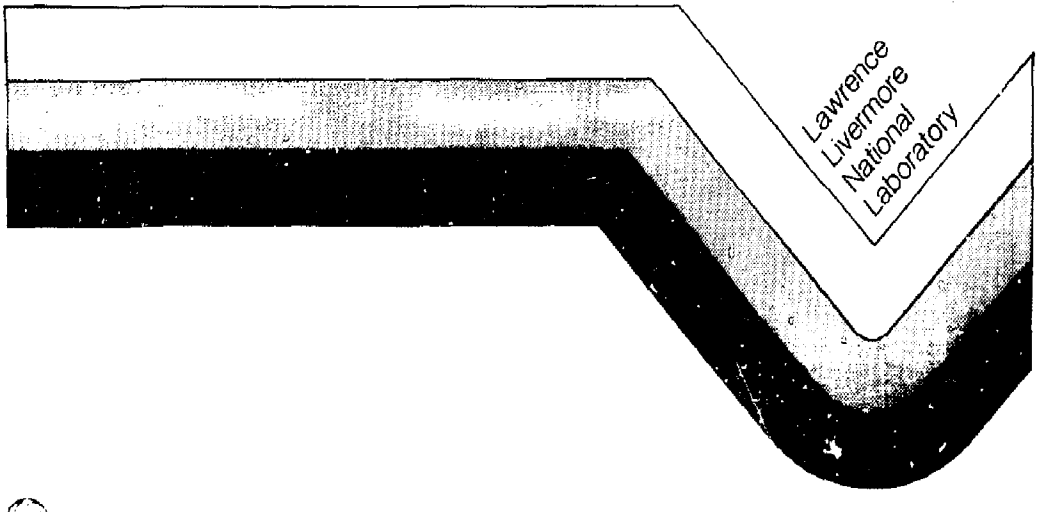
UCRL--15674

DE85 012957

Annotated Bibliography of Human Factors Applications Literature

Prepared for
U.S. Department of Energy
Office of Nuclear Safety
by
Lawrence Livermore National Laboratory
Livermore, California 94550
and
Essex Corporation
Alexandria, Virginia 22314

September 30, 1984



DISCLAIMER

Work performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract W-7405-Eng-48.

ANNOTATED BIBLIOGRAPHY OF HUMAN FACTORS APPLICATIONS LITERATURE

Prepared for

U.S. Department of Energy
Office of Nuclear Safety

by

Lawrence Livermore National Laboratory
Livermore, California 94550

and

Essex Corporation
Alexandria, Virginia 22314

September 30, 1984

CONTENTS

ACKNOWLEDGEMENTS

The principal investigator and task manager for development of this bibliography was Denise B. McCafferty of Essex Corporation. Overall technical direction was provided by L. Rolf Peterson of Lawrence Livermore National Laboratory and Barbara Paramore of Essex. Charles C. Campbell was the technical monitor for the Office of Nuclear Safety, U.S. Department of Energy.

Major contributions were made in the development and preparation of the bibliography by the following Essex personnel:

Literature Search and Annotation

Phil Durham

Mike Francher

Cindy Gal

Lois Grealis

Jennifer Payette

Editing

Jim Cammisa

Production

Vanessa Weedon

Karen Miller

SECTION 1.0
INTRODUCTION

1.0 INTRODUCTION

1.1 Background

This bibliography was prepared as part of the Human Factors Technology Project, FY 1984, sponsored by the Office of Nuclear Safety, U.S. Department of Energy. The project was conducted by Lawrence Livermore National Laboratory, with Essex Corporation as a subcontractor.

The material presented here is a revision and expansion of the bibliographic material developed in FY 1982 as part of a previous Human Factors Technology Project. The previous bibliography was published September 30, 1982, as Attachment 1 to the FY 1982 Project Status Report.

1.2 Organization

The remaining sections of this volume contain the bibliography and an index. Section 2.0 presents the annotated bibliography; references are given in alphabetical order on individual pages, followed by an abstract and suggested applications. The upper right-hand corner of each page lists applicable topic areas for the references. Section 3.0 is a supplemental bibliography, listing in alphabetical order those references for which no abstracts were available. Appendix 1 indexes the annotated bibliography by topic area, listing all references applicable to each topic.

SECTION 2.0
ANNOTATED BIBLIOGRAPHY

Acoustical Society of America. (1971). Associated terminology (including mechanical shock and vibration) (ANSI 91.1-1971 R1960). New York: Author.

ABSTRACT

This standard establishes acoustical terminology including mechanical shock and vibration. Terminology is outlined in alphabetical order within the following categories: acoustics, vibration frequency, harmonics, velocity, levels, and criteria for sensory and auditory thresholds.

APPLICATION

This report was intended for use by industrial psychologists, industrial human factors personnel, and various vendors involved with acoustical considerations in design systems. This may prove useful to personnel performing noise surveys in control room desir reviews.

Advisory Committee on Reactor Safeguards. (1980). An approach to quantitative safety goals for nuclear power plants (NUREG-0739). Washington, DC: Nuclear Regulatory Commission.

ABSTRACT

A possible approach to quantitative safety goals for nuclear power plants is provided by the Advisory Committee on Reactor Safeguards. The report contains three parts: 1. A review of several proposals for quantitative risk criteria. 2. A preliminary proposal for a possible approach to quantitative safety goals. 3. A brief evaluation of several technologies, including nuclear, in terms of the proposed criteria. The trial approach to quantitative safety criteria is divided into two major tasks: The first is the predominantly social and political problem of setting the safety criteria, which are termed decision rules; the second is the technical question of estimating the risks and deciding whether the safety criteria have been met.

The proposed numerical values for use in decision rules are intended to stimulate further discussion and evaluation leading to the future development of suitable risk acceptance levels.

APPLICATION

Since safety is of great importance in the nuclear field, this paper offers a quantitative approach to those interested in nuclear safety.

American National Standards Institute. (1971). Method for the physical measurement of sound (ANSI 91.2-1962). New York: Author.

ABSTRACT

This report provides information as to different methods and types of sound detection. Measurements are made in sound pressure levels, decibels, and ambient sound pressure level correction. Determinations are made to standardize data collection methods through calibrated microphones, sound frequency analyses, and directivity. Summarily, results indicate that low-frequency sounds need absorption in order to reduce reverberation.

APPLICATION

This report provides information which is intended for sound measurement in human factors engineering as well as job performance analysis. This material may be useful for noise surveys for control room design reviews.

American National Standards Institute. (1972). American national standard administrative controls and quality assurance for the operational phase of nuclear power plants revision of N18.7-1972 (ANSI 18.7-1976). LaGrange Park, IL: Author.

ABSTRACT

Historically, quality assurance as an accepted discipline has been associated with manufacturing and construction activities from which it originated as a separate function.

In contrast to potential effects of deficiencies in manufacturing and construction, deficiencies in operating activities can be much more immediate in their effect. For example, it is important that the dynamic aspects of operation be monitored on an essentially continuous basis. Instrumentation for monitoring, control, and actuation of safety systems, and observations by and response from the operating staff, are both extensively used for this purpose in nuclear power plants. In a nuclear power plant employing proper administrative controls and quality assurance practices, the critical appraisal by supervisory personnel of plant operating evolutions, trends in parameters, maintenance, and day-to-day work practices is the most significant portion of assuring the quality of plant operation (in the broad sense of the term "quality assurance"), whereas quality assurance (as a technical discipline or an organizational unit) of operating activities is associated principally with checking the adequacy and completeness of work after it is completed. This revision emphasizes that both operating staff and personnel performing other quality assurance functions have important roles in the ". . . planned and systematic activities. . ." specified in the Appendix B definition of quality.

APPLICATION

This ANSI standard discusses administrative controls and quality assurance for operations and maintenance. This report is especially useful for persons involved with generation, production, or control of procedures and documentation.

American National Standards Institute. (1980). IEEE trial-use standard criteria for the design of the control room complex for a nuclear power generating station (ANSI/IEEE Std 567). New York: Author.

ABSTRACT

This standard addresses the central control room of a nuclear power generating station and the overall complex in which this room is housed. The purpose of this standard is to provide guidance for the design of the nuclear power plant control room complex, which must meet applicable criteria in Appendix A of 10 CFR 50. Requirements are established and recommendations are offered to aid the designer in meeting the applicable general design criteria.

APPLICATION

This standard provides guidance for the design of nuclear power plant control rooms which meets the criteria in Appendix A, 10 CFR 50.

American Nuclear Society. (1978). American national standard for selection and training of nuclear power plant personnel (ANSI/ANS 3.1-1978). LaGrange Park, IL: Author.

ABSTRACT

This report provides criteria for the selection and training of personnel for stationary nuclear power plants. It addresses itself to the qualification, responsibilities, and training of personnel in operating and support organizations necessary to efficiently operate a nuclear power plant.

APPLICATION

This report is intended to provide support for training personnel, supervisors, and licensing personnel.

American Nuclear Society. (1979). American national standard guidelines for considering user needs in computer program development (ANSI/ANS 10.5-1979). LaGrange Park, IL: Author.

ABSTRACT

This report provides guidelines for accommodating user needs in preparing computer programs for scientific and engineering applications. These guidelines were developed to ensure proper application and to simplify using the computer program.

APPLICATION

This report is intended for use by data processing personnel and computer programmers for application in their own programs.

American Nuclear Society. (1979). Immediate evacuation signal for use in industrial installations (ANSI/ANS N2.3-1979). New York: Author.

ABSTRACT

This standard defines the characteristics of signals for situations requiring prompt evacuation of personnel to prevent serious injury. Devices required to activate the signal are discussed although not specified. The reliability requirements of the signal-generating system are specified. Operational testing requirements are specified for the signal-generating system.

APPLICATION

This standard was developed for use in installations where ionizing radiation exposures might occur, but it may be used for other establishments where immediate evacuation is required.

American Nuclear Society. (1983). Criteria for remote shutdown for light water reactors (ANSI/ANS 58.6-1983). LaGrange Park, IL: Author.

ABSTRACT

This report provides design criteria for specific controls and monitoring equipment which are utilized during a safe shutdown condition. Control locations are placed in areas that are physically remote from the control room. These control locations are utilized only when control room access is not possible or desirable. Various standards are applied in the design, cable spreading, and auxiliary locations of controls and transfer devices.

APPLICATION

This report is utilized in remote shutdown criteria development in either normal operating modes or emergency procedures.

