRO to understand how his crew thinks, it was decided that the foundation of SRO Supervisory Skills would be an explanation of the way humans process information. A recent model of information processing developed by Wickens[2] was chosen, but the descriptions were modified to fit our application.

A discussion of the Human Information Processing model is the starting point. We will explore each stage and describe its purpose. Refer to **Figure 1**.

*Stimuli* in the form of process indicators, alarms, and communications come into the *Perception* stage. This stimuli is then compared to information templates in *Long Term Memory*. The system then uses past learning and experiences to influence what we presently perceive.

In the *Decision and Response Selection* stage the operator must make a decision. Which information needs further processing? This information is placed on the "table top" of *Working Memory* where we "think about it" accessing Long Term Memory until a decision to take action is made.

Long Term Memory is divided into two areas: *Procedural Memory* and *Declarative Memory*. Procedural Memory contains "If-then" statements. If the reactor trips, then trip the turbine. Declarative Memory is organized into a network of nodes (facts) and links (relationships). The game where a word is spoken and we are to say the first word that comes to our mind is a way of mapping our Declarative Memory.

Based on the information processed, a *Response Execution* occurs. For example, the reactor has tripped; the decision is to trip the turbine; the "Response" is to depress the turbine trip pushbutton.

One salient point in the discussion of HIP theory is the analysis of the "pool" of Attention Resources. This pool represents the overall processing capacity of the system. When resources are in short supply, operator stress increases and errors are more apt to occur. After gaining an understanding of the HIP model, the question "How can an SRO interact with the process?" needs to be addressed.

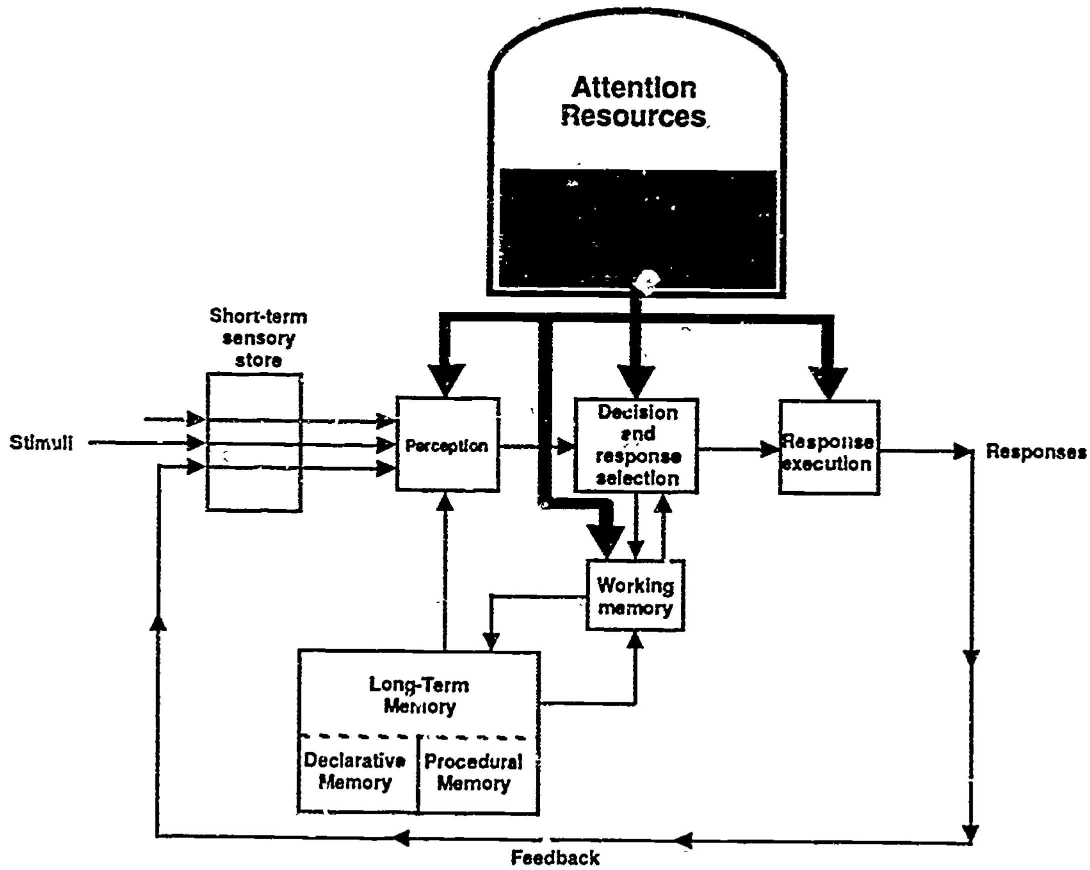


FIGURE 1: THE HUMAN INFORMATION PROCESSING MODEL

## IQIOC: The Task

The (I) **Integration** of **Questioning, Intervention, Observation** and **Coaching** is the task used to interact with the process. This task is used by the SRO to shape as necessary the response execution of his operations crew.

The SRO interacts with the HIP model in two ways, as shown in **Figure 2.** One is the inferred link to *Decision and Response Selection* and the other is the link to *Response Execution*. These links must be made through observation.

**Observation** is the bridge; without it the SRO will not be able to cross over these pathways into the Human Information Process. In order to master this skill he must be strategically positioned. This means to be in a location that does not interfere with operator action but allows for observation to take place. There are two ways to observe. The first is visually. This occurs by monitoring plant response or watching operator action. The second method is critical listening. This means being attentive to the communication that takes place in the control room. Conversations between operators can give the SRO a "heads up" on possible misconceptions. This gives the SRO an opportunity to clarify a problem area before it turns into an operator error.

**Questioning** as part of the task helps the SRO to clarify for himself intended operator actions. The SRO may also use this skill to pre-cue the operator to a condition he might not have considered. For example, if a downpower is intended to 85% he might ask, "When we get to 85% power what will your dilution rate be to compensate for xenon?" This technique gives the operator an important point to consider in the form of a question.

**Coaching** is the skill of bringing the operator from a lower level of performance to one that is closer to what the SRO desires. Through coaching, teamwork is built. When the crew begins to see that the SRO is concerned for them and is willing to share his expertise in a non-threatening manner, the crew will open up voluntarily more opportunities for this interaction to take place.

**Intervention**, both mental and physical, stops those actions which could place the plant in an undesired condition or cause personnel injury. Unlike the other skills, Intervention takes place after the Decision and Response selection has been made.

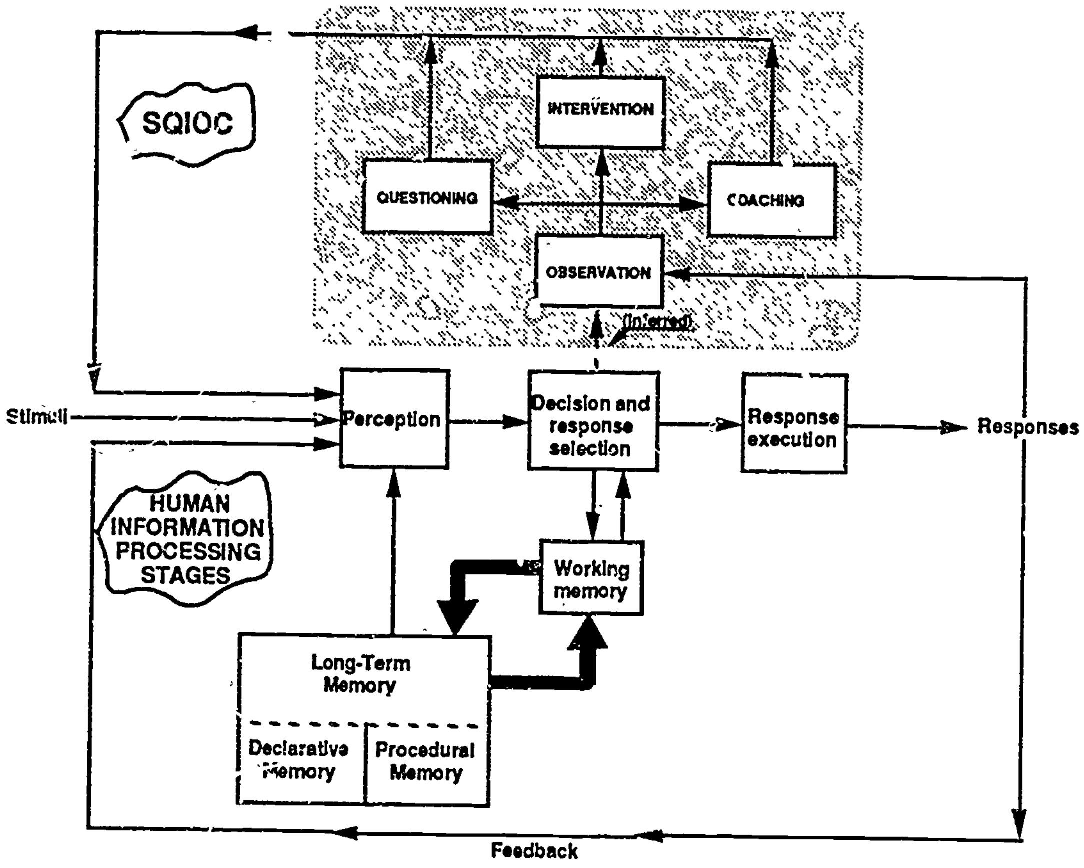


FIGURE 2: SQIOC/HIP INTERRELATIONSHIP

The **Integration** of these skills is the real key to the success of the task. Too much of one skill or none of another creates an imbalance. The question then is, "How much of each skill does an SRO need to do?"

In order to get a grip on the answer refer to **Figure 3**. This graph represents the distribution of SRO Supervisory Skills given the operator experience of his crew. We see that as an operator climbs the ladder of experience, the amount of coaching on small details will be less. The type of questions will go from low order (knowledge) to higher order (application).

Observation goes from looking at the details of an evolution to scanning the big picture.

Remember Observation, Questioning, and Coaching are skills to help the SRO anticipate errors before errors get to Response Execution. Therefore, if they are mastered, the use of Intervention should take place seldomly.

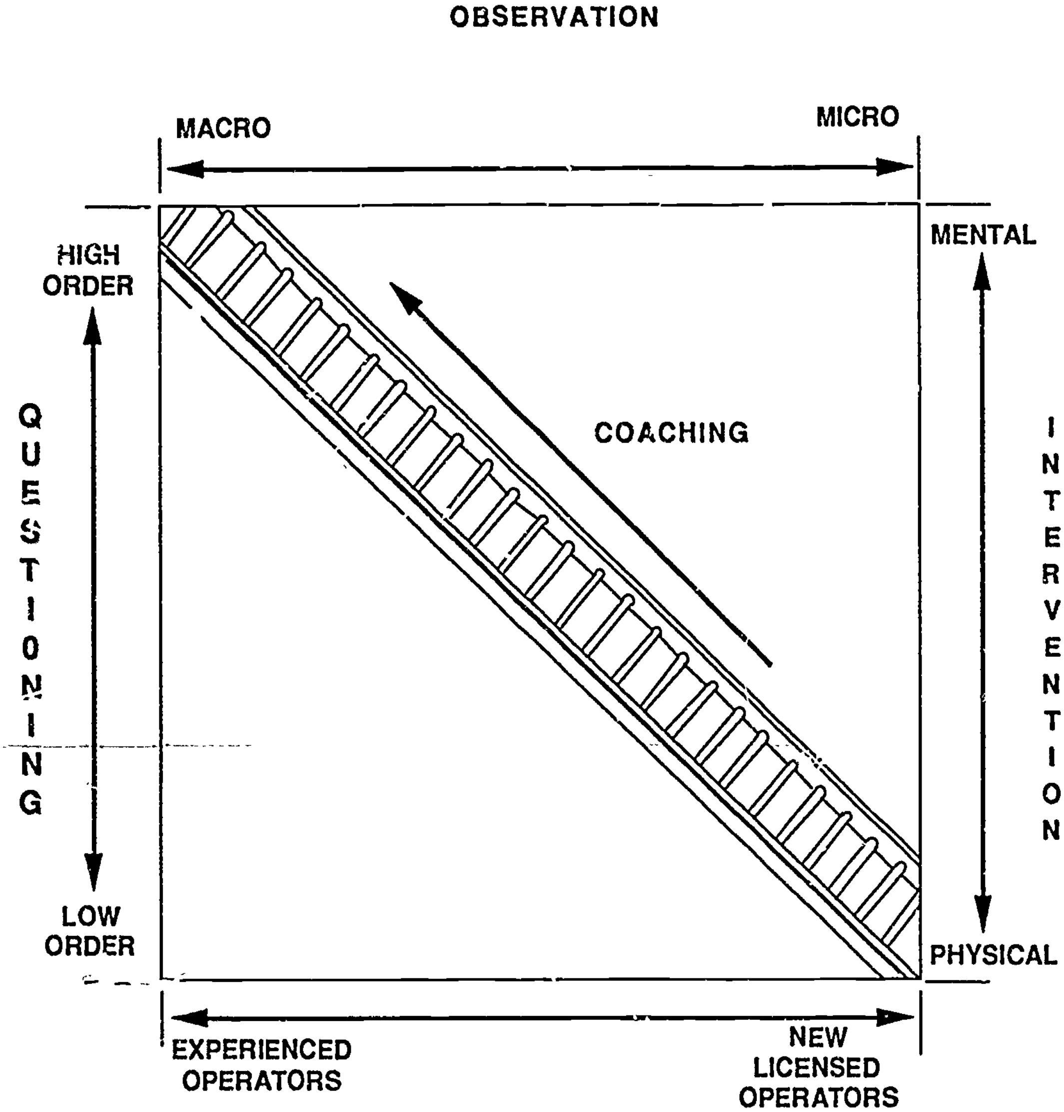


FIGURE 3: QIOC - ADAPTATIONS OVER TIME

## SQIOC's Practical Application

On The Job

A group of new R.O. licenses have been issued by the NRC. Dan, a new licensee, has been assigned to your crew. On Saturday peak shift a downpower for waterbox cleaning is required. After a crew meeting on the evolution, you **observe** a confused look on Dan's face. You **question**, "Are you unsure of something, Dan?"