Analysis and Technology. (1983). Guidelines for job and task analysis for DOE nuclear facilities (Report No. DOE/EP-0095). Washington, DC: Department of Energy.

ABSTRACT

The guidelines are intended to be responsive to the need for information on methodology, procedures, content, and use of job and task analysis since the establishment of a requirement for position task analysis for Category A reactors in DOE 5480.1A, Chapter VI. The guide describes the general approach and methods currently being utilized in the nuclear industry and by several DOE contractors for the conduct of job and task analysis and applications to the development of training programs or evaluation of existing programs. In addition, other applications for job and task analysis are described, including: operating procedures development, personnel management, system design, communications, and human performance predictions.

APPLICATION

This guide outlines the job and task analysis process necessary for position task analysis projects for DOE Category A reactors. This information could also be helpful for similar projects in other DOE facilities.

Anderson, J.L. (1981). Operational aids for reactor operators. Interim report: ORNL foreign trip report (ORNL/FTR-1032). Washington, DC: Nuclear Regulatory Commission.

ABSTRACT

This trip report covers participation in two workshops at the Halden Reactor Project, Sarpsborg, Norway, and a visit to operating reactors in the United Kingdom. Of particular note are the following:

1. The intent of the Halden Reactor Project to procure a new simulator for operator performance experiments.

2. The development of functional and design requirements for a stand-alone system to simplify the presentation of alarm information.

3. The relative aggressiveness with which the UK has implemented computer technology in their reactors and the apparent wealth of operating experience this has generated.

APPLICATION

This trip was generated by an NRC-sponsored research program, "Operational Aids for Reactor Operators." The program's objective is to provide a technical basis for developing design requirements, developing regulatory review criteria, and assessing the impact on safety for methods to enhance the capabilities of reactor operators.

Bagchi, C.N., & Gottilla, S.C. (1981, February). Application of human engineering criteria to annunciator display systems in a large fossil power station. Proceedings of the IEEE Power Engineering Society Winter Meeting, Atlanta, GA.

ABSTRACT

This paper presents a conceptual design of a human engineered alarm system for a large fossil-fueled power generating station. Well-known human factors engineering principles have been incorporated into the design. Main features of this design are integration of hard-wired annunciators, localized alarms, and CRT alarms into a comprehensive system.

APPLICATION

The primary objective is that the alarm interface between the operator and the plant during a multifaceted emergency should become manageable and useful to the operator.

Baker, J.T. (1980, February). Automated preventive maintenance program for service industries and public institutions. Industrial Engineering, 18-21.

ABSTRACT

The maintenance of a company's physical plant has always been extremely important. This article outlines the important aspects of a facility maintenance program, as well as an automated program. Also outlined are ways to implement the program.

APPLICATION

This program for a multi-facility operation can be adapted for other applications.

Banks, W.W. (1980). *Some suggestions for human engineering design guidelines relating to CRT displays and software development* (Report No. SD-D-80-002). Idaho Falls, ID: EG&G Idaho, Inc.

ABSTRACT

The present set of guidelines was developed using several techniques including analysis of existing literature, review of recent studies, and application of standard human engineering principles. Interface guidelines relating to CRT displays and software development are developed for the following areas: display formats, frame content, command language, recovery procedures, user entry techniques, and response time considerations. The chief characteristic of these guidelines is specificity, reflecting specific issues rather than general considerations. In addition, wherever possible, stress is placed on quantitative rather than qualitative considerations. At the time of publication, these guidelines were not complete or final.

APPLICATION

This report contains a series of specific guidelines which, it is hoped, will aid in the design of visual interfaces and contribute to more effective man-computer interactions.

Banks, W.W. (1981). Human engineering CRT display development guidelines (Report No. SD-B-81-002). Idaho Falls, ID: EG&G Idaho, Inc., System Safety Division.

ABSTRACT

This internal company report contains specific and general guidelines for designing electronic visual displays (CRTs) to enhance the interface between man and machines. These guidelines cover the following areas: general considerations, display formats, frame content, color, command language, recovery procedures, user entry techniques, response time considerations, and unobtrusive assessment. The report focuses on quantitative rather than qualitative considerations of CRT display guidelines.

APPLICATION

Since CRT displays are the dominant medium for users of interactive computing and control systems, guidelines are needed to design effective interface devices. The report covers aspects of CRT man-machine interface design including displays, procedures, and software.

Banks, W.W. & Boone, M.P. (1981). A method for quantifying control acces ibility. Human Factors, 23, 299-303.

ABSTRACT

A method of statistically quantifying the accessibility of controls is proposed and validated. The resulting index of accessibility (I_a) takes into account three sources of variability: operators' reach envelope, frequency of use, and relative physical position of controls with respect to the operator. Operator ratings and measurement (percent) of controls reached were highly correlated with I_a values, lending support to the notion that I_a is sensitive to very small changes in control placement.

APPLICATION

The purpose of the present study is to test the feasibility of a method for quantifying selected human factors design criteria which originally elicited a subjective or qualitative judgment. The objective is to provide a technical basis for developing design requirements and regulatory review criteria, and for assessing the impact on safety for methods to enhance the capabilities of reactor operators.

Banks, W.W. & Boone, M.P. (1981). Nuclear control room annunciators: Problems and recommendations (NUREG/CR-2147). Washington, DC: Nuclear Regulatory Commission.

ABSTRACT

This report provides an extensive analysis of two test power reactors and two commercial pressurized water reactors. Serious problems were uncovered with the control room annunciators. Interviews were conducted with operators, shift supervisors, managers, and maintenance workers. As a result of the interviews and inspections, specific problems were identified. Recommendations were made for improvement in system engineering standerdization.

APPLICATION

This report is intended for application in the systems design, emergency planning, and human factors engineering aspects of nuclear control rooms.

Banks, W.W. & Clark, M.T. (1981). Some human engineering color considerations using CRT displays: A review of the literature (Report No. SD-B-81-001). Idaho Falls, ID: EG&G Idaho, Inc.

ABSTRACT

The purpose of this study is to provide an in-house document to answer many user and programmer questions related to color-generated CRT displays. The scope of the work is limited to the following areas: (1) accuracy in subject identification; (2) color enhancement for redundancy attributes; and (3) speed of information acquisition. The major emphasis is placed on empirical data collected from end-user test subjects.

APPLICATION

This study provides answers to questions which, it is hoped, will aid computer users and programmers in more effective use of color-generated CRT displays.

Banks, W.W., Gertman, D.I. & Petersen, R.J. (1982). Human engineering design considerations for cathode ray tube-generated displays (NUREG/CR-2496). Washington, DC: Nuclear Regulatory Commission.

ABSTRACT

This report identifies relevant issues related to human performance in conjunction with the use of cathode ray tube-generated displays. Twelve primary source documents were identified for human engineering content review. From these documents a set of 22 variables was selected and analyzed. Each variable is discussed in terms of its impact, relevance, and validity with regard to various standards that have evolved over the past 20 years. Studies related to each standard were also identified and cited that either support or weaken a particular standard. The conclusions drawn in this report indicate that there are areas needing further investigation before valid standards can be generated. However, there are many current standards that have ample research support to justify them as candidate standards for use by the Nuclear Regulatory Commission. Suitability of these various standards is discussed.

APPLICATION

The preliminary findings in this report suggest that human factors engineering research is needed in the following areas of CRT-generated displays: image distortion, display formats, work surface light reflection, cognitive fidelity, response time, and phosphor types.

Banks, W.W., Meyer, O. & Clark, M. (1980, August). Human factors considerations in the design of nuclear process displays. Paper presented at the Engineering Technology Conference, San Francisco, CA.

ABSTRACT

Process graphic CRT displays in the nuclear industry are the current focus of engineers and scientists involved in advanced display/control development. These types of graphic presentations must be capable of presenting a wide range of information to meet a diversity of human information requirements. These new displays often present a number of new design problems for both engineers and human factors scientists, while at the same time they provide solutions to other problems. For example, advanced control displays must project a highly flexible system of overlapping schematic information and yet simultaneously minimize the effect of too much information, clutter, noise, and visual symbol interference which impedes a clear, concise transfer at the man-display interface.

APPLICATION

It is the intent of this paper to organize and present cognizant literature and issues related to human factors and process control CRT displays.

Banks, W.W. & Sprague, R.L. (1982). The physiological and psychological effects of high pressure sodium lighting on graphics arts personnel: A critical review. Idaho Falls, ID: EG&G Idaho, Inc.

ABSTRACT

An intensive literature review was initiated to determine whether or not sound evidence exists to support the hypothesis that High Pressure Sodium Vapor Lighting (HPS) may be causatively related to degraded visual performance of graphics arts workers. The literature review yielded rather strong and consistent results indicating that the narrow bandwidth light produced by HPS significantly degrades certain human oculomotor functions, distorts color perception across the color spectrum (especially in the extreme ranges, such as blue and red), and is highly correlated with psychological reports of blurring, eye fatigue, dizziness, and headaches. Also, measurements taken in the graphics arts work area produced a calculated color rendition index range of 25 to 67, well below the minimum acceptable standard of 90 as published in the American National Standards for color rendition suggested for graphics arts workers.

Economic aspects of lighting were found to be a major concern in the literature because of the high ratio (approximately 1:250) between lighting cost and productivity costs. Given this ratio, it appears that a one-half of one percent increase in production would be more than enough to justify the doubling of lighting expenditures. The report recommends a number of approaches to enhancing the performance and productivity of graphics arts employees through changes to the existing lighting environment.

APPLICATION

Although the specific focus here is on lighting in the context of graphics production, the findings are applicable to any environment (such as a control room) where reading of displays and indicators takes place under artificial lighting.

Barks, D.B., Kozinsky, E.J. & Eckel, S. (1982). Nuclear power plant control room task analysis: Pilot study for pressurized water reactors (NUREG/CR-2598). Washington, DC: Nuclear Regulatory Commission.

ABSTRACT

The purposes of this nuclear plant task analysis pilot study were:

1. To demonstrate the use of task analysis techniques on selected abnormal or emergency operation events in a nuclear power plant

2. To evaluate the use of simulator data obtained from an automated Performance Measurement System (PMS) to supplement and validate data obtained by traditional task analysis methods

3. To demonstrate sample applications of task analysis data to address questions pertinent to nuclear power plant operational safety: control room layout, staffing and training requirements, operating procedures, interpersonal communications, and job performance aids.

Five data sources were investigated to provide information for a task analysis. These sources were (1) written operating procedures (event-based); (2) interviews with subject matter experts (the control room operators); (3) videotapes of the control room operators (senior reactor operators and reactor operators) while responding to each event in a simulator; (4) walk-/talk-throughs conducted by control room operators for each event; and (5) simulator data from the PMS.

A Westinghouse pressurized water reactor nuclear power plant simulator was utilized in this study. A simulator gives researchers the ability to observe actual control manipulations during accident scenarios. Four abnormal or emergency events were studied: nuclear instrument failure; small break loss of coolant accident (LOCA); steam generator tube leak; and inadvertent safety injection at power. Upon completion of the task analyses, computerized data reduction was performed. A PRIME 1-1000 computer was used to manage the task analytic data base.

APPLICATION

This task analysis will be of interest to those working in the areas of control room design, procedures, job performance, and simulators in conjunction with training.

Bartter, W.D., Siegel, A.I. & Federman, P.J. (1982). Job analysis of the maintenance supervisor and instrument and control supervisor positions for the nuclear power plant maintenance personnel reliability model (NUREG/CR-2668). Washington, DC: Nuclear Regulatory Commission.

ABSTRACT

This report attempts to define and elaborate the acts of maintenance technicians in nuclear power plants. The methods, procedures, and results of an analysis of the job of supervisors of maintenance mechanics and of instrument and control technicians in such plants are presented. The results of such analyses have direct implications relative to the organization and content of a nuclear plant maintenance reliability model.

APPLICATION

This study is applicable in the area of task analysis in relation to performance, time, safety, training, and various other abilities for task performance.

Bauman, M.B., Davidson, M.K. & Van Cott, H.P. (1984, October). Enhancing plant effectiveness by improving organizational communication. Proceedings of the Human Factors Society - 28th Annual Meeting, San Antonio, TX.

ABSTRACT

The purpose of this EPRI-sponsored study is to investigate the impact of communication problems on nuclear power plant (NPP) operations and to design, implement, and evaluate alternative programs that address nuclear power plant communication issues. Preliminary survey results from four nuclear power plants showed that six communication areas warranted special attention. These were: timeliness, redundancy, withholding of information, feedback, information amount, and quality of work-related documentation. Two approaches that have been developed to address plant-specific problem areas are presented. One approach involves evaluating the effectiveness of automated work request systems at two plants as mechanisms for improving interdepartmental communications and job performance. Another focuses on determining the effectiveness of interdepartmental meetings for improving organizational communication. The methods for longitudinally evaluating the effects on organizational communication and plant effectiveness are also presented.

APPLICATION

This report presents an approach for assessing departmental interfaces and plant communication in the work request process. Methods for enhancing plant effectiveness through improved communication and coordination of work are discussed.

Bauman, M.B., Pain, R.F., Van Cott, H.P. & Davidson, M.K. (1983). Survey and analysis of work structure in nuclear power plants (Report No. EPRI NP-3141). Palo Alto, CA: Electric Power Research Institute.

ABSTRACT

Work structure factors are those that relate to the way in which work at all levels in a plant is organized, staffed, managed, rewarded, and perceived by plant personnel. Research over many years has demonstrated that these work structure factors are closely correlated with organizational effectiveness, safety, and profitability. The work structure of ten nuclear power plants was assessed using questionnaires. Structured "critical incident" interviews were conducted to verify the questionnaire results. The study revealed that a variety of work structure factor problems do exist in nuclear power plants. The study recommends a prioritized set of candidate research issues to be considered as part of EPRI's Work Structure and Performance Research Program.

APPLICATION

This study demonstrates the importance of work structure in effective nuclear power plant operations. The findings may provide insights to nuclear power plant personnel regarding sources of existing problems and methods for improving organizational effectiveness.

Bauman, M.B., Pain, R.F., Van Cott, H.P. & Davidson, M.K. (1983). Work structure in nuclear power plants. Proceedings of the Human Factors Society - 27th Annual Meeting, 1, 571-575.

ABSTRACT

This paper describes the assessment of the work structure of ten nuclear power plants. Questionnaires were given to a cross-section of personnel, and structured "critical incident" interviews were conducted to verify the questionnaire results. The study revealed that a variety of work structure factor problem areas do exist in nuclear power plants.

APPLICATION

This report provides information useful to all plants in identifying priority problem areas within the work structure.

Beare, A.N., Crowe, D.S., Kozinsky, E.J., Barks, D.B. & Haas, P.M. (1982). Criteria for safety-related nuclear power plant operator actions: Initial boiling water reactor (BWR) simulator exercises (NUREG/CR-2534). Washington, DC: Nuclear Regulatory Commission.

ABSTRACT

The primary objective of the Safety-Related Operator Action Program at Oak Ridge National Laboratory is to provide a data base to support development of criteria for safety-related action by nuclear power plant operators. This report presents initial data obtained from ten exercises conducted in a boiling water reactor power plant control room simulator. The ten exercises were performed by 24 groups of operators from three utilities. Operator performance was recorded automatically by a program called the Performance Measurement System run on the simulator's computer. Data tapes were subsequently analyzed to extract operator response time (RT) and error rate information. In addition, demographic and subjective data were collected and analyzed in an attempt to identify and evaluate the possible effects of selected performance-shaping factors on operator performance. Operator RTs to the simulated events generally occurred within the intervals allowed in the draft ANSI-N660 design standard; however, they did not appear to be systematically related to the severity of the event, which was the basis for allocation of time margins in the standard. More collective experience in power plant operations was weakly correlated with faster responses. Limited data on omission errors yielded an error rate of greater than five percent.

The data collected will be compared to field data being collected on similar malfunctions. That comparison will provide a basis for extrapolation of simulator data to actual operating conditions. A base of operator performance data developed from simulator experiments can then be used to establish criteria and standards, evaluate the effects of performance-shaping factors, and support safety/risk assessment analyses.

APPLICATION

This may be of interest to those writing their own data bases or simulating nuclear power plant operations.

Beare, A.N., Dorris, R.E., Bovell, C.R., Crowe, D.S. & Kozinsky, E.J. (1983). A simulator-based study of human errors in nuclear power plant control room tasks (NUREG/CR-3309). Washington, DC: Nuclear Regulatory Commission.

ABSTRACT

The purposes of this study were to empirically establish error rates for control selection and operation during the performance of proceduralized tasks in nuclear power plant control rooms during simulated casualties, and to compare the observed error rates with the human error probabilities in the Handbook of Human Reliability Analysis with Emphasis on Nuclear Power Plant Applications, NUREG/CR-1278.

APPLICATION

This report provides a review of human factors analysis in the following areas: performance models, risk assessment, error probabilities, and reliability analysis within data collection procedures.

Beare, A.N., Dorris, R.E. & Kozinsky, E.J. (1982). Response times of nuclear power plant operations: Comparison of field and simulator data. Proceedings of the Human Factors Society - 26th Annual Meeting, 669-673.

ABSTRACT

This report presents preliminary comparisons of field and simulator performance data for nuclear power plant operators. The performance measure used was the time for operators to initiate the first correct manual action in response to an abnormal or emergency event. Response times (RTs) for experienced operators in the simulator were generally shorter and less variable than in the field data. Two classes of events were distinguished: step events which occur suddenly and ramp events which develop more slowly. For all events, the range of RTs was very large, with the 95th percentile RT averaging 5 times the 50th percentile RT. Both the 50th percentile RT and the range were much larger for ramp than for step events in the field, but not in the simulator. To date, simulator events have not modeled the wide variety of circumstances in which field events are embedded, and which are thought to be responsible for the extreme variability of RTs for field events.

APPLICATION

This paper presents actual data on performance differences on simulators and in the field. This information may prove useful to training specialists.

Bell, B.J. & Swain, A.D. (1983). A procedure for conducting a human reliability analysis for nuclear power plants (NUREG/CR-2254). Washington, DC: Nuclear Regulatory Commission.

ABSTRACT

This document describes in detail a procedure to be followed in conducting a human reliability analysis as part of a probabilistic risk assessment when such an analysis is performed according to methods described in NUREG/CR-1278, "Handbook of Human Reliability Analysis with Emphasis on Nuclear Power Plant Applications." An overview of the procedure describing the major elements of a human reliability analysis is presented along with detailed descriptions of each element and an example of an actual analysis. An appendix consists of some sample human reliability analysis problems for further study.

APPLICATION

This document would be useful for persons interested in or conducting human reliability analysis as part of a probabilistic risk assessment.

Bennett, C.A. (1977). Spaces for people: Human factors in design. Englewood Cliffs, NJ: Prentice-Hall.

ABSTRACT

It is assumed that formal interior design coursework and experience teach design. Rather, this book is meant to present what may be additional knowledge on accommodating people while designing. Topics include design of individual, small or large spaces; luminous, sound, and thermal environments; and how to "put it all together." Certain auxiliary nondesign topics of importance to the designer are also included.

APPLICATION

This book is intended for any designer of interior spaces, whether the practicing professional or the student of interior design or architecture.

Blackman, H.S., Gertman, D.I., Gilmore, W.E. & Ford, R.E. (1983). Noninteractive simulation evaluation for CRT-generated displays (NUREG/CR-3556). Washington, DC: Nuclear Regulatory Commission.

ABSTRACT

The United States Nuclear Regulatory Commission (USNRC) is sponsoring an ongoing research program to develop methods of assessing various types of computer-generated displays currently being implemented in nuclear power plant control rooms. The purpose of this report is to present a noninteractive simulation technique for the evaluation of computer-generated displays. Four safety parameter display formats were evaluated in two separate experiments. Three formats were evaluated in Experiment I (STAR, BAR, METER). Two format were evaluated in Experiment II (BAR, P-T map). All formats contained top-level safety parameters minimally necessary for the safe operation of a pressurized water reactor at the Loss-of-Fluid Test (LOFT) reactor. Subjects of the experiments were current or former operators at the Loss-of-Fluids Test (LOFT) reactor. The results of this experiment have indicated that the noninteractive technique can be used to evaluate the detection and recognition of transients in safety parameter display evaluation. In addition, the data suggest that given a reliable set of parameters and good human engineering that the graphical format of the display has negligible impact on performance. The implications of these results are discussed in terms of future work and display design.

APPLICATION

This report is intended to provide methods of evaluating various displays. Human factors engineers and control room design engineers may be able to apply the findings within this report.