He says, "Well, I didn't want to sound stupid in that meeting, but I am unsure of the governor valve sequence to expect."

You reply, "Well, that is something easy to forget if you haven't used the Turbine controls a lot. It's GV 2,3,1 then 4."

"Thanks, **Coach**," Dan replies.

The downpower is progressing, and you **observe** a large mismatch between $T_{avg}$ and $T_{ref}$. "How much acid did you shoot, John?"

"10 gallons," he replies.

"Dan, what is your load rate?" you ask.

"I haven't started down yet. I am having trouble with the Turbine Control system." You **intervene** and stop the downpower.

After some **questioning**, you find out that this is the first downpower Dan has done since receiving his license. You determine that Dan is under stress, and it is affecting his ability to process information. "Dan, take it easy. I know you can operate the Turbine Control System. Remember, you did it on the simulator during your training. You have the computer entry sequence reversed." Dan looks relieved.

"You're right. I just need to relax a bit. Thanks again, **Coach**," Dan replies. The evolution continues and teamwork is building.

Does this sound familiar? This is just one example of how SQIOCing applies as a group of SRO supervisory skills. As an SRO you can probably think of many accounts like these. The skills helped you to prevent an unplanned shutdown or an operator error.

In The Classroom

The best way to show ∫QIOC's application to the SRO student is by developing case studies. To develop a case study take a look first at human error related trips that have occurred at your plant. An examination of In House Event Reports as well as Licensee Event Reports yield more data. Research each event to see if inadequate supervisory skills were a cause. Then analyze what skills could have been used more effectively to prevent the operator error. This process yields events that are written into case study format. These case studies represent a cross-section of deficient skills in the ∫QIOC task. These studies can be used in a classroom session.

Discussion and Interactive video are an excellent media to show practical application in the classroom. We used this method. All the case studies were acted out by RCO's and recorded on video tape. Different angles of viewing were selected using the camera as if it were the eyes of the SRO. We used this opportunity to show why strategic positoining is important. When viewing the video, the SRO could see where he stands makes a difference in seeing all or part of an evolution.

These taped case studies were used to drive a classroom session. Using the "Big Screen TV" and the taped case stuides as the back drop, the stage was set. All of the candidates were in the classroom, with one selected to be the supervisor positioned in front. To ensure the students understood the intent, an SRO instructor "role modeled" using the first case study. Then, instructions were given for the remaining case studies: You are the ANPS in charge of a crew, utilize the skills of ∫QIOC to supervise, if at any time you want to question, coach or intervene, we will pause the tape and allow you to interact. The video recorder was selected to play and the students were seeing practical application of the task.

### In The Simulator

Utilizing a simulator is another method of showing practical application. Scenarios were developed by the same process used for case study development. We selected evolutions where SRO supervisory skills are a must (ie. Reactor Startup). This phase allows SRO's to practice their skills in a dynamic environment. During the classroom sessions "real time" can stop. On the simulator, time is not allowed to stand still. He must now interact with his crew in a "real time " e vironment.

## CONCLUSION

SRO's throughout the Nuclear Industry have a large responsibility. They are accountable for the health and safety of the public while generating electricity. In order to do this effectively, they must first be technically competent in all areas of plant operation, and, secondly, they must master the skills to be in command of an operating crew. The SRO Supervisory Skills course at St. Lucie Nuclear Plant is another step, a step which brings the SRO closer to the control room, where he must function as the hub of an operations

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INFLUENCE OF OPERATOR TRAINING IN THE DESIGN OF ADVANCED CONTROL ROOMS AND I&C AT WESTINGHOUSE

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## THE DEVELOPMENT AND IMPLEMENTATION OF QUALITY BASED TEAM AND DIAGNOSTIC SKILLS TRAINING AT THE ADVANCED TEST REACTOR

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### ABSTRACT

The Department of Energy's (DOE) Advanced Test Reactor (ATR) has been involved in Team and Diagnostic Skills training since the early part of 1988. This training was developed in-house utilizing material from numerous sources. To assist in achieving a high quality program that would be both well received by operations and effective in bringing positive behavioral changes, concepts of adult learning were utilized in the development and implementation. This paper will state the concepts and discuss how they were and continue to be used to develop, revise, and implement Team and Diagnostic Skills training at ATR.

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### BACKGROUND

The Advanced Test Reactor (ATR) is a 250 MW research reactor located in Idaho. Its primary mission is to support DOE's requirements for fuel and material irradiation data. In addition, limited space is made available to industry for materials irradiation and radioactive isotope production. The facility is somewhat unique in that it utilizes four separate control stations, manned by 11 operators, to operate the reactor and the experiment systems. This separation of control stations creates challenges for good communications and team problem solving. In the past ATR operators have viewed themselves as mavericks - working pretty much independently to monitor the facility and solve problems. As the need to better ensure plant safety has evolved so did the realization that operators need to work better as a team - the advantages have already been well documented. Towards the end of 1987 an ATR safety task team recommended training operators in team and diagnostic skills training.

Development efforts included participating in training sessions at commercial nuclear facilities, reviewing INPO and NRC training guidelines, reviewing relevant articles, and purchasing lesson plans and in-house instructor training from an outside vendor. This effort was focused on finding the best materials and methods available at the time. In the end all materials purchased and reviewed were combined and customized in-house to meet our uniqueness and expectations. The final product included eleven 3 1/2 hour lessons to be presented once a month over the course of a year. A typical lesson includes 1 1/2 hours of classroom time and two hours of hands-on simulation.

Part of the development effort involved a review of learning theory including adult learning theory (the differences between teaching adults and youth are often neglected). This review was completed in order to better ensure that "good" teaching practices were included in the training. The purpose of this paper is to state basic principles of adult leaning and how they are being used to help ATR crew members learn the knowledge, skills and attitudes of team and diagnostic training.

## PRINCIPLES OF ADULT LEARNING

Malcom Knowles in his book titled "The Adult Learner - A Neglected Species" outlined four assumptions about adults as learners that distinguishes them from teaching youth. Each assumption and its application will be discussed separately.

### Assumption 1

"They have a deep psychological need to take responsibility for themselves--to be self-directing -or at least share in making decisions that affect their learning".

Adults have a self-concept of being responsible for their own decisions, for their own lives. They resent and resist situations in which they feel others are imposing their wills on them. In harmony with this is a basic finding of applied behavioral science that people tend to feel committed to a decision or activity in direct proportion to their participation in or influence on its planning and decision-making. The reverse is even more relevant: people tend to feel uncommitted to any decision or activity that they feel is being imposed on them without their having a chance to influence it. In practice, the teacher should share his/her thinking about options available in the designing of learning experiences and the selection of material and methods and involve students in deciding among these options jointly.

A few examples of how this principle was applied at the ATR facility are discussed below.

1. The decision to teach team and diagnostic skills training was first presented to the operators during a carefully planned two hour lesson titled "Introduction to Team and Diagnostic Skills Training". This lesson included the video "Why Planes Crash", research studies on "operator errors", and plant related case studies. At the conclusion, an outline of the proposed training

(objectives) was presented to the operators and comments were solicited. Each operator was given the chance to approve the proposed outline and/or make recommendations. Never once were the operators told that this training was mandatory. In the end, the operators saw the value of the training and gave their support. Comments such as "This is something we've needed for a long time." were the rule.

2. In the training material we had gathered, it was recommended that simulator sessions be video taped. Instead of initiating this "good idea" without discussion, the operators were given the choice. At ATR there are still a few operators who do not like being recorded. Though we encourage it, it's still their choice.

3. For each simulator scenario exercise run for training purposes, members of the crew are used to evaluate their peers. Consequently, during the post exercise critique the operators themselves have control over the evaluation. Training personal facilitate and reinforce comments.

4. Anonymous session evaluation forms are routinely used to solicit ideas and concerns for the next month's session.

Assumption 2

"They bring with them to an educational activity, a wide variety of experiences and prior learning which are, themselves, a rich resource for their learning, and therefore, methods should be used which tap into and make use of those experiences".

One of the greatest values derived from the classroom portion of the training is when operators openly discuss operating concerns based on plant experience. In fact, the content should be presented with the goal of stimulating operators to share successes, concerns, and solutions to team and diagnostic skills issues. Such high interaction is accomplished by thought provoking content and an atmosphere of mutual trust, respect, freedom of expression, and acceptance of differences. Some ideas for maintaining thought provoking content include:

1. Utilize plant related case studies during the discussion of concepts.

2. Role play in the classroom situations similar to those occurring in the facility.

3. Utilize high quality commercially available video tapes to effectively illustrate a concept (i.e. the Nova film "Top Gun and Beyond" has a segment that very effectively illustrates information overload).

4. Utilize HRD related activities to provide hands-on experience of concepts (i.e. University Associates Publishers puts out a yearly annual loaded with exercises).

5. Rule of thumb - 10 minutes talk, then involve students. Important concepts for creating a "discussion" environment include:

1. Physical conditions that are comfortable and conducive to interaction.
2. The instructor accepts each student as a person of worth and respects his/her feelings and ideas.
3. The instructor seeks to build relationships of mutual trust and helpfulness among the students by encouraging cooperative activities and avoiding competitiveness and judgmentalness.
4. The instructor expresses his/her own feelings and contributes his/her resources as a co-learner.
5. Time is available for discussion. Classroom marathons (i.e. trying to cover all material in 8 hours or bust) are avoided.

### Assumption 3

"Their readiness to learn particular things is a product of what they discover they need to know or be able to do in order to perform more effectively and satisfyingly in their own life situations."

Adults need to know why they need to learn something before undertaking to learn it. One study found that when adults undertake to learn something on their own they will invest considerable energy in probing into the benefits they will gain from learning it and the negative consequences of not learning it. At the very least, instructors can make an intellectual case for the value of the learning at the beginning of each lesson or simulator exercise (i.e. stating the importance of the lesson/activity). An even more potent tool for raising the level of awareness of the need to know are real or simulated experiences. From these experiences the learners discover for themselves the gaps between where they are now and where they want to be. Three examples, based on experience at ATR, of how experience can be used to create a "need to know" atmosphere are as follows.

1. From the video tape titled "Why planes crash" the operators watched as pilots, simulating an actual crash, became so fixed on a malfunctioned light bulb that the plane ran aground. From the tape, operators related similar experiences and the setting for teaching diagnostic biases was established.

2. A simulator scenario involving a multiple incident and several distractors was performed with each crew. The Shift manager became saturated with information and was unable to recall some of the communications that occurred. This "real" experience was later used to introduce the topic of feedback (when to give feedback).

3. A discussion of "real life" problems relating to poor communications (oral, written, kinetics) in the facility was used tointroduce a lesson on communications.

## Assumption 4

They enter into an educational activity with a different orientation to learning from that of traditional students who are subject centered in their orientation. Adults are life centered, task centered or problem centered in their orientation.

Adults are motivated to devote energy to learn something to the extent that they perceive that it will help them perform tasks or deal with problems that they confront. Furthermore, they learn new knowledge, understandings, skills, values, and attitudes most effectively when they are presented in the context of real-life situations. The application of this principle to team and diagnostic skills training is that memorizing five steps, role playing, reviewing case studies, defining terms, for its own sake without knowing how to use them to perform a task is demeaning and will probably be forgotten before getting back on the job. The simulator exercises conducted during team and diagnostic skills training is certainly on target. Ideas for accomplishing this same "task" orientation in the classroom include the following.

1. Instead of approaching a subject such as Influence" with an objective like: "Define two components of effective influence", approach it with an objective such as: "Apply the concept of influence to defend your interpretation of a plant problem". Even though the lesson content may be the same, the approach is task oriented which leads to greater motivation to learn.

2. At the end of a class presentation, discuss how material presented can be applied to the job. Discuss how procedures, equipment, or training can be adjusted to help encourage or maintain skills learned. Invite the shift supervisor and other team leaders to discuss their own successes and concerns. This type of summary has promoted positive changes at the ATR facility.

One last thought. Research has shown that one-shot, team building efforts do not produce the desired long-range results and that few, if any, changes take place without effective follow-up. With this mind, ATR team and diagnostic skills training was broken down into 11 lessons with only one lesson being presented each month. The idea was to concentrate on only a few skills/concepts each month. This creates an overlap between each month so that previously learned skills could be reviewed and practiced again. This breaking the training down into smaller chunks is only part of the solution to the basic problem of regression (returning to the same habits as before the training). The whole idea of regression following team and diagnostic skills training is an extremely important issue that needs to be looked at. At ATR, solutions are still being looked at.

## REFERENCES


1. M. S. Knowles, The Adult Learner: A Neglected Species, Gulf Publishing Company Book Division, Houston, 1984

2. Nova: Top Gun and Beyond (video), Coronet Film & Video, Northbrook, Illinois

3. Nova: Why Planes Crash (video), Coronet Film & Video, Northbrook, Illinois

4. J. W. Pfeiffer, The 1988 Annual: Developing Human Resources, University Associates, San Diego, CA

# DEGREE EDUCATION
# ON-SITE, ON-LINE, ON-TIME

J. R. Mueller
T. A. Janke
J. R. Fisher

ABSTRACT

Nuclear utilities' efforts in response to industry wide pressures to provide operations staff with degree opportunities have encountered formidable barriers. This paper describes the development and operation of The University of Maryland University College (UMUC) special baccalaureate degree program in nuclear science. This program has successfully overcome these barriers to provide degree education on-site, on-line, and on-time.

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## DESCRIPTION OF THE WORK

Meeting the nuclear power industry's requirements for degree program access is confounded by:

- difficulty in offering on-site courses due to shift-work and plant operating schedules,
- prohibitive costs of employee release and support to attend off-site (on-campus) programs, and
- wide variation in educational and training preparation of its adult employee groups.

In the early 1980's, Wisconsin Public Service Corporation (WPSC) made a firm commitment to pursue development and subsequent delivery of an appropriate, academically accredited program leading to a baccalaureate degree in nuclear science for its nuclear operations personnel. Recognizing the formidable tasks to be accomplished, WPSC worked closely with The University of Maryland University College.

The University of Maryland University College brought to this challenge some powerful assets. Most importantly, as the outreach campus of the University, it had 40 years of experience and expertise in developing and delivering high quality college programs under difficult off-campus circumstances to employed adults. It also had full access to the academic departments of the entire University of Maryland system, its own Open University programs, an historical relationship with the business community, and the educational technology resources of its Center for Instructional Development and Evaluation (CIDE).

A unique industry/education partnership was formed to confront the matters of curriculum development and program delivery. Led by the efforts of WPSC, this partnership grew to include four Owner utilities (WPSC, South Carolina Electric & Gas, Louisiana Power & Light, and Baltimore Gas and Electric), Utility Resource Associates (URA), The University of Maryland University College (UMUC), and the Nuclear Engineering Department of The University of Maryland College Park (UMCP). The Owner utilities provide practical program requirements, development funds, and delivery advice; UMCP provides academic and content expertise; URA provides applications expertise; UMUC provides course development, educational technology, and delivery expertise honed by its years of outreach learning experience.

Program criteria set by the partnership were:

- academic integrity and rigor of the program,
- responsiveness to the needs of nuclear utilities,
- maximum effectiveness of any educational technology used, and
- cost-effectiveness in delivery.

The efforts of this group produced a computer managed, calculus based, 120 semester hour Bachelor of Science (Nuclear Science) degree program. The curriculum, designed to meet the University's academic standards and the industry's delivery needs, consists of University of Maryland courses of three types:

- General education and management courses in the Open University format,

- Lower division engineering courses (math, physics, chemistry) supplemented by turnkey PLATO software and,
- Nuclear and othe engineering courses supplemented by couise materials repurposed for computer use. The development of this course software was accomplished by CIDE and funded by the Owners consortium of neclear power utilities.

These courses are integrated into the curiculum as indicated in Table 1. The curriculum was designed in response to the express needs of the industry; the major is nuclear science, but a strong minor was developed in science and management.

Program delivery is the responsibility of UMUC's Office of Special Programs (OSP). The curriculum is complemented by OSP's multiple method delivery processes. Developed in response to the program criteria, there include:

- individual student PLATO packs for self-paced personal computer learning,
- on-line telecommunications with UMUC's mainframe computer for course progress testing, faculty access and program management (modem access is possible from the students' home),
- monthly faculty teaching visits on-s , scheduled to fit utilities' operating needs and including multiple sections to accommodate shift work,
- home study materials, workbooks, and textbooks.

As a complement to the on-site courses, the University provides for a wide variety of ways for students to earn program credits. These include, but are not limited to, transfer credits from other schools, credit awards for utility and military training programs, standardized test credit, and challenge examinat ons for program courses.

Program delivery begins with analysis of individual student records. From these, study plans for each student and a consolidated curriculum

Table 1. Nuclear Science Degree Program Course Requirements

| | |
|---|---|
| **I. General Education Requirements** | **(32 semester credits)** |
| Communications | 9 credits |
| Social Sciences | 6 credits |
| Humanities | 6 credits |
| Pre-Calculus | 3 credits |
| Calculus | 8 credits |
| **II. Courses Related to Concentration** | **(10 semester credits)** |
| General Chemistry | 4 credits |
| Materials and Applications | 3 credits |
| Computer Applications | 3 credits |
| **III. Primary Concentration: Nuclear Science** | **(24 semester credits)** |
| Introduction to Nuclear Technology | 3 credits |
| Thermodynamics | 3 credits |
| Nuclear Reactor Operation | 3 credits |
| Nuclear Technology Laboratory | 3 credits |
| Nuclear Reactor Engineering | 6 credits |
| Nuclear Heat Transfer | 3 credits |
| Reactor Systems Analysis | 3 credits |
| **IV. Secondary Concentration: Science and Management** | **(22 semester credits)** |
| Physics | 7 credits |
| Fluid Mechanics | 3 credits |
| Writing for Managers | 3 credits |
| Technology/Management | 9 credits |
| **V. Electives** | **(32 semester credits)** |

plan for the utility are developed. Classes are scheduled to meet utility operating needs and always begin with a faculty, multiple meeting, visit on-site. Between visits, students use the course materials and the stand alone PC learning disks to study independently. When a student completes a course lesson module, he or she accesses UMUC's mainframe CYBER to take diagnostic tests. This also provides both the utility and the University a means of monitoring student progress. Students, faculty, and OSP use the CYBER network for communications between monthly visits, but final course examinations are proctored on-site. Student advisement and counseling are continuous.

## RESULTS

Program delivery began in 1984 with one utility and a single site. It is currently delivered at eight sites under contract to six utilities with a total active student count of over 500. The first graduates are expected in 1989. The program is an accredited University program and enjoys licensure approval from the six states within which it operates. In addition to meeting Nuclear Regulatory Commission proposed guidelines for degreed operators, the program increasingly appears as part of utility management development programs for all plant personnel and a significant factor in employee retention and advancement.

The participation and progress of utility personnel in the program are sound testimonials of the program's success. As University of Maryland students, they have experienced not only the pride of accomplishment, but also tangible University recognition of their efforts through the Dean's list and other honors. As employees graduate, armed with plant experience, a formal degree in nuclear science, and professional education in management, they can become real candidates for advancement in their nuclear organizations.

The Owner utilities, the University of Maryland, and the growing User's Group are committed to the academic integrity, technical capability, and responsiveness of the program. The full support of this partnership speaks well for the long-term service of the Bachelor of Science in Nuclear Science program to the nuclear power industry.

## DEVELOPING A PERFORMANCE BASED RETRAINING PROGRAM FOR THE ADVANCED TEST REACTOR (ATR) REACTOR OPERATORS AND SUPERVISORS

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### ABSTRACT

The Department of Energy's (DOE) Advanced Test Reactor (ATR) is operated to support DOE's requirements for fuel and material irradiation data. In addition, limited space is made available to industry for materials irradiation and radioactive isotope production. The 250 $MW^{th}$ ATR was designed in the early 1960's, constructed in the mid 1960's and placed in operation in 1967. It has operated successfully for the past 22 years. A staff of approximately 90 operators and supervisors (includes the equivalent of non-licensed operators) are available to operate this facility. Internal policies require that these individuals have either a bachelors degree in one of the sciences or two years prior nuclear experience prior to employment as reactor operators at the ATR. Therefore, the initial training and retraining programs have been structured accordingly to meet the needs of this type of individual.

Several improvements were made to the initial training and retraining programs after the TMI accident to make them comply with DOE Order 5480.6 section 8e, "Reactor Personnel Training and Qualification Program"[1]. In early 1985 an Employee Action Team was formed to look at further improvements to these programs. This team focused on improving the retraining programs for reactor operators and their supervisors and recommended sweeping changes to the current retraining program. These changes were accomplished and the new program was implemented in June of 1986. This paper discusses these activities.

In formulating the Performance Based Retraining program for ATR reactor operators and supervisors, industry experience, INPO Guidelines, DOE requirements, ANS 3.1, and the experience of 22 years of ATR operation/training were considered. This approach to retraining is consistent with INPO Guidelines and Good Practices, and DOE requirements. This paper addresses the following key elements in the development and implementation of a performance based retraining program.

Selection of retraining items utilizing task analysis.

Features of the program.

Program evaluation.

Lessons learned after two years of conduct.

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## BACKGROUND

In early 1985 an Employee Action Team was formed consisting of ATR trainers and operators to look at improving the current training programs for ATR operations personnel. After weeks of deliberation the team selected the current retraining program as a likely target for major improvements which would result in a significant savings in time and money to the company and DOE. The existing retraining program consisted of:

Three days a month for each shift crew. Five shift crews were established after TMI to allow for the conduct of this retraining. A portion of the time was devoted to the conduct of classroom training on selected and required topics (i.e., Reactor Physics, Systems Reviews, Plant Modifications, Unusual Occurrence Report (URO) Reviews, Safety/Emergency Brigade Training, Radiation Worker Training). The remaining time was utilized to conduct the structured Drill Program and Simulator Training (including the performance of the required control manipulations).

Completion of a refresher on-the-job training checklist for positions certified (licensed) every two years. The refresher checklist was a modified initial checklist which was based on the task analysis conducted in late 1983. The checklist was divided into five major areas, Theory, Systems and Components, Normal Operations (procedure/practical factor reperformance), Emergency/Abnormal Operations, and Administrative Knowledge. All checkouts in all areas were conducted by certified ATR operations personnel.

The major recommendations for improvement from the Employee Action Team were:

Ensure all classroom training is based on the task analysis for that position and is taught at the shift manager (SRO) level to allow maximum benefit to be derived by each participant. Allow credit on the refresher checklist for attending a classroom training session on that topic. Ensure that all performance items on the refresher checklist are necessary and are based on the task analysis. Develop a retraining schedule for a 24 month period that has major/required items identified, thus reducing the time required to prepare and obtain approval on the schedule.

The remainder of this paper describes how these major objectives were met.

## SELECTION OF RETRAINING ITEMS

### Rating Tasks

The first step was to rate each task for each position in the task analysis based on difficulty, importance, and frequency of performance as no-train, train, or overtrain using the rating system provided in the "Guidelines for Job and Task Analysis for DOE Nuclear Facilities" DOE IEP-0095, June 1983[2]. Application to commercial reactor facilities would necessarily use INPO and NRC guideline documents. Overtrain tasks are those tasks that require a combination of initial formal training plus periodic practice of the task (retraining). These tasks became the basis for the entire retraining program. In addition, during the conduct of the initial ATR Task Analyses certain tasks were identified as "Critical Tasks" based on having a high rating in difficulty, probability of error, and severity. These tasks were also considered as overtrain tasks even if they did not fall into this category.

### Selection of Classroom Topics for Retraining

Knowledge requirements are specified for each task in the ATR Task Analyses. These are grouped into three major areas: Academic Knowledge, Systems Knowledge, and Administrative Knowledge. The knowledge requirements were collected from each overtrain task. Any additional knowledge requirements specified in the individual refresher checklists were added. This resulted in a listing of knowledge requirements necessary to support the overtrain tasks. From this list topics were prioritized and selected with significant involvement from operations personnel which could be covered in a one to three hour presentation and were relevant up to and including the shift manager (SRO) certification. All topics (except for Administrative items) were divided into 24 sessions. Twenty-four monthly checklists were developed. These checklists included additional required items such as, Management Discussion/URO Review, Safety/Brigade Training, Plant Modifications, Plant Drills, Simulator Training, etc. (See Fig. 1 for an example of a monthly retraining checklist.) All operators were given a chance to review the checklists and implementation procedures prior to implementation. A similar approach was utilized to develop a program for our equivalent of non-licensed operators. These monthly checklists are utilized to document completion of required items and identify which topics are mandatory for which certification levels. Items are signed off by the instructor when individuals have satisfactorily completed the item. Administrative items were divided similarly and are included on the checklists and are covered with an oral checkout from a certified shift manager. This allowed removal of the Theory, Systems and Components, and the Administrative portions of the refresher checklists. The emergency and abnormal tasks rated as overtrain and any additional emergency/abnormal procedures from the refresher checklists were also added to the drill program (all were already included) and completion documented using the monthly retraining checklists. Then the emergency/abnormal section was removed from the refresher checklists. Completion of the monthly checklist is a prerequisite to recertification for a position. This also resulted in a generic monthly and a twenty-four month retraining schedule. For a typical monthly retraining schedule see Fig. 2.

## Selection of Performance Tasks

The refresher checklists were then modified with significant input from operations personnel to include only overtrain tasks and grouped into two performance checklists, one of which is due to be completed each year during the two year retraining cycle. In addition to those tasks identified as overtrain from the task analysis, operator surveys were conducted on any other procedures that may have been missing from the original task analysis. These surveys ask operators to rate procedures performed in regard to difficulty, importance, and frequency of performance. Those tasks/procedures classified as overtrain by the survey were also added to the performance checklists. These checklists require reperformance of important tasks in order to maintain proficiency and familiarity with these specific tasks. Again, a similar approach was utilized for our non-licensed equivalent positions. Also included in these checklists is the documentation of the required operational evaluations for each position. These checklists and implementation procedures were reviewed by the operators prior to their implementation. The completion of these checklists is also a prerequisite to recertification.

## FEATURES OF THE PROGRAM

The program meets all the major objectives specified by the Employee Action Team (i.e., All classroom training is based on the task analysis and taught at the shift manager level. Use of the monthly checklists allows the operators to receive appropriate credit for classroom training received. The performance checklists only contain necessary items based on the task analysis and operator input. A 24 month retraining schedule is available in advance of the conduct of the retraining.)

Additional benefits of this program are:

The documentation of completion of all required classroom drills, simulator training, etc. is accomplished using one piece of paper-the monthly checklist. All operators receive the same information on a given topic which leads to a consistent knowledge level across shift crews. Teaching information at the shift manager level allows personnel to improve their knowledge level on a given topic and be better prepared when advancing in certifications. The operations personnel do not have to spend as much time giving oral checkouts on the retraining topics because most items except for performance items, are covered utilizing the monthly checklists.

## PROGRAM EVALUATION

As part of the overall training program effectiveness program each month shift managers, operators and non-licensed operators are selected randomly to fill out a content survey form. They are asked to evaluate the retraining topics and instructors for that particular month. The results of this evaluation are tabulated and a report issued to Operations and Training Management for any necessary follow-up or indicated improvement needs. In addition, benchmark data was established in the first year of the program for each major element. The current data is compared to the benchmark data to determine trends and make any necessary improvements to maintain above or at the benchmark values. Corrective actions and agreed upon improvements are tracked to ensure that they are completed in a timely manner. Evaluation of operator knowledge by operational, written, and oral examination on abnormal/emergency procedures is required annually. A complete recertifcation utilizing the above means is required biennially.