Blackman, H.S., Gertman, D.I. & Petersen, R.J. (1983). PBF task and training requirements analysis (Report No. EEG-REP-6274). Idaho Falls, ID: EG&G Idaho, Inc.

ABSTRACT

Task analyses were used to assist in identifying improvements needed in the training curriculum for selected positions at the Power Burst Facility (PBF). Four positions were examined: Experiment Power Reactor Operator, Experiment (EPRO-EX); Experiment Power Reactor Operator, Plant (EPRO-P); Experiment Power Reactor Operator, Console (EPRO-CO); and Shift Supervisor (SS). A complete position task listing and core of tasks defined in terms of (a) level of difficulty to perform, (b) severity of consequence if performed improperly, and (c) associated error probability were identified by each position. The systems, academic, and administrative knowledge needed by job incumbents to perform each task was noted. Strategies for teaching the knowledge associated with these tasks are presented.

APPLICATION

This report may prove useful to individuals involved with job or task analysis activities. It would be especially useful to DOE personnel.

Bockhold, G., Jr. & Roth, D.R. (1978). Performance measurements system for training simulators (Report No. EPRI-NP-783). Palo Alto, CA: Electric Power Research Institute.

ABSTRACT

In the first project phase, the project team has designed, installed, and test-run on the Browns Ferry nuclear power plant training simulator a performance measurement system capable of automatic recording of statistical information on operator actions and plant response. Key plant variables and operator actions were monitored and analyzed by the simulator computer for a selected set of four operating and casualty drills. The project has the following objectives: (1) to provide an empirical data base for statistical analysis of operator reliability and for allocation of safety and control functions between operators and automated controls; (2) to develop a method for evaluation of the effectiveness of control room designs and operating procedures; and (3) to develop a system for scoring aspects of operator performance to assist in training evaluations and to support operator selection research.

The performance measurement system has shown potential for meeting the research objectives. However, the cost of training simulator time is high; to keep research program costs reasonable, the measurement system is being designed to be an integral part of operator training programs. In the pilot implementation, participating instructors judged the measurement system to be a valuable and objective extension of their abilities to monitor trainee performance.

APPLICATION

An automatic performance measurement system tested at Browns Ferry is discussed. Financial implications are also reviewed.

Bolton, P.A., Faigenblum, J.M., Hope, A.M. & Rankin, W.L. (1984). Simulator fidelity and training effectiveness: A comprehensive bibliography with selected annotations (NUREG/CR-3726). Washington, DC: Nuclear Regulatory Commission.

ABSTRACT

This document contains a comprehensive bibliography on the topic of simulator fidelity and training effectiveness, prepared during the preliminary phases of work on an NRC-sponsored project on the Role of Nuclear Power Plant Simulators in Operator Licensing and Training. Section A of the document is an annotated bibliography consisting of articles and reports with relevance to the psychological aspects of simulator fidelity and the effectiveness of training simulators in a variety of settings, including military. The annotated items are drawn from a more comprehensive bibliography, presented in Section B, listing documents treating the role of simulators in operator training both in the nuclear industry and elsewhere.

APPLICATION

This report provides references which may be used by curriculum developers in developing guidelines for a variety of applications. The report itself is a bibliography with some annotations.

Boone, M.P. & Banks, W.W. (1980). Human factors engineering evaluation of the advanced test reactor control room (Report No. EGG-SSDS-5288). Idaho Falls, ID: EG&G Idaho, Inc.

ABSTRACT

This informal working document describes the results of a human engineering evaluation of the Advanced Test Reactor (ATR) Control Room. Problem areas of the control room are identified, and specific recommendations are made for immediate and long-term improvements in man-machine interface design, human factors engineering of controls and displays, and overall control room design and configuration. Recommendations for future redesign include suggestions regarding use of control technology, provision of abnormal condition indicators, and reduction of unnecessary operator workload.

APPLICATION

Recommendations presented in this report are applicable to improvement, from a human engineering standpoint, of the control room design of the Advanced Test Reactor (ATR) specifically, and other process control operations and control rooms generally.

Bott, T.F., Kozinsky, E., Crowe, C. & Haas, P.M. (1981). Criteria for safety-related nuclear power plant operator actions: Initial pressurized water reactor (PWR) simulator exercises (NUREG/CR-1908). Washington, DC: Nuclear Regulatory Commission.

ABSTRACT

Nuclear plant control room simulator exercises for seven pressurized water reactor (PWR) events were conducted with ten control room teams. Operator performance was recorded by an automatic Performance Measurement System (PMS) and by subjective evaluation. Response times and error probabilities were estimated for selected actions. The effect of some experimental variables on operator performance is discussed. Application of the response time data to ANSI Standard N660 is included. The data collected will later be compared to field data being collected for similar events in order to provide a basis for extrapolation of simulator data to actual operating conditions.

APPLICATION

A base of human performance data will be developed from the simulation experiments which can be used to establish criteria and standards, evaluate effects of key performance-shaping factors, and support safety/risk assessment analyses.

Bray, M.A., Petersen, R.J., Clark, M.T. & Gertman, D.I. (1981). Advanced diagnostic graphics (Report No. EGG-M-09581). Idaho Falls, ID: EG&G Idaho, Inc.

ABSTRACT

This paper is from a CSNI specialist meeting on operator training and qualifications, and reports NRC-sponsored research at Idaho National Engineering Laboratory involving evaluations of computer-based diagnostic graphics. The specific targets of current evaluations are multivariate data display formats which may be used in Safety Parameter Display Systems (SPDS) being developed for nuclear power plant control rooms.

APPLICATION

The purpose of the work is to provide a basis for NRC action in regulating licensee SPDSs or later computer/CRT applications in nuclear control rooms.

Brooke, J.B. & Duncan, K.D. (1983). A comparison of hierarchically paged and scrolling displays for fault finding. Ergonomics, 26, 465-477.

ABSTRACT

The selection of test points when fault finding with a hierarchically paged display is more efficient than when using a scrolling display. However, this difference is not found with more able subjects. An unexpected finding is that both displays seem to facilitate more consistent performance than that obtained when the operator's view of the system is unrestricted. The effect of restricting system information by a "window," as done by both types of display, is discussed in terms of strategies operators may adopt in consequence, in particular strategies to cope with memory load.

APPLICATION

Efficient human information processing is essential to jobs where information is received through a CRT and time and decision making is of importance.

Brown, C.M., Burkleo, H.V., Mangelsdorf, J.E., Olsen, R.A. & Williams, A.R., Jr. (1981). Human factors engineering standards for information processing systems. Sunnyvale, CA: Lockheed Missile & Space Company.

ABSTRACT

This document presents human factors standards and guidelines for the human interface with computer systems. The general topics for which criteria are presented include:

- o Operating System Characteristics
- o Display Format
- o Language and Coding
- o User Control of the Interaction Sequence
- o Online Guidance Capabilities
- o Input Procedures
- o Color Displays.

Each design principle is presented either as a standard or as a guideline. For standards, compliance is considered mandatory unless a specific exemption is granted by data base management. For guidelines, compliance is important for a good user interface, but may not be feasible in all situations.

APPLICATION

The goal of this document is to aid system designers of software, applications, and display formats in developing user-oriented, people-friendly systems.

Brune, R.L. & Weinstein, M. (1980). Procedures evaluation checklist for maintenance, test and calibration procedures (NUREG/CR-1369). Washington, DC: Nuclear Regulatory Commission.

ABSTRACT

This document describes the checklist to be used by the U.S. NRC Office of Inspection and Enforcement inspectors for evaluating maintenance, test, and calibration procedures and provides guidelines for its application. The procedures evaluation checklist is the product of a human factors study of nuclear power plant operations and procedures sponsored by the Office of Inspection and Enforcement. A detailed description of the study is provided in a companion document, Development of a Checklist for Evaluating Maintenance, Test and Calibration Procedures Used in Nuclear Power Plants, NUREG/CR-1368, SAND80-7053.

As part of the study, abstracts of licensee event reports (LERs) submitted by all plants during the four-year period 1975-1978 were reviewed. The purpose of the review was to identify the specific kinds of procedures-related personnel error that have been associated with the performance of maintenance, test, and calibration activities. A total of 751 LERs were attributable to procedural deficiencies. An analysis identified eight categories of performance errors resulting from procedural deficiencies.

APPLICATION

The checklist is intended to aid Office of Inspection and Enforcement inspectors in identifying procedural deficiencies that can lead to errors in performance. Each of the procedures evaluation criteria contained in the checklist deals with procedural characteristics related to one or more categories of performance error. The use of a procedure that is deficient with respect to these criteria can lead to errors in performance.

Brune, R.L. & Weinstein, M. (1981). Checklist for evaluating emergency procedures used in nuclear power plants (NUREG/CR-2005). Washington, DC: Nuclear Regulatory Commission.

ABSTRACT

This document describes a checklist to be used by U.S. Nuclear Regulatory Commission Office of Inspection and Enforcement inspectors during their evaluation of emergency procedures. The objective of the checklist is to aid inspectors in identifying characteristics of procedures that can lead to operator performance deviations. Methods of performing the evaluations are described and suggestions for applying the checklist to increase the effectiveness of the inspection process are made.

APPLICATION

This checklist could prove useful in a self-evaluation of current procedures or used as a step in the development process for new procedures.

Burgy, D.C., Doyle, P.A., Barsam, H.F. & Liddle, R.J. (1980). Applied human factors in power plant design and operation. Columbia, MD: General Physics Corporation.

ABSTRACT

This textbook provides an introduction to human factors engineering principles and techniques and their application to power plant design and operation. Individual chapters deal with: recent government recommendations and future regulation relating to control room improvement; the outlook for research funding; systems analysis in human factors engineering; performance evaluation techniques; effects of stress and fatigue on operator performance; the simulator as a training device and research tool; the role of human factors engineering in training; assessment of equipment reliability and maintainability from a human factors engineering standpoint; evaluation of plant operability using human factors analysis techniques; use of human factors engineering evaluation tools to determine and recommend control room improvements; and advanced power plant control room concepts. A comprehensive bibliography lists source and reference materials relevant to this field.

APPLICATION

An introduction to the philosophical and technical basis for applying human factors engineering to the improvement of power plant control room design and operation. Potential applications include: design of training programs and plant systems; development of operational procedures; assessment and evaluation of training programs, equipment and systems, and operational procedures; and use of simulators.

Burgy, D.C., Newell, W.J. & Van Cott, H.P. (1982, October). Task analysis of nuclear power plant control room crews data collection approach and methodology. Paper presented at the Human Factors Society - 26th Annual Meeting, Seattle, WA.

ABSTRACT

This paper describes the data collection approach and methodology used to conduct a task analysis of nuclear power plant control room crews. The objective of the research project, funded by the NRC Office of Nuclear Regulatory Research, is to provide task data for evaluating six areas: (1) human engineering designs of new control rooms and retrofitting of current control rooms, (2) the numbers and types of control room operators required with requisite skills and knowledges, (3) operator qualification and training requirements, (4) normal, off-normal, and emergency operating procedures, (5) job performance aids, and (6) communications. The task analysis methodology used in this project is discussed and compared to traditional task analysis and job analysis methods. A data collection approach is described which focuses on a generic structural framework for assembling the multitude of task data that will be observed. Control room crew task data is observed and recorded within the context of an "operating sequence." The data collection will be conducted at eight power plant sites by teams comprised of human factors and operations personnel. Plants were sampled according to NSSS vendor, vintage, simulator availability, architect-engineer, and control room configuration. The results of the data collection effort will be compiled in a computerized task data base. Preliminary discussion of illustrative examples to demonstrate suitability for data analysis will be presented.

APPLICATION

The information in this paper is useful for individuals or departments involved in task and job analysis. Data collection approaches and methodology are discussed.

BWR Owners Group.(1980, October). Control room survey checklist. Included in manual prepared for Control Room Survey Workshop: Human Factors Engineering, conducted by General Electric Company.

ABSTRACT

This workshop provides a general introduction to the Control Room Survey Program, including historical background and HFE principles. A Control Room Survey is conducted to meet NRC requirements for safety review of design and procedures, identify modifications in the operator-control room interface to minimize the potential for human error, and determine an implementation plan for corrective action.

APPLICATION

The topics covered by this workshop can help train team members in the performance of Control Room Survey, standardize survey methods, and organize actual survey teams.

Cakir, A., Hart, D.J., and Stewart, T.F.M. (1980). Visual display terminals: A manual covering ergonomics workplace design, health and safety, task and organizations. New York: John Wiley & Sons.

ABSTRACT

The main purpose of this report is to provide the designers, planners, and users of computer systems with the most recent ergonomics knowledge relevant to the design and selection of VDTs and VDT workplaces. This knowledge has been derived from a large number of experiments and field studies conducted by the present authors and many others in recent years.

APPLICATION

This book is useful to individuals designing or modifying VDT interfaces or workstations. Five different areas are covered: (1) how a VDT works; (2) the VDT as a systems component; (3) light and vision; (4) ergonomics of VDTs; and (5) VDT workplaces.

Canadian Standards Association. (1979). Operations quality assurance for nuclear power plants (CSA N286.5-1979). Rexdale, Ontario, Canada: Author.

ABSTRACT

This report applies to the operations of all safety-related systems and equipment. Described in the report are requirements of a quality assurance program related to implementing the guidelines through detailed management of operations quality. The areas examined are policy, programs, review of programs, training, verification, operations, performance, and corrective actions. Emergency procedures are identified and procedures are prepared for implementation if needed.

APPLICATION

This report provides guidelines for quality control in nuclear power plants. Emphasis is placed on the operational aspects of quality assurance and organizational criteria.

Card, S.K., Moran, T.P., & Newell, A. (1983). The psychology of human-computer interaction. Hillsdale, NJ: Lawrence Erlbaum Associates.

ABSTRACT

This book lays a scientific foundation for an applied psychology concerned with the human users of interactive computer systems. An empirically-based cognitive theory of skilled human-computer interaction was constructed as a keystone for linking science and application. The theory is shown to be a consistent extension of the science of human information processing. It is also simplified into practical engineering models, which are the tools for designers to apply the theory.

APPLICATION

This book is intended for persons interested in the topic of human-computer interaction — cognitive psychologists, computer scientists, system designers, human factors specialists, or man-machine engineers.

Clark, M.T., Banks, W.W., Blackman, H.S., & Gertman, D.I. (1982). Advanced display concepts in nuclear control rooms. Manuscript submitted for publication.

ABSTRACT

Precursors necessary for the development of a full-scale predictor display/control system have been under development since the mid-1940s. The predictor display itself has been available for use in manual control systems since 1958. However, the nuclear industry has yet to explore the uses and benefits of predictor systems. This paper provides information on the application of this technology to the nuclear industry. The possibility of employing a simulation-based control system for nuclear plant systems that currently use conventional auto/manual schemes is discussed. By employing simulation-based systems, a predictor display could be made available to the operator during manual operations, thus facilitating control without outwardly affecting the overall control scheme.

APPLICATION

This paper describes options for applying predictor display/control technology in nuclear power plant control rooms.

Clarke, M.M., Garin, J. & Preston-Anderson, A. (1981, October). Development of a standard methodology for optimizing remote visual display for nuclear maintenance tasks. Proceedings of the Human Factors Society - 25th Annual Meeting.

ABSTRACT

The aim of the present study is to develop a methodology for optimizing remote viewing systems for a fuel recycle facility (HEF) being designed at Oak Ridge National Laboratory (ORNL). An important feature of this design involves the Remotex concept — advanced servo-controlled master/slave manipulators with remote television viewing — which will totally replace direct human contact with the radioactive environment. Therefore, the design of optimal viewing conditions is a critical component of the overall man/machine system.

APPLICATION

This report presents a methodology for optimizing remote visual displays for nuclear maintenance tasks. The usefulness of this approach has been demonstrated by preliminary specification of optimal closed-circuit TV systems for such tasks.

Cochran, D.J. & Riley, M.W. (1982). An evaluation of handle shapes and sizes. Proceedings of the Human Factors Society - 26th Annual Meeting, 408-412.

ABSTRACT

In many industries there are numerous hand tools in use which vary considerably in handle size and shape with no apparent reasons. This research sought to investigate capabilities of males and females on two-thrust maximum force tests, using various shapes and sizes of handles. To accentuate the characteristics of each size and shape, the force tests were conducted with the coefficient of friction between the hand and the handle surface reduced by the use of a disposable plastic glove and the application of a slippery film.

APPLICATION

Persons interested in selecting the shape and size of a handle to be used in push/pull situations may find this evaluation helpful.

Cochran, D.J. & Riley, M.W. (1983). An examination of the speed of manipulation of various sizes and shapes of handles. Proceedings of the Human Factors Society - 27th Annual Meeting, 1, 432-436.

ABSTRACT

This research examined the effects of handle size and shape on two types of manual manipulation of handles. The first task evaluated was one in which the subject rotated a handle 180° in his/her hand one way, then reversed the rotation for 180° in the opposite direction. On this task smaller handles could be manipulated faster. Also triangular handles were significantly slower to manipulate than all other shapes tested except the square ones. The second task evaluated the speed of flipping a handle in the hand. For this task shape had no significant effect on the time but size did. Once again, the smaller handles could be manipulated quicker than the larger ones.

APPLICATION

This is a useful guide in selecting size and shape of handles for task-dependent hand tools.

Code of federal regulations: 10 — Energy, parts 0 to 199 (rev. ed.), Appendix A, Criterion 19. (1984). Washington, DC: U.S. Government Printing Office.

ABSTRACT

Criterion 19, "control room," of 10 CFR 50 (Appendix A) specifies the functions that a nuclear power plant control room and remote equipment must be able to perform with respect to safe operation of the plant and shutdown of the reactor. The control room must be able to maintain the plant in a safe condition under accident conditions, including loss-of-coolant accidents. Radiation protection must be provided under such conditions sufficient to preclude personnel exposures in excess of five rem whole body or part body equivalent. Remote equipment must be provided with a design capability for both hot and cold shutdown of the reactor.

APPLICATION

This contains one of the federal regulations arising out of TMI-2, governing control room/remote equipment capabilities under both normal and accident conditions.

Comer, M.K., Kozinsky, E.J., Eckel, J.S. & Miller, D.P. (1983). Human reliability data bank for nuclear power plant operations. Volume 2: A data bank concept and system description (NUREG/CR-2744/2 of 2). Washington, DC: Nuclear Regulatory Commission.

ABSTRACT

The U.S. Nuclear Regulatory Commission (NRC) is conducting a research program to determine the need for a human reliability data bank unique to the nuclear industry. Human performance data contained in such a data bank would be used to conduct human reliability analysis (HRA) segments of probabilistic risk assessments (PRAs) of nuclear power plants.

APPLICATION

This report provides information on the human reliability data bank concept which may be tested in order to determine the effectiveness of the data bank concept. Data includes storage by equipment standards, human actions at the system level, and individual control display levels.

Corcoran, W.R., Church, J.F., Cross, M.T., & Porter, N.J. (1981, April). Plant designer's view of the operator's role in nuclear plant safety. Paper presented at the 4th Symposium on Training of Nuclear Facility Personnel, Gatlinburg, TN.

ABSTRACT

The nuclear plant operator's role supports the design assumptions and equipment with four functional tasks. He must set up the plant for predictable response to disturbances, operate the plant so as to minimize the likelihood and severity of event initiators, assist in accomplishing the safety functions, and feedback operating experiences to reinforce or redefine the safey analyses assumptions. The latter role enhances the operator effectiveness in the former three roles. The Safety Level Concept offers a different perspective that enables the operator to view his roles in nuclear plant safety. This paper outlines the operator's role in nuclear safety and classifies his tasks using the Safety Level Concept.

APPLICATION

This paper will be of interest to anyone involved in control room design or in the operator's role in nuclear safety.

Cunningham, C.E. & Cox, W. (1972). Applied maintainability engineering. New York: John Wiley & Sons.

ABSTRACT

This book gives examples and methodology for each maintainability task, with a complete chapter for each numbered paragraph of the MIL-STD-470 standard. It will provide implementation guidance for human factors specialists, maintainability engineers, and equipment design engineers.

APPLICATION

This book will provide implementation guidance to the maintainability engineer or organization delegated to the responsibility of compliance with the definition of maintainability as given in MIL-STD-721.

Danchak, M.M. (1977). Alphanumeric displays for the man-process interface. Paper presented at meeting of Instrument Society of America, Niagara Falls, NY.