## LESSONS LEARNED

The first complete two year retraining cycle was completed in June of 1988, and the next two year cycle has been implemented based on feedback from ATR Operations as to where more or less emphasis is required. This feedback was from the evaluation program and operator surveys. As a result of this feedback, a few items were added such as Procedure Review Sessions and Standing Directives Review (these are policies on how operations are to be conducted). The times were adjusted to emphasize certain areas, more or less depending on the feedback. However, the overall content of these sessions have changed very little, and most have involved the addition of topics such as Diagnostics and Team Skills Training and to accommodate more Simulator Training. As with all the best laid plans, more changes are required to the monthly checklists than anticipated due to unanticipated plant modifications or new regulatory requirements, so topics have to be shifted around and rescheduled to accommodate these impacts. Conduct of the required retraining topics adds to the Operations Training work load simply because more training is being provided. Overall, this retraining program has been and continues to be accepted and supported enthusiastically by operations personnel and their management.

## REFERENCES

1. DOE Order 5480.6 section 8e, "Reactor Personnel Training and Qualification Program", (Sept. 23, 1986)

2. DOE IEP-0095, "Guidelines for Job Task Analysis for DOE Nuclear Facilities", (June 1983)

## Figure List

02-03-89
Rev. 2

ATR RETRAINING CHECKLIST
Session 14 (February 1989)

ALL = EPRO, SRE, SM, PO

Name ________________ Certification ________ Date Completed _________

| | | Signature | Date | |
|---|---|---|---|---|
| **A.** | **Plant Fundamentals** | | | |
| | 14.1 ______________________ | | | |
| **B.** | **System and Component Knowledge** | | | |
| | 14.2 RPS Components and Operation | | | (EPRO,SRE,SM) |
| | 14.3 Service Water Systems LDW/HDW/RAW | | | (All,HP) |
| **C.** | **Administrative Knowledge** | | | |
| | 14.4 10-CFR-100 | | | (All, HP) |
| **D.** | **Emergency/Abnormal Discussion** | | | |
| | 14.5 Chemical Spill with a Loss of Instrument Air to H&VS | | | (All,HP) |
| **E.** | **Plant Drills** | | | |
| | 14.6 Loss of PPS Channel (4.2.1) | | | (All,HP) |
| **F.** | **Procedure Reviews** | | | |
| | 14.7 DOP 7.5.3 Diesel Bus Load Transfer | | | (PO) |
| | 14.8 LOM 3.10.3.2.7.2 Operation with Crud Probes | | | (EPRO,SRE,SM) |
| | 14.9 Standing Directives 11.1.8, 11.1.19, and 11.4.4 | | | (All,HP) |
| **G.** | **Management Discussion** | | | |
| | 14.10 Management Discussion | | | (All,HP) |
| **H.** | **Supplemental Training** | | | |
| | 14.11 Re-entry Team Actions During Radiological Emergencies | | | (All,HP) |
| | 14.12 Loop Decon Lab Training | | | (SRE-CH, EPRO-CH) |
| | 14.13 Plant Modifications | | | |
| | .1 Install Support System Rupture Disc | | | (PO,SM,SA) |
| | .2 Replace HDW Chem Feeder System, Replace Chlorine TK-TRA-671 | | | (PO,SM,SA) |
| | .3 Process Lab Hood Replacement | | | (PO,SM,SA) |
| | 14.14 ASO Training | | | (UAO) |

Fig. 1. Retraining Checklist

## ATR RETRAINING SCHEDULE SESSION 13 (JANUARY 1989)

**NOTES:**
1. LWP will monitor the discussion. The SM is responsible for conducting the session.

2. The administrative knowledge topic for January is "Cycle Reference Document (CRD)."

**INITIALS:**

| | |
|---|---|
| GRA | G. R. Adamson |
| DRC | D. R. Charlton |
| CWD | C. W. Darland |
| JAJ | J. A. Jacobi |
| KWM | K. W. Moore |
| LWP | L. W. Peterson |
| JR | J. Ray |
| DWS | D. W. Suthers |
| RLW | R. L. Wolz |
| OTE | Ops Training Engineer<br>Shift 1 - G. R. Adamson<br>Shift 2 - L. W. Peterson<br>Shift 3 - W. O. Olson<br>Shift 4 - D. R. Charlton<br>Shift 5 - C. W. Darland |

**UORs, CRITIQUES, AND NON-ATR PALTN ITEMS REVIEWED DURING DECEMBER RETRAINING**

UOR EG&G-88-33 (ATR-88-10)

Critique Report CR-88-43

"Public Citizen Blasts Operator Training" Nuclear News Dec. '88

Nucleonics Week - Oct. 6, 1988

Procedure Compliance Note to Shift Managers

SD 11.2.17 and 11.2.2

| Inst | Day 1 | Inst | Day 2 | Inst | Day 3 |
|---|---|---|---|---|---|
| | 01-09-89 Shift 2 01-23-89 Shift 4<br>01-13-89 Shift 5 01-30-89 Shift 3<br>01-16-89 Shift 1 | | 01-10-89 Shift 2 01-24-89 Shift 4<br>01-17-89 Shift 1 01-31-89 Shift 3<br>01-20-89 Shift 5 | | 01-11-89 Shift 2 01-27-89 Shift 5<br>01-18-89 Shift 1 02-01-89 Shift 3<br>01-25-89 Shift 4 |
| LWP | 0815 - 1130<br>Diagnostic Skills Training - "Quality in Team Performance" (All, HP) | JAJ/<br>DRC | 0815 - 1600<br>New Simulator Operational Evaluation (See Attachment for Schedule) | JAJ/<br>DRC | 0815 - 1600<br>New Simulator Operational Evaluation (See Attachment for Schedule) |
| | Drill--Primary Leak - Small/ Inside the Gas Tight Area (5.1.2) (All, HP) | SM/<br>LWP | 0815 - 0915<br>Emergency/Abnormal Discussion - Simultaneous Event (Compound Casualty) (All, HP) (Note 1)<br>- Fire in Process Control Room and Loss of Power to Console Indicating Lights (How do you verify the reactor is shut down?) | CWD | 0815 - 1130<br>Loop Instrumentation (EX, SRE, SM) |
| | | LWP/<br>KWM | 0930 - 1040<br>Procedure Review (All, HP)<br>LOM 3.10.3.2.6.2 - Termination of Purification Flow During Reactor Operation<br>DOP 7.3.5 - Mill East Ion Exchange Bed Resin Removal and Addition | SM | 0815 - 1130<br>Discretionary Time (PO) |
| | | SM | 1050 - 1130<br>Monthly Safety Meeting (All, HP)<br>Video Annual Emergency Action | | |
| | LUNCH | | LUNCH | | LUNCH |
| DRC | 1230 - 1500<br>Log Book and Data Requirements and Log Keeping SD (All, HP) | JR | 1230 - 1600<br>Validation of EPRO-EX Job Analysis (EX, SRE) | DWS | 1230 - 1445<br>Management Discussion (All) |
| JAJ | 1515 - 1600<br>Simulator Demonstration - Effects of a Loop Draining Accident (EPRO, SRE, SM) | GRA | 1230 - 1600<br>Experiment Loop Overview (HP) (Location TBD) | OTE/<br>KWM | 1500 - 1600<br>Review Exambank (All) |
| | | KWM | 1230 - 1600<br>Fuel Element Inspection and Arc Saw Operation (SM, SA, PO) | RLW | 1230 - 1600<br>Generic HP Training at CF-612 (HP)<br>01-04-89 - Industrial Hygiene<br>01-11-89 - Contamination Control<br>01-18-89 - Contamination Control<br>01-25-89 - Contamination Control<br>02-01-89 - Contamination Control |

Prepared by: [signature] 12-22-88
ATR Operations Training Engineer — Date

Reviewed by: [signature] 12-29-88
Facility Training Manager — Date

Approved by: [signature] 12/23/88
ATR Operations Assistant Manager — Date

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Fig. 2. Monthly Retraining Schedule

WHC-SA-0459-FP

# Effective Transition from Panel Board to CRT-Based Process Control

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# EFFECTIVE TRANSITION FROM PANEL BOARD TO CRT-BASED PROCESS CONTROL

N. E. Mayfield
P. A. Baynes

ABSTRACT

Nuclear process operators have controlled process operations using Panel-Board Mounted Instrumentation (PBMI) at Hanford since 1943. The decision was made to upgrade the B Plant Defense Waste Processing facility to state-of-the-art CRT-based process control, commonly referred to as a Distributive Control System (DCS) to improve operations safety, plant efficiency, and product quality. The safe and effective transition from PBMI to a DCS was the result of a cooperative effort between engineering, operations, and training, with full plant management support. Many elements of the upgrade had to be addressed: operator apprehension, vendor courses for the instructor and engineers, training interface with engineering and procurement, closed-loop communications, and structured implementation. Plant management considers this project a model example of effective implementation of new technology. This was a proactive and cooperative approach on a major facility upgrade. All too often training is left out of the planning stages on such projects. This more often than not creates reactive and unproductive training responses because of a lack of technical expertise and program development time. Other nuclear processing facilities are or will be facing this challenge. This paper presents the challenges and successes encountered during the transition to CRT-based process control. The intent of this presentation is to better prepare other training organizations for this type of transition.

## INTRODUCTION

As computer technology continues to advance, it is becoming increasingly common for industry to use microprocessor-based DCSs. To keep pace with current technology and remain competitive, many facilities are utilizing state-of-the-art DCSs. The DCSs are used to improve safety, product quality, efficiency of operations, and process reliability. Many of our nation's older plants and factories have obsolete, unreliable, and inefficient process control equipment. In addition many of our experienced operations personnel are either retired or are in the process of retiring. The DCSs are becoming industry standards for overcoming these problems and improving process control. The growing trend to retrofit older facilities with modern DCSs is and will continue to be a challenge for industry.

The U.S. Department of Energy (DOE) Defense Waste Management Division is incorporating DCSs in selected processing facilities to improve process control, process accountability, and recordkeeping. B Plant is one of the facilities that has been upgraded with a DCS. The B Plant Defense Waste Processing Facility, located on the DOE Site at Hanford, Washington, was built in 1943 and underwent extensive modifications in the 1960s. In the past, processing in this facility has been controlled with PBMI. At B Plant, effective implementation of DCS technology and a smooth transition minimized costs, risks, and resistance to change. This paper presents the background, situation, problems, and resolutions of this challenging transition. Details of the training efforts are explained to assist other organizations in similar transitions.

### Plant History and Background

B Plant is a versatile facility that, with some modifications, can readily change process capabilities. It was built in 1943 to 1944 as part of the Manhattan Project to separate and purify plutonium in support of national defense. Its first mission was completed in 1955 and B Plant was shut down. After extensive modifications in the 1960s, the facility was reactivated. Its mission at this time was separating radioactive by-products generated during the reprocessing of spent nuclear fuels. The objective of the process was isolation of the longer-lived fission products, $^{137}Cs$ and $^{90}Sr$, for storage in a safer form, and to return the short-lived products to underground storage to await ultimate disposal. This campaign was completed in 1984.

Currently B Plant is being upgraded for future defense waste missions. The next mission for B Plant is the processing of Neutralized Current Acid Wastes (NCAW). The objective of the new process will be to separate the feed stream into two separate products, a stream with high levels of radionuclides and a stream with relatively low levels of radionuclides. This process will consist of a settle and decant step followed with a polishing filter, and an ion exchange process to remove $^{137}Cs$ from the low-level waste stream. The NCAW processing is justified based on the cost differential between disposal of high-level and low-level waste. High-level waste streams will be sent to the Hanford Waste Vitrification Plant (HWVP). The HWVP will produce encapsulated cylinders of vitrified waste from the feed for long-term storage in a repository. Low-level waste streams will be sent to the Hanford Grout Treatment Facility (GTF). The GTF will produce a concrete-like product (grout) from the feed. This grout will be placed in underground concrete vaults. The NCAW processing is scheduled to last for several years followed by other potential waste management programs.

The nature of nuclear waste processing at B Plant requires the liquid and gaseous effluent streams be closely monitored. High levels of radiation associated with process waste solutions, the physical characteristics of the process materials, and the nature of the process itself have necessitated installation of many special features in the waste management facility. Safe operation of the facility requires the prevention of hazardous releases to the environment. Ensuring that wastes sent to GTF and HWVP meet process specifications is essential. To improve process control and accountability and to ensure compliance with applicable regulations, changes in the process monitoring and control system were required. At B Plant this process upgrade was implemented with the installation of a DCS.

## Plant Situation

Before the latest series of upgrades, operators and engineers operated B Plant as many of us, at one time or another, have handled a temperamental old family car. With unpredictable old equipment and instrumentation, personnel could not consistently control the processes. Adjustments of instruments and valves became an art for the experienced operators and engineers. The dispatcher's office (nerve center) in the plant was becoming overcrowded with instrumentation displays and annunciators required to ensure compliance with new regulations (see Figure 1). Obsolete and poorly functioning instrumentation did not provide satisfactory control of the Low-Level Waste Concentrator System. Replacement parts for these old instruments became difficult, if not impossible, to locate. Facility management decided to upgrade the instrumentation and control system to improve operations safety, process efficiency, product quality, and regulation compliance. Process engineering performed an engineering analysis of the process control system and recommended installation of a DCS with a CRT-based operator interface (see Figure 2).

The technical issues encountered during this type of transition have been addressed and resolved by several companies and will not be greatly expanded on in this paper. The primary issue addressed here is training and transition for the operations staff.