ABSTRACT

Display techniques used for printers are often carried over to CRTs with little regard for the drastic change in display medium. This paper attempts to recognize that change and offers suggestions for the intelligent design of such computer output. The basic characteristics of CRTs are surveyed and the attributes of alphanumeric characters discussed from the human standpoint. The characters are then integrated to form display pages that satisfy the operator's need for information. Recommendations are made for creating the more traditional lists of alphanumeric information as well as the unusual layouts necessary for process control. All the recommendations are then summarized for easy reference and implementation.

APPLICATION

The recommendations are summarized for the convenience of display designers. Briefly, the attributes of the operator, rather than the computer, must dictate the design of alphanumeric CRT displays.

Danchak, M.M. (1981). Techniques for displaying multivariate data on cathode ray tubes with applications to nuclear process control (NUREG/CR-1994). Washington, DC: Nuclear Regulatory Commission.

ABSTRACT

Current methods of graphic display design using cathode ray tubes depend solely on the skill of the designer for choosing the appropriate display technique. This report formalizes the selection process by describing 65 graphical representations and categorizing them according to the type of data they best portray. The use of the display is also accounted for by attaching a "use category," such as a qualitative reading, to each technique. The representation selection process is then formalized by asking the designer to consider both data and use. Recommendations for techniques are given for the various data types and uses. The method was applied to data for representation of the multivariate state of a typical nuclear power plant under both normal and transient conditions. Nine alternative techniques were tested, three of which — Circular Profiles, Chernoff Faces, and Fourfold Circular Displays — were considered very adequate for the data and use given.

APPLICATION

This report would be most useful to personnel working in data display, control room operations, and nuclear control room design systems.

Danchak, M.M. (1982). Alarms within advanced display systems: Alternative and performance measures (NUREG/CR-2776). Washington, DC: Nuclear Regulatory Commission.

ABSTRACT

This study surveys five advanced alarm handling systems in industries having problems similar to nuclear process control. The survey identifies the uniqueness of each system as well as features common to all. One such common feature is the use of alphanumeric alarm message strings displayed on cathode ray tubes (CRT). The study presents alternatives for display of this information and dynamic techniques for the addition and deletion of alarms. A software package is described that incorporates the alternatives and allows low-fidelity experiments to be conducted in an environment that simulates nuclear process control. The package was used to test static aspects of alarm CRTs and led to the conclusion that quantitative data should come before qualitative data in alarm message strings. Methods for low-fidelity testing of display dynamics are also discussed.

APPLICATION

This report is intended to illustrate that a fundamental change is needed in the areas of human factors engineering and system evaluation.

Das, B. & Grady, R.M. (1983). Industrial workplace layout design. An application of *engineering anthropometry*. Ergonomics, 26, 433-448.

ABSTRACT

Workplace layout design parameters or dimensions were determined mathematically by using the existing anthropometric data, for performing industrial tasks in sitting, standing and a combination of sitting and standing positions for the general male, female and a combination of male and female operators and the individual male and female operators for the 5th, 50th, and 95th percentiles. The data were duly adjusted to account for the clothing, shoe and posture allowances. The reach dimensions were based on the most commonly used industrial operations which require a grasping movement. Appropriate allowances were provided to adjust the reach dimensions for other types of operations. The horizontal and vertical clearance dimensions and reference points for the horizontal and vertical clearances were established. For the determination of the normal working area in the horizontal plane, Squires' concept was recommended in preference to Farley's concept.

APPLICATION

Since the design of a workplace is related to performance, this paper presents a useful guide for proper ergonomic design.

Deeb, J., Drury, C.G. & Begbie, K. (1983). Handle positions in a holding task as a function of task height. Proceedings of the Human Factors Society - 27th Annual Meeting, 1, 422-426.

ABSTRACT

Six handle positions in a two-handed container holding task were tested with the container at floor, waist and shoulder heights. Handle position effects on forces exerted, heart rate and psychophysical indices were large, comparable to a 25 percent change in container weight. As in a previous study (at waist height only) and an industrial survey, handle positions providing both horizontal and vertical stability were better than symmetrical positions. Optimal angles of handle to container changed greatly with task height, giving almost horizontal angles at floor level and almost vertical angles at waist and shoulder level. Implications for the design of handle cutouts on containers are discussed.

APPLICATION

Persons who are looking for optimal handle positions which cause the least exertion and discomfort can find a good reference here.

Department of the Air Force. (1980). AFSC design handbook 1-3: Human factors engineering (3rd edition, Revision 1) (AFSC DH 1-3). Andrews AFB, DC: Headquarters Air Force Systems Command.

ABSTRACT

This handbook provides system designers with human factors engineering (HFE) design principles, information, guidance, and criteria; and estabishes a central source of HFE design data (any type of factual information that can be used as a basis for design decisions).

APPLICATION

Chapters include topics on human engineering, biomedical/life support, personnel and manning, training and training equipment, job performance aids, and test and evaluation.

Department of Defense. (1975). Military standardization handbook: Human factors engineering design for Army material (MIL-HDBK-759). Redstone Arsenal, AL: U.S. Army Missile Command.

ABSTRACT

The purpose of this report is to establish in handbook form general data and detailed criteria for human factors engineering applications in the design and development of Army material.

APPLICATION

This manual provides specifications for training curriculum, physical criteria, ergonomics, maintenance tasks, and a section on human factors in test and development evaluation.

Department of Defense. (1977). Technical writing style guide (MIL-HDBK-63038-1 (TM)). Washington, DC: Author.

ABSTRACT

This guide complements the Technical Manual Writing Handbook (MIL-HDBK-63038-1 (TM)). The intent of this manual is to highlight and summarize the important elements of technical writing style as compared to literary writing. Also considered are the problem areas in which frequent mistakes are made in technical writing.

APPLICATION

The guidelines presented supplement official specifications by describing specialized applications of established principles, and by making orderly choices among approved variations in style. This guide could prove useful for individuals involved with writing procedures or developing Writer's Guides for procedures.

Department of Defense. (1979). Human engineering requirements for military systems, equipment and facilities (MIL-H-46855B). Washington, DC: Author.

ABSTRACT

This application establishes and defines the requirements for applying human engineering to the development and acquisition of military systems, equipment, and facilities. These requirements include the work to be accomplished by the contractor or subcontractor in conducting a human engineering effort integrated with the total system engineering and human development effort. These requirements are the basis for including human engineering during proposal preparation, system analysis, task analysis, system design (including computer software design), equipment and facilities design, testing, and documentation and reporting.

APPLICATION

This handbook provides general information on human engineering. This information would be useful to persons involved with system analysis, task analysis, system design, test and evaluation, documentation or reporting.

Department of Defense. (1981). Military standard: Human engineering design criteria for military systems, equipment and facilities (MIL-STD-1472C). Washington, DC: Author.

ABSTRACT

This standard establishes general human factors engineering criteria for design and development of military systems, equipment and facilities. The purpose is to present human engineering design criteria, principles and practices to:

a. Achieve required performance by operator, control, and maintenance personnel

b. Minimize skill and personnel requirements and training time

c. Achieve required reliability of personnel-equipment combinations

d. Foster design standardization within and among systems.

APPLICATION

This document provides design criteria for operations, maintainability, and testing. It also provides anthropometric data for the full range of women and men.

Department of Energy. (1983). Guidelines for job and task analysis for DOE nuclear facilities (Report No. DOE/EP-0095). Washington, DC: Author.

ABSTRACT

The guidelines are intended to be responsive to the need for information on methodology, procedures, content, and use of job and task analysis since the establishment of a requirement for position task analysis for Category A reactors in DOE 5480.1A, Chapter VI. The guide describes the general approach and methods currently being utilized in the nuclear industry and by several DOE contractors for the conduct of job and task analysis and applications to the development of training programs or evaluation of existing programs. In addition, other applications for job and task analysis are described including: operating procedures, development, personnel management, system design, communications, and human performance predictions.

APPLICATION

This document would be useful to persons, particularly DOE personnel, involved with job or task analysis.

Department of Energy. (1984). Guidance for training program evaluation (Report No. DOE/EV/10782-T1). Washington, DC: Author, Office of Scientific and Technical Information.

ABSTRACT

The subject guide was developed in response to the requirements contained in DOE Action Plan DOE/S-0007 to develop criteria and guidance for use by the field for assessment and validation of reactor operator training programs at DOE Category A reactors.

A general framework for the systematic evaluation of training programs for DOE Category A reactors is given. The evaluation process recommends self-evaluation by the operating contractor followed by a comprehensive review by the local field office. The guide also outlines good practices and evaluation factors in seven review areas.

APPLICATION

This report provides general guidance for producing training programs at DOE Category A reactors.

DeSteese, J.G., Pelto, P.J., Rankin, W.L., Rideout, T.B. & Shikiar, R. (1982). Human factors affecting the reliability and safety of LNG facilities, Volume 1, control panel design enhancement (Report No. GRI-81/0106.1). Chicago: Gas Research Institute.

ABSTRACT

The principal objectives of this project phase were to (1) expand the relevant human error probability (HEP) data base, (2) develop human factors (HF) design guidelines for LNG control panels, and (3) identify research needed to improve HF considerations in other LNG plant systems and operations. The existing HEP data base applicable to LNG facilities was expanded to nine task categories containing human error rate information from analogous activities in other industries. HF considerations in control room design were ranked according to potential impacts on plant reliability and safety. An assessment of five representative LNG control panels showed significant HF design quality variations. Detailed HF design guidelines were developed for workspace, labels and location aids, controls, displays, annunciators, gas and flame detectors and emergency shutdown systems. Examples show HF enhancement resulting from application of these guidelines to existing panel designs and the layout of a model panel. A checklist with over 270 checkpoints was developed to facilitate control panel design evaluation. This checklist and the guideline package are of potential practical value to utilities engaged in evaluating or improving HF design of control panels at individual plants. Thirteen projects are recommended to extend consideration of HF effects into other aspects of LNG facility design and operation.

APPLICATION

Persons interested in expanding their relevant HEP data base and developing human factors design guidelines for LNG control panels will find this a useful resource.

DeSteese, J.G., Pelto, P.J., Rankin, W.L., Rideout, T.B. & Shikiar, R. (1982). Human factors affecting the reliability and safety of LNG facilities, Volume 2, control panel design guidelines and checklist (Report No. GRI-81/0106.2). Chicago: Gas Research Institute.