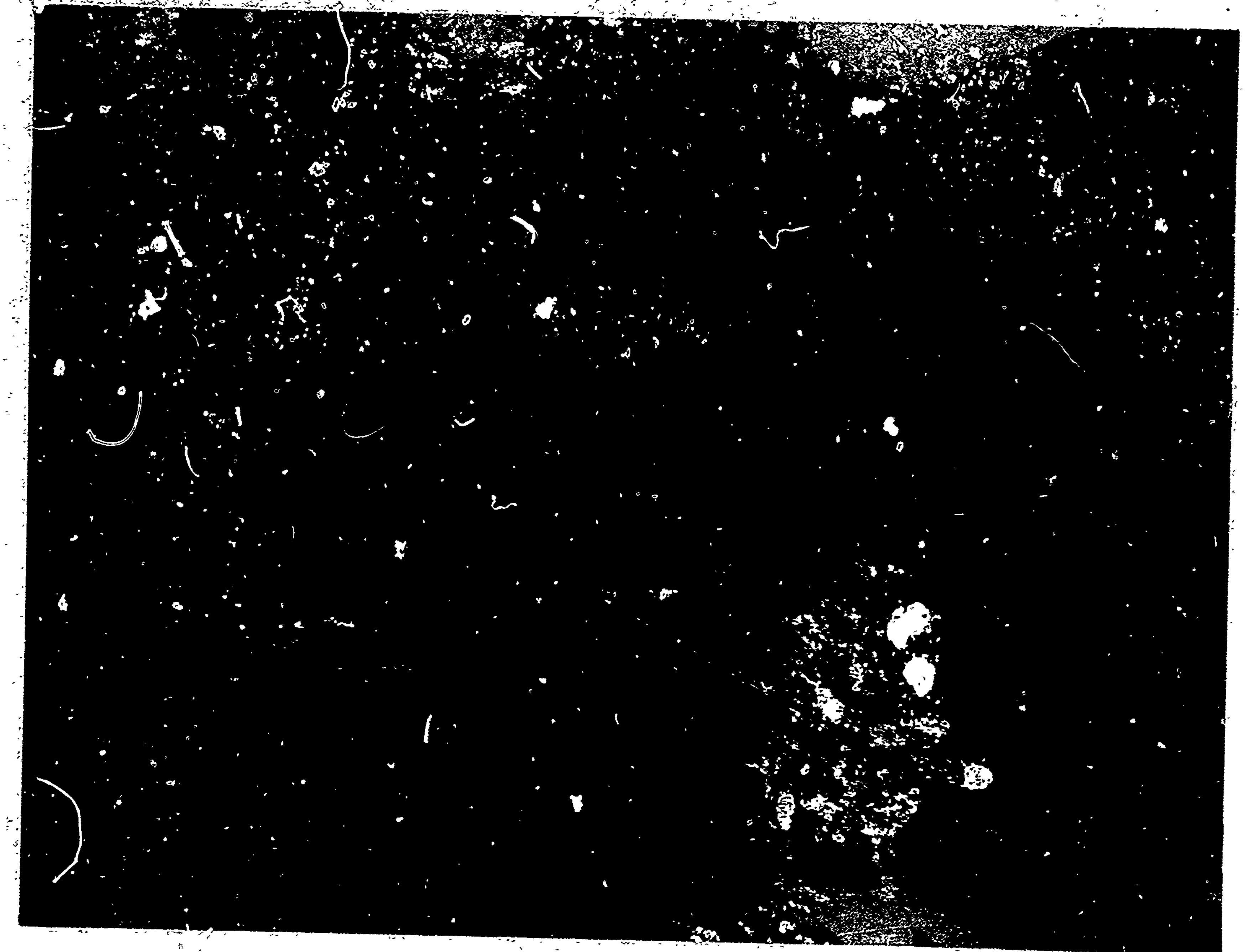

Figure 1. Instrumentation Displays and Annunciators Located in Plant Dispatcher's Office.

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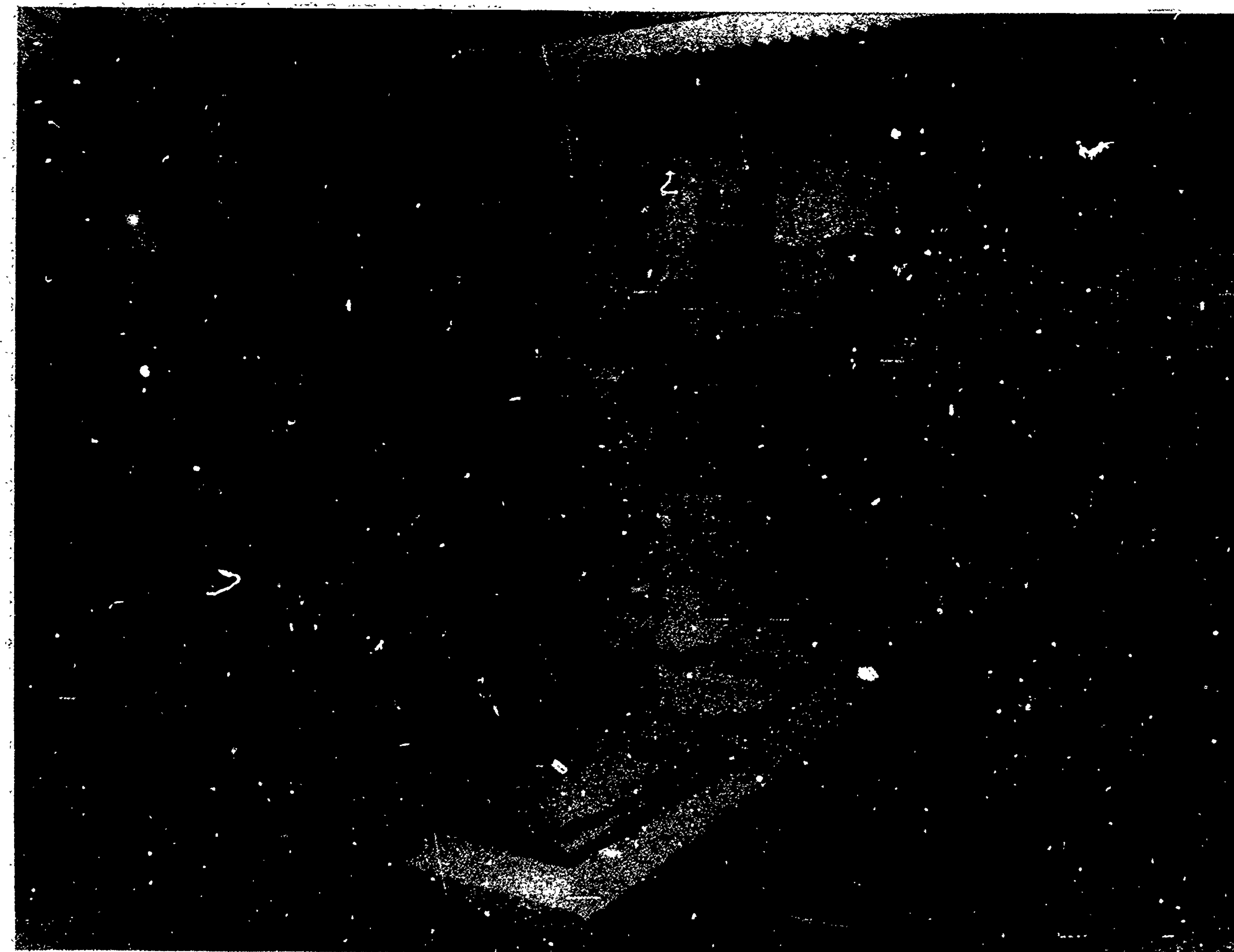

Figure 2. Distributive Control System with CRT-Based Operator Interface.

## Problems and Challenges

The transition to DCS had to be implemented safely without creating any process upsets or causing any hazardous releases to the environment. Several essential building functions had to be maintained and monitored during conversion. The effluent monitoring capability could not be interrupted. Control of the building pressures, used for contamination control, had to be maintained. The new DCS had to be brought on-line without losing continuity of operations.

In the early planning stage the lead process engineer served as the plant's subject-matter expert on the DCS. This created the challenge to design the installation of the system along with planning and organizing its implementation. A major challenge the engineer faced was to effectively sell the system to plant operations and operations management.

It was considered important that the operations staff have a positive experience during transition so they would accept the new DCS and be enthusiastic supporters for future expansion. This meant dealing up front with initial operator apprehension and resistance to change. The very thought of computer control for processing was not well received by everyone. Especially resistant were those experienced operators and engineers who had mastered the operational idiosyncrasies and learned to adjust the aging instruments and equipment. They maintained that they had operated the plant safely and efficiently for the past 30 years and that there was no good reason to make such a drastic change. A typical quote was: "I am familiar and comfortable with manual controls; the computer will complicate operations."

Operators had to be trained and qualified on the DCS while they continued to operate using the old PBMI. The qualification had to be well documented and thorough enough to ensure that the operators could function safely and respond to changing conditions correctly. Due to construction schedules there was limited time to develop and implement the comprehensive training program.

Each input to the DCS had to be functionally tested as it was being connected. There were several problems with the existing plant instrumentation systems that were not apparent until the systems were functionally tested. This put an added burden on the construction crew, plant maintenance, and operations staff.

## Resolution and Implementation

During the DCS conversion, routine plant work had to continue. Due to the close coordination between engineering, operations, training, and construction personnel there were very few instances where the conversion to the DCS actually affected work in the process areas. These instances were well planned and scheduled so as to minimize any negative impacts.

The engineering department included the training organization in the early planning phases of this project which ultimately benefited operations, training, and engineering. Early technical instructor involvement with the project was a primary requirement for a successful transition, and provided a thorough preparation of operations personnel for using the new system. Initially the instructor was not familiar with a DCS. Engineering had to communicate enough information to the instructor for planning purposes until he could attend the vendor training course. The instructor was able to gain much-needed background information as well as offer feedback relevant to training needs. This allowed the instructor to assist in explaining the DCS concept to operations personnel. Informal contacts between the instructor and operators helped to alleviate some operator concerns. Formal presentations to senior operations personnel and management were required to convince them that the new technology would not adversely impact plant operations.

The thought of installing a DCS in B Plant generated concern for many of the operations personnel. There were concerns and fears common to new and experienced operators and engineers alike:

- I know little or nothing about computers.
- The upgrade seems too ambitious.
- What would happen in the event of a service outage?
- Is this system going to place my job in jeopardy?
- How are we going to function during construction?
- Will I be able to operate as proficiently as before?
- I do not understand DCS jargon.

Steps to overcome this resistance were taken first during the preparation of the engineering study. First-line operations management provided input by way of review of the engineering study. The study was used to select the technology for dealing with previously identified process problems. They gained a vested interest in making the system work because they helped select the replacement technology.

To further overcome operator and engineer apprehension and resistance, engineering and training initiated a sales and education approach. Most of the operator and engineer fears resulted from a lack of knowledge and understanding of the new DCS. Dealing with concerns and challenges in a constructive manner minimized process errors, operator apprehensions, and costly delays. Effective training and education were used to reduce operator apprehension and minimize resistance.

Development of the training program began in earnest after attendance of a 2-week-duration, vendor-supplied training course. This allowed the instructor and engineers to develop a more thorough technical background. With the vendor courses completed and feedback available from engineering, the instructor conducted a job analysis. The analysis was reviewed for technical accuracy by engineering and was used to provide a road map for training needs.

The instructor, with technical input and review from engineering, next developed an operator's user manual. The vendor supplied a comprehensive user's guide that contained operational, equipment, and engineering configuration information. The instructor prepared a facility-specific user manual by eliminating all of the directions for configuring the system and all of the references to vendor equipment that did not apply. The user manual provides an expanded glossary of terms and acronyms used to familiarize the operators with DCS jargon. This manual is not only a step-by-step training guide but also is a valuable technical reference for operation of the DCS.

The training implementation strategy called for training operators who were previously certified on the B Plant processes using PBMI. The operators were first qualified on general operation of the DCS. This process was carefully documented to support readiness review requirements. After qualification on use of the DCS, the instructor revised process training packages to recertify operators on processes using the DCS. Emphasis on on-the-job training (OJT), using qualified engineering personnel support, enhanced this effective transition from operator certification using PBMI to DCS.

The general DCS training course, outlined and prepared based on the job analysis, consisted of 12 hours of classroom instruction with hands-on training via a simulated training program developed on the DCS. A vendor-supplied video tape, incorporated into the classroom instruction, provided background information to the operations staff. A course outline was provided to operations personnel along with the user manual before the classroom training so they could become familiar with the DCS jargon. The simulation program provided the needed hands-on training and practice. The training simulation included procedures modeled after existing plant operating procedures.

The instructor utilized a formal OJT check list to document operator performance and to verify that the operators could manipulate the new system sufficiently well to perform their required duties.

Operator proficiency with the DCS has increased substantially since completion of the initial training. Original resistance has faded as operators became familiar and comfortable with the system and realized that their jobs were not in jeopardy. New operations and engineering personnel are required to attend the DCS qualification course. When the software or system configuration changes, the course is updated to reflect the current information.

Problems with existing plant instrumentation and monitoring systems were compounded by the lack of complete as-built drawings. Experienced operators with comprehensive knowledge of the plant were relied upon to operationally and functionally test the existing systems. The existing drawings were corrected as the project identified discrepancies. After the instruments were functionally checked and were deemed operational the old PBMI would either be removed or tagged "Display on DCS". Engineering maintained a log book to track the instrument conversions and to pass down to the off shifts which instruments had been converted.

The training and the construction schedules were closely integrated to minimize adverse impacts on the construction schedule. This was important because of the costs incurred for delays and other plant upgrades were scheduled that could not begin until this project was complete.

## CONCLUSION

The challenges and successes encountered at B Plant during this transition from PBMI to DCS should provide useful information to other facilities in similar situations. The successes were the result of careful planning, enthusiasm, cooperation, project ownership, quality closed-loop communication, and the general proactive approach used throughout the upgrade.