ABSTRACT

The principal objectives of this project phase were to (1) expand the relevant human error probability (HEP) data base, (2) develop human factors (HF) design guidelines for LNG control panels, and (3) identify research needed to improve HF considerations in other LNG plant systems and operations. The existing HEP data base applicable to LNG facilities was expanded to nine task categories containing human error rate information from analogous activities in other industries. HF considerations in control room design were ranked according to potential impacts on plant reliability and safety. An assessment of five representative LNG control panels showed significant HF design quality variations. Detailed HF design guidelines were developed for workspace, labels and location aids, controls, displays, annunciators, gas and flame detectors and emergency shutdown systems. Examples show HF enhancement resulting from application of these guidelines to existing panel designs and the layout of a model panel. A checklist with over 270 checkpoints was developed to facilitate control panel design evaluation. This checklist and the guideline package are of potential practical value to utilities engaged in evaluating or improving HF design of control panels at individual plants. Thirteen projects are recommended to extend consideration of HF effects into other aspects of LNG facility design and operation.

APPLICATION

Persons interested in expanding their relevant HEP data base and developing human factors design guidelines for LNG control panels will find this a useful resource.

Dowling, E., Bybee, R., Shukla, J., Howland, R., Blomsnes, B. & Netland, K. (1978). Assessment of technologies essential to the application of advanced systems for process control (EPRI NP-640). Palo Alto, CA: Electric Power Research Institute.

ABSTRACT

This report assesses the adequacy of certain underlying technologies which may be required for the successful design and implementation of "advanced computer supported control rooms". The assessment is based upon the answers provided by Babcock and Wilcox, General Electric and the Institutt for Atomenergi to a detailed set of technical questions developed by EPRI (the questions and answers are documented in the appendices to this report). Among the technical areas addressed are: definition and justification of functional and design requirements; information assimilation techniques; operability; validation; reliability; and maintenance capabilities. The report discusses the need for techniques to evaluate the impact of different design alternatives on operator performance, the increasing importance of software validation to assure adequate availability, and the role of utility personnel in the support of these systems.

APPLICATION

This report would be useful to anyone interested in applying the technology of computer-based systems to advanced control room design.

Doyle, P., Lothar, S. & Brewer, S. (1983). An evaluation of the equipment tagging process in nuclear power stations. Proceedings of the Human Factors Society - 27th Annual Meeting, 1, 93-96.

ABSTRACT

The technique of "tagging" involves identifying inoperable equipment with small tags or other indications and maintaining records of equipment status. Operator reliability in the proper placement of tags is a function of training, good tagging procedures, adequate equipment identification techniques and tag design, among other things.

APPLICATION

This investigation of the tagging process in nuclear power plants identified problems in the areas of procedures, orientation aids, and labeling.

Dutton, J.W. & Brown, W.R. (1981, April). Human factors in training. Paper presented at 4th Symposium on Training of Nuclear Facility Personnel, Gatlinburg, TN.

ABSTRACT

The human factors concept is a focused effort directed at those activities which require human involvement. Training is, by its nature, an activity totally dependent on the human factor. This paper identifies several concerns significant to training situations and discusses how human factor awareness can increase the quality of learning. Psychology in the training arena is applied human factors. Training is a method of communication represented by sender, medium, and receiver. Two-thirds of this communications model involves the human element directly.

APPLICATION

This paper concerns increasing the quality of training by using human factors concepts.

Easterby, R., Kroemer, K.H.E. & Chaffin, D.B. (Eds.). (1980). Anthropometry and biomechanics, theory and application. New York: Plenum Press.

ABSTRACT

This book is the result of a conference of which the aim was to (1) review the current status of anthropometric and biomechanical data, (2) consolidate the theoretical and methodological advances in biomechanical studies, (3) to evaluate the role of computer-assisted techniques in the acquisiton, presentation, and application of biomechanical and anthropometric data, and (4) to provide a source book by way of publishing comprehensive proceedings, for use by researchers and practitioners alike.

APPLICATION

This source book of comprehensive proceedings is of use to those interested in the anthropometrics and biomechanics of humans at work.

Edsberg, E. (1981). Human factors engineering in control system design. Halden, Norway: Institutt for Energiteknikk, OECD Halden Reactor Project.

ABSTRACT

The human factors engineering professional is a new participant in planning and designing complex control systems such as nuclear power plant control rooms. The role of the operating crew and the task allocation between crew and automatics is now an issue within the nuclear power community. The importance of crew qualifications and of a well-designed organization as an infrastructure for control room operations is becoming evident. Computer technology is characterized by more accurate, more reliable, more digested, and above all more information to the crew on plant situations. HFE can make its contributions within many of these problem areas, but the major effort will have to be undertaken by the nuclear power industry itself, and its people.

APPLICATION

This report describes intelligent use of all the man-machine interaction possibilities without inundating the crew with new and sophisticated operator support aids.

El-Bassioni, A.A., Hedrick, R.A., Starostecki, R.W. & Penland, J.R. Review of standards and requirements affecting human factors in nuclear power plant control rooms. Oak Ridge, TN: Oak Ridge National Laboratory.

ABSTRACT

The study provides a clear and documented understanding of the current requirements and design practices in the nuclear industry to: (1) evaluate and enhance the design of the control room to support the operator, and (2) develop operator aids to enhance the information provided to the operator. These purposes are approached by tabulating codes, standards, and design practices of the nuclear industry as they relate to operator performance and reliability. In particular, current requirements and practices of the IEEE, the ANS, and the NRC are examined and then planned directions are identified.

APPLICATION

The results of this study provide the necessary data base for the new designers entering the nuclear control room design market. It also provides a first supportive step in evaluating the adequacy of these requirements impacting the human operators' interface with the plant.

Electric Power Research Institute. (1982). Accident sequences for design, validation and training — Safety parameter display system (Report No. EPRI-NSAC-40). Palo Alto, CA: Author, Nuclear Safety Analysis Center.

ABSTRACT

This report presents a methodology for selecting simulated real-time accident sequences. It is based on the Zion probabilistic risk assessment. Three compact accident sequence sets that can be used at the various stages in implementing a Safety Parameter Display System (SPDS) are described. The study demonstrates that a limited number of sequences (29) is adequate to test the complete range of potential accidents and the options for their termination.

APPLICATION

The methodology presented can help select simulated real-time accident sequences that can be used as important tools in the development, validation, and operator training for an SPDS.

Electric Power Research Institute. (1982). Evaluation of safety parameter display concepts (Volumes 1 and 2) (Report No. EPRI NP-2239). Palo Alto, CA: Author.

ABSTRACT

Two experimental concepts for a Safety Parameter Display System (SPDS) were evaluated to assess benefits and potential problems associated with the SPDS concept and its integration into control room operations. In Volume 1, the background of the SPDS is provided, and a description of the evaluation — including details of data collected and analyzed on crew responses to seven simulated accident conditions — is given. Volume 2 contains Appendix G, Protocols: Transient Timelines, and Appendix H, Decision Charts.

APPLICATION

The contents of this report are useful as a model for the evaluation of display systems and concepts. The two SPDS concepts themselves have potential applicability to the display of safety-related parameters.

Embrey, D.E. (1983). The use of performance shaping factors and quantified expert judgement in the evaluation of human reliability: An initial appraisal (NUREG/CR-2986). Washington, DC: Nuclear Regulatory Commission.

ABSTRACT

The first part of the report considers the nature of human reliability assessment, and the techniques currently employed. It is concluded that most approaches are limited by the availability of data. Approaches to the subjective assessment of error are surveyed. A particular technique which has been developed, the Success Likelihood Index Methodology (SLIM), is described in detail, together with the practical steps for its implementation. The results from a trial application of a questionnaire designed to elicit judges' perceptions of the relative importance of performance shaping factors in determining human reliability are analyzed. A revised form of the questionnaire is presented for future use. A pilot experiment to investigate the relationship between subjectively derived indices of success for six tasks and their objective probability of success is described. The results indicate that SLIM has potential value as a predictive technique. Some requirements for a program of research to produce a generally applicable methodology are set out.

APPLICATION

The report discusses human reliability assessment and the associated techniques. One technique, Success Likelihood Index Methodology (SLIM), is presented in depth. Persons interested in or anticipating the assessment of human reliability may find this report useful.

Embrey, D.E., Humphreys, P., Rose, E.A., Kirwan, B. & Rea, K. (1984). SLIM-MAUD: An approach to assessing human error probabilities using structured expert judgment (NUREG/CR-3518). Washington, DC: Nuclear Regulatory Commission.

ABSTRACT

This two-volume report presents the procedures and analyses performed in developing an approach for structuring expert judgments to estimate human error probabilities. Volume I presents an overview of work performed in developing the approach: SLIM-MAUD (Success Likelihood Index Methodology, implemented through the use of an interactive computer program called MAUD — Multi-Attribute Utility Decomposition). Volume II provides a more detailed analysis of the technical issues underlying the approach.

APPLICATION

This report describes the SLIM-MAUD method for estimating human error probabilities. This approach and the technical issues underlying the approach are discussed.

The Emergency Operating Procedures Implementation Assistance (EOPIA) Review Group. (1982). Emergency Operating Procedures Implementation Assistance Program (Report No. INPO 82-013). Atlanta, GA: Institute of Nuclear Power Operations.

ABSTRACT

The purpose of this program description document is to provide information that can be used by a utility in developing its approach to implementing the new emergency operating procedures (EOPs). The Emergency Operating Procedures Implementation Assistance (EOPIA) Program identifies how assistance will be provided to the individual utility for use in implementing new EOPs. Members from the four nuclear industry groups participated in the evolution of this program: the Nuclear Regulatory Commission, the owners group/NSSS vendors, INPO, and several individual utilities.

This document does not provide guidance and is for general information only. Four areas are identified in which development of guidance documents would assist the individual utility in implementing its EOPs. Assistance will be provided in the form of the companion documents to be published later.

APPLICATION

This is the first document in INPO's Emergency Operating Procedures Implementation Assistance (EOPIA) Review Group series. This document describes the EOPIA approach to the EOP upgrade. Together with the companion documents the report is useful to plants implementing Procedure Generation Package projects.

The Emergency Operating Procedures Implementation Assistance (EOPIA) Review Group. (1982). Emergency Operating Procedures Writing Guideline (Report No. INPO 82-017). Atlanta, GA: Institute of Nuclear Power Operations.