This project was designed and planned to succeed. Several well-meaning suggestions were offered for designing a contingent manually operated system that would work in parallel with the DCS. These suggestions were not accepted because it was felt that a contingent system would be used as a crutch or an alternative to completing the project on time. All of the concerns that caused these suggestions were addressed by thorough planning and design.

A project of this complexity, changing operations to such a degree, provided many seemingly insurmountable obstacles. The professionalism and enthusiastic approach by engineering and training minimized negative impacts and helped gain support as the project developed. Many times determination and a can-do attitude will carry a difficult project to successful completion. The enthusiasm generated in the plant from the professional can-do attitude projected by engineering and training during this upgrade has carried forward to other projects as well.

Effective transition from PBMI to DCS was due to a cooperative effort between all affected organizations. The level of cooperation between the different plant organizations reflected a real sense of project ownership.

A prime factor contributing to the success of the conversion was the quality of the closed-loop communication among the different plant organizations. Problems, concerns, and suggestions were cycled between engineering, operations, and training. All problems, concerns, and suggestions that were brought up were given attention along with a response. This approach allowed all groups to get involved, creating a positive feedback mechanism that aided in the success of the transition.

Early involvement of the training department on this project was a prime example of the proactive approach taken during the entire upgrade. Installation design, system procurement, and training development were accomplished in parallel rather than in series to minimize the time required to complete the project. System installation and actual operator hands-on training were accomplished in parallel as well. This allowed adequate time for operator hands-on training with the simulation program. Operators were able to be qualified in a timely manner with minimal time constraint pressures due to the thorough training preparation provided by the technical instructor and engineering. As plant personnel became educated to the DCS, their fears and concerns diminished. Many people who were originally skeptics became advocates of the DCS which made the transition all the more effective.

This upgrade project further emphasizes the important role that training takes in our ever-changing process industries. It is important that each facility discover a formula for effectively utilizing their training department.

# SIMULATOR APPLICATION IN A NUCLEAR TECHNOLOGY DEGREE PROGRAM

James R. Sherrard William E. Burchill

## ABSTRACT

Thames Valley State Technical College in Norwich, Connecticut is in its sixth year of providing an Associate's Degree Program in Nuclear Engineering Technology. A major distinguishing characteristic of this program is the use of a fundamentals nuclear reactor training simulator in the sixth (final) quarter of the curriculum. This paper describes the Thames Valley Nuclear Technology Curriculum, the Nuclear Reactor Simulator course in this curriculum, and the importance of the simulator in the application for accreditation of the Nuclear Engineering Technology Program by the Accreditation Board for Engineering and Technology.

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## INTRODUCTION

Thames Valley State Technical College (TVSTC) in Norwich, Connecticut is in its sixth year of providing an Associate's Degree Program in Nuclear Engineering Technology. This program, which was started in December 1983, accepts about 25 students each year. To date, 72 people have earned a degree from this program; most of the graduates have been employed by Northeast Utilities. A major distinguishing characteristic of the TVSTC Nuclear Engineering Technology Program is the use of a fundamentals nuclear reactor training simulator in the sixth (final) quarter of the curriculum.

The Nuclear Engineering Technology Program is central to the TVSTC mission of providing a comprehensive course of study to prepare men and women for employment in the field of Nuclear Engineering

Technology. As only one of three institutions of higher learning in all of New England (and the only one in Southern New England) offering a degree program in Nuclear Engineering Technology, TVSTC has the unique and distinct responsibility of providing this academic degree program to support the state's expanding business and commerce needs.

In December 1987, Th-mes Valley State Technical College was designated a "Center of Excellence" by the Connecticut Department of Higher Education. Under this program, TVSTC plans to install the nuclear reactor simulator as a permanent facility; it is presently leased from Combustion Engineering.

One critical aspect of any technology program is its acceptance and accreditation by the Accreditation Board of Engineering and Technology (ABET). The formal recognition of the academic worth of a program certifies to both the graduate and industry that the curriculum fully meets high, documented standards of academic excellence and industry relevance. Similarly, formal recognition of this two-year program insures the smooth continuity of academic growth when graduates pursue Baccalaureate technology/engineering degree programs.

TVSTC submitted its application to ABET for accreditation of the Nuclear Engineering Technology Program in June 1988. ABET conducted its accreditation visit to TVSTC in January 1989. Accreditation is expected before the Fall 1989 term begins.

## NUCLEAR ENGINEERING TECHNOLOGY PROGRAM

The Nuclear Engineering Technology (NET) Program is designed to give students a broad background in the basic sciences with specific nuclear applications to prepare them for careers in the nuclear power industry. Possible positions include health physics technician, chemistry technician, reactor engineering technician, and nuclear power plant maintenance technician. The program is also good academic preparation for the reactor operator career path which requires further training and successful completion of a licensing examination administered by the Nuclear Regulatory Commission. Thames Valley State Technical College also encourages part-time students to attend.

## NET Course Categories

The NET courses can be broadly grouped into the following four categories: math and science, humanities, nuclear technology specialties, and support technical specialties. Course titles and weekly contact hours in each category are listed in Table 1.

The math and science courses are provided by the TVSTC Departments of Mathematics, Physics, and Chemistry. Nuclear Engineering Technology students take these courses along with students enrolled in other technology programs. The same is true of the humanities courses which are all taught by the Arts and Sciences Department.

The support technical specialties are available in the areas of Data Processing, Electrical Technology and Electronics, Manufacturing Technology, and Mechanical Technology. In each case, NET students are enrolled with students from other technology programs and are provided a broad foundation for application in their major program.

All nuclear technology specialties are taught by the Nuclear Engineering Technology faculty. Although these courses may be selected and attended by students from other technology programs as support technical specialties, their enrollment has been exclusively NET students.

Table 1. Nuclear Engineering Technology Course Categories

| | Class Hours | Lab Hours | Qtr Hour Credits |
|---|---|---|---|
| **Math and Science** | | | |
| Technical Mathematics I | 4 | 0 | 4 |
| Technical Mathematics II | 4 | 0 | 4 |
| Calculus I | 4 | 0 | 4 |
| Calculus II | 4 | 0 | 4 |
| Physics (Mechanics) | 3 | 2 | 4 |
| Physics (Heat, Sound, Light) | 3 | 2 | 4 |
| Principles of Chemistry | 3 | 2 | 4 |
| **Humanities** | | | |
| Introduction to Literature | 4 | 0 | 4 |
| Basic Communication | 4 | 0 | 4 |
| Technical Communication | 3 | 2 | 4 |
| Economics | 3 | 0 | 3 |
| Psychology & Human Relations | 4 | 0 | 4 |
| Sociology | 3 | 0 | 3 |
| **Nuclear Technology Specialties** | | | |
| Atomic Physics | 4 | 0 | 4 |
| Reactor Theory I | 4 | 0 | 4 |
| Reactor Chemistry | 4 | 0 | 4 |
| Reactor Theory II | 4 | 0 | 4 |
| Nuclear Materials | 3 | 2 | 4 |
| Introduction to Nuclear Systems | 3 | 0 | 3 |
| Nuclear Radiation Health & Safety | 3 | 2 | 4 |
| Topics of Nuclear Power Generation | 3 | 0 | 3 |
| Nuclear Reactor Simulator | 1 | 2 | 2 |
| **Support Technical Specialties** | | | |
| Introduction to Application Software | 2 | 2 | 3 |
| AC/DC Machinery | 3 | 2 | 4 |
| Automated Process Control Systems | 3 | 2 | 4 |
| Materials of Engineering | 3 | 3 | 4 |
| Applied Mechanics | 4 | 0 | 4 |
| Power Systems Thermodynamics | 4 | 0 | 4 |
| Fluid Mechanics | 3 | 2 | 4 |
| Heat Transfer | 3 | 2 | 4 |
| Electricity and Electronics | 3 | 2 | 4 |

## NET Curriculum

The Nuclear Engineering Technology curriculum is structured to serve two major expected job classifications: non-reactor operators (NROs) and reactor operators (ROs). In addition, the program is intended to provide a solid two-year foundation for coordinated opportunities to continue toward a Baccalaureate degree at a four-year college.

The NET curriculum is listed in Table 2. The Nuclear Reactor Simulator course is taken in the final (sixth) quarter by students enrolled in the NRO option. It is omitted in the RO option because licensed reactor operators are required to undergo training on a nuclear reactor simulator at the plant site as part of their licensing program.

## Nuclear Reactor Simulator

The nuclear reactor simulator is a classroom-sized, digital/analog simulator designed for use in education and training programs on the concepts and fundamentals of nuclear power plant operations. The simulator models the nuclear reactor, steam generator, and turbine generator systems of a pressurized water reactor (PWR), along with many of the associated support and auxiliary systems. The simulator consists of a students' primary and secondary plant control console, a computer, and an instructor's interface console. Major plant parameters are displayed in both digital and analog form.

The simulator represents a functionally complete nuclear power plant, but without auxiliary systems that have a minor impact on basic plant operation. The students' control console allows the students to manipulate the plant controls and practice operating the plant. By demonstrating plant operation through manipulating the controls, the important operating characteristics are reinforced and this knowledge

Table 2. Nuclear Engineering Technology Curriculum

| FIRST YEAR | | | | SECOND YEAR | | | |
|---|---|---|---|---|---|---|---|
| First Quarter | C | L | Q | Fourth Quarter | C | L | Q |
| Tech Math 1 | 4 | 0 | 4 | Calculus II | 4 | 0 | 4 |
| Physics (Mech) | 3 | 2 | 4 | Psych & Hum Rel | 4 | 0 | 4 |
| Princ of Chem | 3 | 2 | 4 | Reactor Theory I | 4 | 0 | 4 |
| Intro to App Software | 2 | 2 | 3 | Power Systems Thermo | 4 | 0 | 4 |
| NET PO1* | 4/3 | 0/0 | 4/3 | Fluid Mechanics | 3 | 2 | 4 |
| Second Quarter | | | | Fifth Quarter | | | |
| Basic Comm | 4 | 0 | 4 | Economics | 3 | 0 | 3 |
| Tech Math II | 4 | 0 | 4 | AC/DC Mach | 3 | 2 | 4 |
| Physics (HSL) | 3 | 2 | 4 | Appl Mechanics | 4 | 0 | 4 |
| Elec & Electr | 3 | 2 | 4 | Heat Transfer | 3 | 2 | 4 |
| Atomic Physics | 4 | 0 | 4 | Reactor Theory II | 4 | 0 | 4 |
| Third Quarter | | | | Sixth Quarter | | | |
| Tech. Comm | 3 | 2 | 4 | NET PO2* | 3/4 | 0/0 | 3/4 |
| Calculus I | 4 | 0 | 4 | Sociology | 3 | 0 | 3 |
| Reactor Chem | 4 | 0 | 4 | Nuclear Matls | 3 | 2 | 4 |
| Mat of Engr | 3 | 3 | 4 | Topics of Nuclear Power Gen | 3 | 0 | 3 |
| Nucl Rad Health & Safety | 3 | 2 | 4 | Auto Proc Cont | 3 | 2 | 4 |
| | | | | NET PO3* | 3/1 | 0/2 | 3/2 |

Program Options (PO)

| Reactor Operator (RO) | | | | Non-Reactor Operator (NRO) | | | |
|---|---|---|---|---|---|---|---|
| PO1 Hum Res Mgmt | 4 | 0 | 4 | PO1 Nuc Systems | 3 | 0 | 3 |
| PO3 Prin of Supv | 3 | 0 | 3 | PO2 Intro to Lit | 4 | 0 | 4 |
| PO2 NDT 1 | 3 | 0 | 3 | PO3 Nuc Reac Sim | 1 | 2 | 2 |

C - Class Hours    L = Laboratory Hours    Q = Quarter Hours Credit

TOTAL CURRICULUM*   Quarter Credits - 118/117   Contact Hours - 132/132

*First digit - RO credit; second digit - NRO credit.

is better retained. Dynamic color CRT displays allow graphical, clear demonstration of cause and effect relationships.

The students' console is set up to allow from 2 to 4 students to operate the plant simultaneously. Students can perform such routine activities as plant startup from cold shutdown conditions, approach to critical, and power range maneuvering using either control rod assemblies or boration and dilution by means of the chemical and volume control system (CVCS). Reactivity feedback due to fuel and moderator temperature can also be studied and observed on three cathode ray tube (CRT) displays.

The simulator models axial xenon concentration, axial core flux shape, and axial fuel and coolant temperature profiles at several radial locations in the reactor core. These axial profiles may be visually displayed on the CRTs. This allows students to observe the axial redistribution of these parameters during operational transients, plant maneuvering, equipment malfunctions, or accident conditions. The instructor can initiate axial xenon oscillations to demonstrate their effect on axial power shape and routine reactor operation.

The simulator can also be used to study plant operating and transient characteristics at various times throughout plant lifetime, i.e., at beginning-of-cycle, middle-of-cycle, or end-of-cycle. Specific capabilities of the simulation program are listed in Table 3. Malfunctions which can be introduced by the instructor are listed in Table 4.

The simulator includes the usual capabilities of creating and storing snapshots for future use as initial conditions, freeze and restart of the simulation, backtrack to up to thirty automatically stored snapshots, slow time (factor of 10), fast time (factors of 5, 50, and 150), and replay.

Table 3. Nuclear Reactor Simulator Simulation Capabilities

- decay heat
- natural circulation
- residual heat removal
- charging and let-down
- reactor coolant pump heat
- pressurizer to form (or collapse) pressurizer bubble and control
- pressure
- dilution or boration
- control rod withdrawal/insertion
- criticality and power escalation to heating range
- nuclear heat to normal operating temperature and pressure
- temperature control using atmospheric steam dump valves or condenser steam dump valves
- steam generator level control
- roll turbine to synchronous speed
- synchronize generator to grid and close breaker
- load generator and increase reactor power

Table 4. Nuclear Reactor Simulator Malfunction Capabilities

- o Drop of a single control rod
- o Fault in automatic rod control system
  Rod bank uncontrolled out
  Rod bank uncontrolled in
  Operation blocked
- o Trip of one or more reactor coolant pumps
- o Failure in pressurizer pressure controller (to maximum or minimum)
- o Failure in pressurizer spray valve (open, jammed shut)
- o Proportional heaters in pressurizer non-operating
- o Failure in the automatic pressurizer level controller (to maximum or minimum)
- o CVCS: leak from primary system
- o CVCS: fault in auto-mode
- o Turbine trip/reactor trip
- o Load rejection
- o Opening of a dump valve (excess steam demand)
- o Dump valve stuck
- o Loss of condenser circulating water pumps
- o Fault in feedwater controller (loss of steam flow signal)
- o Feedwater control valve failure
- o Bypass of feedwater preheaters
- o Loss of offsite power
- o Steam generator tube rupture

## Nuclear Reactor Simulator Course Description

The TVSTC Nuclear Reactor Simulator course provides the first opportunity for Nuclear Engineering Technology students to experience integrated PWR plant operation. The course is organized in both classroom and laboratory sessions structured to illustrate major operating characteristics of various plant systems: primary, secondary, control, rod drive mechanism control, nuclear instrumentation, and plant protection. In addition, the laboratory sessions include general plant operating characteristics, estimated critical position calculation, plant startup, plant shutdown, plant abnormal conditions, and selected accidents.

Each class meeting consists of tandem classroom and laboratory sessions. The classroom session, lasting one hour, provides students with a description of the system or operating characteristics being studied. Fundamentals from earlier courses are recalled, and their applications are illustrated. This is followed by a two-hour laboratory session in which each student is given the opportunity to operate the simulator while others observe, take notes, and perform calculations.

The course concludes with a comprehensive written examination. The objective is for each student to demonstrate the ability to apply fundamental concepts to understanding integrated plant operation. There is no examination on the simulator, itself, since development of operating skills is not an objective of the course.

## Assessment of Effectiveness

Thames Valley State Technical College has found the Nuclear Reactor Simulator course to be perhaps the most important course offering in its Nuclear Engineering Technology Program. It combines all of the earlier technical course work into a practical, hands-on simulator course by which students can develop and demonstrate their total knowledge of nuclear engineering technology.

Benefits which are provided by the Nuclear Reactor Simulator course include:

Classroom knowledge is retained more completely when students understand the application in the plant and, therefore, can relate the fundamentals to plant operation.

Students become more effective on the job when they acquire greater knowledge of and better understand the importance of their knowledge to overall plant operation.

Students are brought to a higher point on the learning curve, and are better prepared for advanced courses beyond the NET Program.

Students are more aware of the safety issues in nuclear power technology.

Simulated transients help students recognize that abnormal operating situations must be routinely managed in nuclear power reactor operation.

An additional benefit of the Nuclear Reactor Simulator course is its positive influence on the ABET accreditation process. As would be expected, ABET accreditation actions are both rigorous and demanding to ensure the academic excellence of a degree program. While every facet of the program is fully evaluated, special emphasis is devoted to final project or laboratory coursework which ties earlier acquired academic knowledge to the pragmatic realities of the real world application of this knowledge. In a Nuclear Engineering Technology

Program, the recognized culmination of this academic education is the actual operational control of a nuclear reactor or the utilization of a sophisticated, state-of-the-art nuclear reactor simulator.

The use of an actual nuclear reactor would require significant capital funding, substantial physical space requirements, burdensome security needs, and be more conducive to a research-oriented academic institution. A nuclear reactor simulator, however, is relatively inexpensive, portable, readily adaptable to changing nuclear industry environment requirements, and well-suited to the needs of a two-year academic degree program.

# MANAGING TRAINING TO MAXIMIZE EMPLOYEE ARTICULATION

N. C. Rockwell


ABSTRACT

Through agreements with other training and educational institutions, training managers can make it possible for employees to work toward career and eductional goals without having to duplicate previously acquired competencies. By considering both company goals and employee educational goals, training managers can realize some of the articulation benefits typically associated with the public school system. At the Idaho National Engineering Laboratory, several contractor training managers have established cooperative agreements with local college administrators, agreements that allow contractor employees university credit for completing specific contractor training and professional development courses.


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Student articulation is a widely-used term that describes a common practice in the public school system. Articulation allows students to progress efficiently from one learning level to the next. This efficient progression may occur within an institution (a particular high school, for example), and it may occur between institutions (a high school to a postsecondary technical school).

Kraska[1] defined articulation as "the process which permits the smooth transfer and progression of students moving from one educational level, institution, program, course, or activity to the next highest level; and which provides a coordinated and interrelated curriculum for students enrolled in programs, courses, or activities which exist at any educational level." Student articulation has many advantages; students, the various institutions, and taxpayers all benefit from programs that maximize articulation.

For articulation to be successful, several criteria must be met. Training/education programs that are going to be accepted by other organizations must be accountable; requirements for mastery must be defined for each program. Articulation requires a high level of cooperation within educational institutions and between institutions. Administrators and instructors must maintain open communication among personnel at various levels within an organization and with personnel from participating organizations. Organizations or programs involved in articulation agreements must also maintain accurate records substantiating that the requirements of the various arti- .ation agreements have been met.

The mission of most training organizations is different from that of educational institutions. Instead of broad educational goals, most training organizations have a very specific mission: train employees to safely and efficiently perform specific tasks. In the nuclear industry most training programs are based on specific job requirements. Some form of job analysis is used to arrive at performance based knowledge and skill learning objectives. Once employees have mastered the knowledge and skill objectives, they are qualified to perform the job tasks. In many cases there will also be a continuing training program or requalification program to ensure that task specific competencies are maintained. Most technical training programs demonstrate one aspect of the articulation process. Employees progress smoothly from one training level to the next with minimal duplication. A health physics technician progressing to the next level does not start all over at the very beginning, but builds on existing competencies and masters additional performance based objectives.

Changes in today's work environment give training managers reason to be concerned with articulation, especially cooperative agreements with other training and/or educational institutions. Specific articulation agreements will depend on many variables, such as the business or industry, the size and organizational structure of the training organization, the mission of the training organization, and so on.

Peters[2] maintains that for U.S. industry to be competitive, companies must:

"Invest in human capital as much as hardware."
"Train everyone in problem-solving techniques to contribute to quality improvement."
"Use training as a vehicle for instilling a strategic thrust."

Carneval[3] noted that in much of today's technologically sophisticated work environment, "nonsupervisory employees need skills commonly associated with the managerial function: self-management skills, interpersonal skills, teamwork skills, and problem-solving skills." Another issue frequently mentioned in current training and education literature is the number of career changes that a typical worker will make. Spanbaur[4] states, "The average person will change job responsibilities at least five times during a lifetime and change employers at least three times."

Related to the frequency of career changes is the idea of lifelong learning. In today's constantly changing work environment, there are no terminal training programs or degree programs. Employees must be constantly learning new skills and acquiring knowledge to keep pace with the advances in technology and the changes in job responsibilities.

With these issues in mind it may be time for some training managers to reevaluate the mission of their organizations. Rather than focusing soley on task specific training, there may be opportunities for training organizations to expand their mission to include developing and delivering a more complex curricula, and developing cooperative arrangements with other training and educational organizations. This expansion will give the employee an enhanced opportunity to pursue career and educational goals and at the same time, will improve the efficiency and adaptability of the work force.

Suggestions for articulation linkages for technical training organizations:

Apprenticeship Progr[illegible]
Military Technical Tr[illegible]ing Programs
Four-Year Colleges
Junior Colleges
Vocational Schools
Secondary Schools
Other Business/Industrial Training Organizations

At the Idaho Chemical Processing Plant, a Department of Energy nuclear fuels reprocessing facility operated by Westinghouse Idaho Nuclear Company (WINCO), several successful articulation agreements have been developed. WINCO has a centralized training organization which provides technical training in four main areas: operations, maintenance, health physics, and industrial safety. One articulation agreement between WINCO and the Eastern Idaho Vocational-Technical School (EIVTS) involves the Radiation Worker Program. WINCO provides radiation worker training to all WINCO employees and accepts the radiation worker training that EIVTS provides to construction contractor personnel. This cooperative agreement has benefited all parties and has required little development or oversight time from WINCO Training personnel.

Another articulation agreement involves the WINCO Training Specialist Qualification Program and the College of Education at Idaho State University. The 148-hour classroom portion of the WINCO Training Specialist Qualification Program has been accredited by Idaho State University for six semester hours credit in the Vocational Teacher and Corporate Training degree programs. The WINCO classes are substituted for two university classes required in both the Vocational Teacher and Corporate Training Bachelor of Science Degree Programs. The benefits of this cooperative agreement have far outweighed the efforts required to maintain the agreement, including program development and ongoing evaluation.

Technical training managers can use a methodology to develop articulation linkages with other organizations that is similar to current curriculum develpment methodologies. The first phase is Analysis. In this phase there should be two main steps.

1. Needs Analysis

Determine the training and professional development needs of your customers.

Find out what career development programs employees are taking on their own time.

2. Resource Analysis

Determine what types of training and professional development is your organization best suited to provide.

Determine what other training and professional development organizations are in your area that have the resources or perhaps just the potential to provide the types of training or professional development you are looking for.

Determine what articulation linkages already exist in your area.

The next phase in the process, Development, may have a wide variety of activities, depending on the particular articulation linkage. Possible steps may include:

Establishing points of contact and holding meetings to establish the cooperative agreement goals.

Establishing a steering committee.

Determining that the program(s) in question, including the records management system(s) for the program(s), meet or can be modified to meet the requirements of the organizations interested in an articulation agreement.

Developing a written articulation agreement.

Developing the implementation and evaluation plans for the articulation agreement.

Implementation is the next step in the process. If the analysis and development work has been accomplished, the implementation phase should be the easiest step. There are two main activities in this phase:

Implement the implementation plan.

Implement the evaluation plan.

Evaluation is the last step in the process. Some of the evaluation concerns that might be considered are as follows:

Determine if the articulation agreement is meeting the original goals.

Determine if the articulation agreement satisfies the requirements of the involved organiztions.

Evaluate if trainees are satisfied with the articulation agreement.

Even though most technical training organizations have a very different charter than do educational institutions, there may be increasing oportunities for training managers to develop employee articulation agreements with other training and educational institutions. Training accreditation activities, the addition of professional development courses to training programs, and job cross-training programs may create new possibilities for establishing employee articulation agreements. If the proper analysis, development, implementation, and evaluation steps are taken to establish an articulation agreement, everyone wins.

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SYSTEMATIC APPROACHES TO TRAINING: LESSONS LEARNED FROM A DECADE OF EXPERIENCE

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## BIOLOGICAL EFFECTS OF IONIZING RADIATION

## CHANGING WORKER ATTITUDES

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### ABSTRACT

Training Resources and Data Exchange (TRADE) Radiation Protection Training Special Interest Group has taken an innovative approach to providing DOE contractors with radiation worker training material information. Newly-hired radiation workers may be afraid to work near radiation and long-term radiation workers may become indifferent to the biological hazard of radiation. Commercially available training material is often presented at an inappropriate technical level or in an uninteresting style. These training problems have been addressed in the DOE system through development of a training videotape and supporting material package entitle "Understanding Ionizing Radiation and its Biological Effects."

The training package, developed and distributed by TRADE specifically to meet the needs of DOE contractor facilities, contains the videotape and accompanying paper supporting materials designed to assist the instructor. Learning objectives, presentation suggestion for the instructor, trainee worksheets, guided discussion questions, and trainee self-evaluation sheets are included in the training package. DOE contractors have agreed that incorporating this training module into radiation worker training programs will enhance the quality of the training and increase worker understanding of the biological effects of ionizing radiation.

TRADE

RADIATION PROTECTION TRAINING

# BIOLOGICAL EFFECTS OF IONIZING RADIATION

## CHANGING WORKER ATTITUDES

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## TRADE AND THE RADIATION PROTECTION TRAINING SPECIAL INTEREST GROUP

Training Resources and Data Exchange (TRADE), established in 1978, is a formal peer-to-peer network of Department of Energy and contractor training and development personnel. TRADE activities are designed to increase communication and exchange of ideas, information, and resources among DOE contractor facilities. Oak Ridge Associated Universities manages TRADE for the Department of Energy (DOE). TRADE Special Interest Groups (SIGs) are formed to involve training-related personnel in TRADE activities. The list of TRADE SIGs include those devoted to Radiation Protection Training (RPT), Industrial Hygiene Training (IHT), Emergency Preparedness (EP), and Computer-Based Training (CBT). The RPT SIG is sponsored by the Office of Safety Policy and Standards, DOE.

Members of the RPT SIG identified a common need for additional training material for radiation workers on the topic of biological effects of ionizing radiation. In 1988 the RPT SIG decided to develop and produce a training package to specifically meet the needs of DOE contractor facilities as they implement the training requirements of DOE order 5480.11. DOE Orders establish policy, rules, regulations, and requirements for the DOE and its contractors. The training requirements that relate to the biological effects of radiation are shown in Table 1.

TABLE 1. DOE 5480.11 Required Radiation Safety Training Related to Biological Effects

| TOPICS FOR RADIATION WORKERS |
| --- |
| Characteristics of ionizing radiation |
| Man-made radiation sources |
| Acute effects of exposure to radiation |
| Risk associated with occupational radiation exposures |
| Special considerations in the exposure of women of reproductive age |
| Mode of exposure--internal and external |
| Basic protective measures--time, distance, shielding |

## AN INNOVATIVE APPROACH TO CHANGING WORKER ATTITUDES

It has been found that newly hired radiation workers may be afraid to work near radiation. Long-term radiation workers often become indifferent to the potential biological hazards of radiation. DOE contractor facilities have been training employees about the biological hazards of ionizing radiation for many years and most trainers are aware that commercially available training material is often presented at an inappropriate level or in an uninteresting style.

The RPT SIG decided to help solve these training problems by developing a training videotape and supporting material package entitled "Ionizing Radiation and Its Biological Effects." The contents of the videotape is generic information that is appropriate for training in all DOE facilities.

The first step to develop the videotape was to determine the learning objectives for the training package. These were based on the training requirements from the DOE order and the need to include information about basic cell biology to increase trainee understanding of the topic. The videotape script and storyboard were written based on the identified learning objectives. The first draft of the script was written from information collected from several DOE contractors. Oak Ridge National

Laboratory provided a large portion of the information. A health physics training manager from Oak Ridge National Laboratory, a DOE facility, served as the subject matter expert for both the script development and the videotape production.

The draft script was reviewed by the members of the RPT SIG Steering Committee to ensure that the content would be applicable across the DOE system. All of the recommended changes were incorporated into the final script before it was reviewed and critiqued by the RPT SIG Steering Committee and by DOE. The extensive pre-production review accomplished two goals. The first of these was to ensure that the videotape addressed the majority of the training topics required by DOE order 5480.11 that relate to the biological effects of ionizing radiation. All of the topics listed in Table I are included in the videotape either as a brief review or as a substantive presentation.

The second goal of the pre-production review was to make sure that the language and level of information was appropriate for the audience. The target audience for the training is radiation workers at DOE contracto facilities. This group is diverse in both education and job responsibility. The language used in the videotape narration is on an eighth grade reading level. The production style and arrangement of information was planned to be interesting, attention-getting, and arranged so that each new subject builds upon information presented earlier in the videotape.

Table 2 lists the major topics included in the videotape. The introduction discusses the establishment of radiation dose limits and the ALARA philosophy. Radiation Exposure Sources contains a review of sources of radiation exposure and includes brief discussions of background radiation, occupational sources and protection procedures, and internal contamination routes of entry.

TABLE 2. Topics Included in Videotape

| |
|---|
| Introduction |
| Radiation Exposure Sources |
| External |
| Internal |
| Types of Ionizing Radiation |
| Units of Radiation Dose |
| Rad |
| Quality Factor |
| Rem |
| Radiation Effects on Cells and Tissues |
| Direct and Indirect Effects |
| Genetic and Somatic Effects |
| Chronic a Acute Effects |

Animation is used to illustrate the penetrating power of ionizing radiation and the amount of energy capable of causing biological damage. In the neutron sequence, for example, the neutron beam approaches and passes through the figure of a man, leaving behind colored dots representing energy deposited in the figure by the radiation.

A chart made up of these colored dots is used to explain the concept of "quality factor" and to define the radiation dose equivalent term, the rem.

The direct and indirect effects of radiation on cells are also conveyed using animation. The last part of the animation sequence explains indirect cellular damage through the action of radiation-generated free radicals.

The concept of radio-sensitive and-resistant tissues is introduced to lead into the discussion of radiation effects on the unborn embryo and fetus. It is expected that an understanding of the biological reasons for fetus protection limits will have a positive influence on the attitudes of th male and female radiation workers toward this vital safety regulation.

Onscreen graphics are also used for the discussion of dose rate and acute and chronic radiation effects. The acute effects of radiation are correlated with exposure level, prognosis with medical treatment, and radiation therapy.

The videotape is only part of the training package. An instructors manual was developed to accompany the videotape. It provides information about how to integrate the videotape into an ongoing training program and includes trainee handouts, pre- and post- training self-evaluation forms, and an appendix of subject matter not covered in the videotape that might be included in a training session if the instructor so chooses.

The instructor notes section of the manual contains suggestions for presenting the biological effects module, the learning objectives for the videotape, a set of masters for preparing overhead transparencies covering the keypoints of the training content with an accompanying storyboard, and a set of questions to stimulate a guided discussion.

The trainee notes section contains a pre-training familiarization quiz, notes keyed to the learning objectives of the videotape, worksheets, and a post-training self-evaluation with answer sheet. The self-evaluation is also keyed to each learning objective.

The content of the training module is generic information and is applicable to all DOE contractor facilities. Seven of the 20 radiation safety training topics required by DOE Order 5480.11 are covered in whole or in part by the "Ionizing Radiation and Its Biological Effects" training module. DOE contractors have agreed that incorporating this training module into radiation worker training programs will enhance the quality of the training and increase worker understanding of the biological effects of ionizing radiation.

# CRISIS MANAGEMENT PROGRAM FOR SENIOR OFFICIALS

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## ABSTRACT

The Emergency Preparedness Special Interest Group (EP SIG), a part of the Training Resources and Data Exchange (TRADE) peer-to-peer network of Department of Energy (DOE) and contractor training and development personnel, developed the Crisis Management Program for Senior Officials. The program was developed in response to commonly-identified training need for basic information in emergency management for DOE and contractor organization senior officials.

The Crisis Management Program for Senior Officials is a set of materials which consists of a program brochure, an introductory videotape, an assessment tool for senior officials, a series of five management briefings on crisis management topics, a suggested one-day seminar for senior officials off-site, follow-up activities on-site, and an instructor's guide. The objective of the program is to offer basic information to the senior official on the proper perspective of crisis management, the phases of a crisis, the strategic role of the crisis manager, constraints and consequences of a crisis, and crisis management stress. The knowledge and skills learned in the crisis management program offer an increased awareness to the senior official of the importance of emergency preparedness, planning and practice before a crisis occurs.

TRADE

EMERGENCY PREPAREDNESS

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CRISIS MANAGEMENT PROGRAM FOR SENIOR OFFICIALS

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## INTRODUCTION

Senior officials at Department of Energy (DOE) and contractor operated facilities are responsible for managing and directing overall actions in an operational emergency and for establishing related administrative and procedural policies. Consequences of inaction or inappropriate action by these senior officials may include injury to personnel, damage to the environment, and damaged or lost property. This presentation focuses on the components for crisis management training at the senior official level and provides information about a course developed by the Training Resources and Data Exchange (TRADE) Emergency Preparedness Special Interest Group (EP SIG). Information is presented about the development of the program, the intended target audience, the approach taken in the program, the materials used, and the presentation of the program.

## TRADE AND THE EP SIG

TRADE, established in 1978, is a formal peer-to-peer network of Department of Energy (DOE) and contractor training and development personnel. TRADE activities are designed to increase communication and exchange of ideas, information, and resources among DOE contractor facilities. Oak Ridge Associated Universities (ORAU) manages TRADE for the DOE.

Under the TRADE umbrella there are several Special Interest Groups (SIGs) of which EP is one. The EP SIG was begun in 1986, and is sponsored by the Office of Emergency Operations, DOE and the Office of Safety Policy and Standards, DOE. Emergency preparedness coordinators and trainers from the DOE and contractor facilities meet several times each year, present information about emergency preparedness training efforts at their facilities, and carry out activities which address their needs. The primary objectives of the EP SIG are to coordinate the exchange of ideas, techniques, and training resources;

to identify common training priorities and interests in emergency preparedness; and to pursue activities that address shared contractor needs. The EP SIG currently has 110 members from 45 DOE and contractor facilities.

## WHY CRISIS MANAGEMENT FOR SENIOR OFFICIALS?

During the first meeting of the EP SIG in 1986, participants identified through discussions with each other the common training needs which existed in emergency preparedness. A survey of EP SIG members was completed which resulted in a listing of 21 activities the members felt would be of benefit to them. The top priority of this survey was to engage in an activity which resulted in a crisis management training program for senior officials at DOE and contractor sites. A Task Force was established to work on this project. At the next EP SIG general meeting, Task Force members held workshops in small group settings with the members to identify the target audience for the crisis management program and to flesh out the components of the program.

## TARGET AUDIENCE

It was determined that the target audience for this training is senior DOE and contractor officials who function as crisis managers or as members of the policy group during a crisis. These senior officials manage and direct overall operations and determine administrative and informational policies and procedures.

Given that some senior officials may have previous experience as an Emergency Operations Center staff member and others may have little if any experience in an emergency setting, it is felt that there is a need to bring all senior officials to an acceptable level of competency through modular, compartmentalized basic training. It is also felt that senior officials with previous experience as an Emergency Operations Center staff member may not view the senior official position with the proper perspective. An overall, strategic perspective rather than a tactical perspective is appropriate for the senior official in this target audience. The knowledge and skills developed in the crisis management for senior officials program will not be used on a regular basis. Thus, there is a need for regular briefing of the senior official as well as participation in facility-specific drills and exercises.

The EP SIG consensus is that the needs of senior officials can most effectively be addressed through a program that is organized into a series of short briefings, does not require the senior official to be off-site for more than one day, covers a core of crisis management fundamentals, and includes facility specific instruction, drills, and exercises.

APPROACH

Based on the perceived training needs of these senior officials, the crisis management program involves several methods of training and several different formats. The program includes one-on-one instruction, lectures, videotape materials, and participation in drills and exercises. Guest lecturers may play a role in the program. The components of the crisis management program for senior officials are:

- Program brochure
- Introductory videotape
- Assessment tool
- A series of five management briefings
- A suggested one-day seminar for senior officials off-site
- Follow-up activities.

In addition, an instructor's guide is provided to the emergency preparedness coordinator/trainer as an integral part of the program. The instructor's guide offers additional resources and suggested follow-up activities for the program as well as instructions for personalizing the program to be site specific.

MATERIALS

Program brochure. The program brochure is an introductory device for the emergency preparedness coordinator/trainer to use in engaging the interest and time of the senior official. It establishes program credibility by offering a description of the crisis management program, identifying program goals, informing the senior official as to the focus of the program, and describing the target audience. The program brochure offers information about the DOE orders and requirements regarding operational emergencies.

Introductory videotape. The videotape also aids in establishing program credibility. It provides an overview of the program content, explains the need for the program, outlines the DOE perspective and philosophy of crisis management, and educates the senior official as to the importance of proper crisis management in order to protect personnel, the local population, the environment, and property.

Assessment tool. The assessment tool aids the senior official in identifying his/her knowledge of the DOE crisis management philosophy and requirements. It covers the salient points from each of the five management briefings, offering questions from each so that the senior official can assess his/her own comfort level with the subject matter contained in the briefings. The assessment tool gives the senior official and the emergency preparedness coordinator/trainer a basis for discussion of the senior manager's knowledge and comfort level in managing a crisis.

Management briefings. A series of five management briefings comprises the backbone of the crisis management for senior officials program. The briefing topics are:

- crisis management in perspective
- the phases of a crisis
- the strategic role of the crisis manager
- constraints and consequences of a crisis
- crisis management stress.

Crisis management in perspective. This briefing identifies the differences between day-to-day and crisis management and discusses the importance of crisis management skills to the senior official. The characteristics of crisis management are discussed and examples of crisis situations are given. The proper DOE philosophy for managing a crisis is discussed. Information about emergency management plans, emergency operations centers, and emergency response levels is given. The organizational structure during an emergency is also discussed.

The phases of a crisis. This briefing explains the evolution and phases of a crisis. It identifies some of the situations which can result in a crisis. The phases of a crisis are identified and the important aspects of each phase are explained. The importance of crisis follow-up evaluations is also discussed.

The strategic role of the crisis manager is the subject of the third briefing. This briefing focuses on developing an understanding of and appreciation for the senior manager's role. Topics covered include responsibilities, information available to the senior official, decision making in a crisis, communications, and the role of the media. Crisis management skills are described. The importance of good media relationships and the media spokesperson is discussed.

The constraints and consequences of a crisis. This briefing discusses time and other constraints in a crisis. It identifies the major critical decision points of a crisis and describes the appropriate amount of time in which to take immediate action. Consequences of poor performance, no action, untimely action, and wrong action during a crisis are covered.

Crisis management stress is the final briefing. The goals of this briefing are to provide a general knowledge of stress, stress symptoms, and post traumatic stress. The symptoms of stress to watch for in yourself and in others are described. Managing stress for senior officials and their team members is discussed. Techniques for handling stress are presented. Dealing with post traumatic stress is also discussed.

One day crisis management seminar. The EP SIG Task Force has recommended that a one day seminar off-site for senior officials who have completed the management briefings be conducted. It is suggested that this seminar occur on a regional basis, giving senior officials from each site the opportunity to meet and discuss crisis management with their counterparts from other facilities. The seminar will also give senior officials the opportunity to discuss information presented in all of the management briefings. The facilitator for the seminar will be a person with substantial crisis management experience at the senior official level. Preliminary plans for this one day seminar are complete.

FOLLOW-UP ACTIVITIES

The instructor's guide for the crisis management program contains suggestions to the emergency preparedness coordinator/trainer for follow-up activities on site. These include senior official participation in drills, exercises, and tabletops; briefings with local resource people about stress management during a crisis, and other activities. The purpose of follow-up activities is to inject the site specific components of crisis management, refresh the senior official's knowledge, provide the program to new senior officials, and keep the appreciation of emergency preparedness activities alive.

TRAINER ORIENTATION

Once the crisis management program for senior officials was completed and produced, its introduction to the EP SIG members was planned. The Task Force and ORAU staff members presented the entire program to the EP SIG membership at their spring meeting, just several weeks ago. Workshops were given for small groups of EP SIG members. The components of the program were presented, the videotape was viewed, and the instructor's guide was discussed in detail. Suggestions were made to the EP SIG members for personalizing the program to include site-specific information and follow-up activities. Each EP SIG member was provided with multiple copies of the program brochure, a videotape, and the other crisis management program materials.

## SUMMARY

The Crisis Management Program for Senior Officials is designed to meet a stated EP SIG need of providing basic information to senior officials at DOE and contractor facilities so that the activities of a senior official during a crisis are appropriate. The senior official gains an appreciation of his/her strategic role and learns to avoid the pitfalls of micromanagement and to think strategically rather then tactically. The knowledge and skills learned in the crisis management program offer an increased awareness to the senior official of the importance of emergency preparedness, planning and practice before a crisis occurs.


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