ABSTRACT

This Emergency Operating Procedures Writing Guideline was developed by the Emergency Operating Procedures Implementation Assistance (EOPIA) Review Group to assist individual utilities in developing or improving a plant-specific emergency operating procedure (EOP). Information is provided on improving or developing a plant-specific writer's guide for EOPs. Examples are provided of a writer's guide outline, a writer's guide and a procedure.

APPLICATION

This document provides useful information and guidance for developing plant-specific writers guides and writing emergency procedures. This is one document in INPO's EOPIA Review Group series.

The Emergency Operating Procedures Implementation Assistance (EOPIA) Review Group. (1983). Emergency Operating Procedures Implementation Guideline (Report No. INPO 82-016). Atlanta, GA: Institute of Nuclear Power Operations.

ABSTRACT

This document provides guidance to utilities for use in developing their implementation plans for emergency operating procedures (EOPs). This document presents basic elements of an implementation plan for EOPs, starting with the receipt of the emergency operating procedure guidelines (EPGs). The following elements are presented and discussed:

- o Shift characteristics
- o Procedure system and network
- o Use of emergency operating procedure guidelines
- o Writer's guide for EOPs
- o EOP verification
- o EOP validation
- o Training
- o Revision, review, and approval process
- o EOP control
- o Supporting documentation control
- o Experience feedback.

APPLICATION

This document provides guidance for plants undertaking implementation programs for new EOPs. This is one document in INPO's EOPIA Review Group series.

The Emergency Operating Procedures Implementation Assistance (EOPIA) Review Group. (1983). Emergency Operating Procedures Validation Guideline (Report No. INPO 83-006). Atlanta, GA: Institute of Nuclear Power Operations.

ABSTRACT

The purpose of this guideline is to provide information that can be used by a utility in developing its Emergency Operating Procedure (EOP) Validation Program. This document provides guidance in three major areas of an EOP validation program. These areas are the program objective, program evaluation criteria, and program process.

The program objective is to determine if the control room operators can manage emergency conditions in the plant using the EOPs. The program evaluation criteria are used to determine if the validation principles are satisfied. The program process supports the actual performance evaluation.

This document is presented for guidance only. Its program is not intended to duplicate existing efforts in EOP review and approval processes. EOP validation as presented in this document is a performance evaluation that addresses whether the EOPs are usable and operationally correct.

APPLICATION

This document provides one perspective on the development of EOP validation programs. Differences between verification and validation are clearly explained. This is one document in INPO's EOPIA Review Group series.

The Emergency Operating Procedures Implementation Assistance (EOPIA) Review Group. (1983). Emergency Operating Procedures Verification Guideline (Report No. INPO 83-004). Atlanta, GA: Institute of Nuclear Power Operations.

ABSTRACT

The purpose of this guideline is to provide information that can be used by a utility in developing its Emergency Operating Procedure (EOP) Verification Program. This document provides guidance in three major areas of an EOP verification program. These areas are the program objective, program evaluation criteria, and program process.

The program objective is to determine that consistency has been maintained between the EOPs and the EOP source documents. The program evaluation criteria are used to determine if the verification principles are satisfied. The program process supports the actual comparative evaluation.

EOP verification as presented in this document is a comparative evaluation that addresses whether the EOPs are written correctly and are technically accurate.

APPLICATION

This document provides one perspective on the development of EOP verification programs. Differences between verification and validation are clearly explained. This is one document in INPO's EOPIA Review Group series.

Enander, A. (1983). Performance and sensory aspects of work in cold environments: A review. Ergonomics, 27, 365-378.

ABSTRACT

Many people are occupationally exposed to cool or cold environments in which human performance and comfort may be affected. Research results on manual function and other performance measures together with certain subjective effects relevant to work in moderate cold are reviewed. The considerable individual differences in reactions to work in the cold are highlighted, and the difficulties in establishing relationships between physiological measures of cooling, performance and sensory reactions are discussed. It is suggested that an integration of these three aspects is a necessary basis for understanding human reactions to work in the cold and for improving equipment, training and work routines.

APPLICATION

This is a good guide for those interested in effects of cold or cool environments on performance.

Engel, S.E. & Granda, R.E. (1975). Guidelines for man/display interfaces (IBM Technical Report No. TR 00.2720). Poughkeepsie, NY: IBM Poughkeepsie Laboratory.

ABSTRACT

This report documents a set of human factors guidelines relating to the interface between a user of an interactive computing system and a display terminal connected to the system. Though intended primarily for the use of developers of software for an interactive system, many of the guidelines should be of interest to hardware developers. Areas covered include display frame layout, frame content, command languages, error prevention and recovery, response times and behavioral principles.

APPLICATION

The guidelines dealing with consistency of presentation, information presentation, and labeling are applicable across a wide range of man/terminal interfaces. The information presented is useful primarily to software developers.

Enlarged Nordic Cooperative Program on Nuclear Safety. (1981, June). NKA/KRU project on operator training, control room design and human reliability publications list. Nordic Coordinating Committee for Atomic Energy.

ABSTRACT

This publication summary is one of a set of documents which constitute the official reporting of the NKA/KRU project on control room design, operator training, and human reliability. While each of the technical reports has its own annotated bibliography, this collection lists all reports, working papers, etc., in chronological order by country for each of the three major areas of work.

APPLICATION

This is a comprehensive bibliography of source and reference materials relevant to the NKA/KRU project on control room design, operator training, and human reliability.

Failure Analysis Associates. (1979). The role of personnel errors in power plant equipment reliability (Report No. EPRI AF-1041). Palo Alto, CA: Electric Power Research Institute.

ABSTRACT

This study is a preliminary quantification of the impact of personnel error on the availability of a cross-section of fossil fuel power plants. Information was collected from three sources: (1) personal interviews with knowledgeable representatives of nine utilities and staff of three vendors, (2) analysis of the trouble memos of two utilities, and (3) a survey of 38 utilities. Although the interviews revealed that personnel errors significantly affect equipment availability, specific data are incomplete, emphasize equipment failure rather than human error, and differ greatly depending upon the information source. Written reports and survey data indicate in excess of 20 percent of all power plant system failures are probably the result of human error. The resulting loss in power generation capability is estimated to exceed 112,000 megawatt hours per average 300 megawatt unit per year. Boilers and boiler tubes were the components reported to be most often affected by personnel errors, and operator errors are identified more often than maintenance errors. The specific root causes of major problem areas were not clearly identified in most cases, but utilities generally agree that improved training and, to a lesser extent, reduced personnel turnover and equipment designs which better consider human capabilities will reduce personnel errors.

APPLICATION

This is a review of the type of personnel errors in a cross-section of fossil-fueled power plants. Difficulties in specifying cause of equipment failures are also discussed.

Felker, D.B. (Ed.). (1980). Document design: A review of the relevant research (Report No. AIR-75002-4/80-TR). Washington, DC: American Institutes for Research.

ABSTRACT

The overall goal in this review was to develop a document design research literature. The approach was to examine research from different disciplines that relate to document design. In addition, a chapter in the form of a case study that illustrates the development of an actual document design experiment was included.

APPLICATION

The information contained in this review would be useful to anyone preparing writer's guides, procedures, or other documentation.

Finlayson, F.C. (1977). Control room human engineering influences on operator performance. In Thermal reactor safety, Volume I. LaGrange Park, IL: American Nuclear Society.

ABSTRACT

This paper presents some of the major results of an evaluation of the effect of human engineering on operator performance in the control room. Primary attention is given to discussion of control room and control system design influence on the operator. Brief observations on the influences of operator characteristics and job performance guides (operating procedures) on performance in the control room are also given.

APPLICATION

Under the objectives of the study, special emphasis is placed on the evaluation of the control room-operator relationships for severe emergency conditions in the power plant. Consequently, this presentation is restricted largely to material related to emergency conditions in the control room, though it is recognized that human engineering of control systems is important for many other aspects of plant operation.

Finnegan, J.P. (1980). Workshop proceedings: The role of personnel error in fossil fuel power plant equipment reliability (Report No. EPRI-AP-1470). Palo Alto, CA: Electric Power Research Institute.

ABSTRACT

This workshop was convened in response to emerging utility concern as the concluding part of the EPRI-sponsored study conducted by Failure Analysis Associates on "The Role of Personnel Errors in Power Plant Equipment Reliability." The purposes of the workshop were to (1) review the results of the study, (2) examine the nature of some personnel errors which affect fossil-fuel power plant equipment reliability, (3) establish priorities and goals aimed at error reduction, and (4) initiate technical planning of the necessary long-range efforts. The workshop began with presentations by utility representatives and human factors engineers. After general discussion, the attendees divided into three working groups. Various aspects of the problem were discussed and potential solutions were identified within each group and discussed with the general audience. Transcripts of each formal presentation and summaries of working group recommendations are included.

APPLICATION

Persons interested in reducing personnel errors may find this paper helpful.

Fischetti, M.A., Adam, J.A., Eisenhut, D.G. & Horgan, J. (1984, April). TMI plus 5: Nuclear power on the ropes. Spectrum, 26-55.

ABSTRACT

The 1979 accident at the Three Mile Island (TMI) nuclear plant triggered a domino reaction that threatens the future of the U.S. nuclear power industry. This five-part special report covers (1) TMI cleanup, (2) the NRC's generation of a plan to alter existing nuclear reactors, (3) the improvements of nuclear hardware, (4) learning fron incidents at sites other than TMI, and (5) the remaining challenges.

APPLICATION

Those interested in a compact review of the last five years at TMI will find this a useful set of articles.

Foley, J.P., Jr. (1973). Task analysis for job performance aids and related training (Report No. AFHRL-TR-72-73). Wright-Patterson AFB, OH: Air Force Human Resources Laboratory. (NTIS No. AD771001)

ABSTRACT

This paper presents several aspects of task analyses for maintenance jobs when these analyses are used as bases for the development of Job Performance Aids (JPAs) and job-oriented training. An effort is made to standardize the task analysis process so that a true systems approach can be applied to the development of maintenance instructions and training for maintenance.

APPLICATION

This document is useful for guidance for the development of job performance aids.

Frey, P.R. & Kismer, R.A. (1982). A survey of methods for improving operator acceptance of computerized aids (NUREG/CR-2586). Washington, DC: Nuclear Regulatory Commission.

ABSTRACT

A review of the available literature revealed about 70 papers that deal with acceptance problems in computerized systems. Two attempts are made to define and measure the characteristics of a user-acceptable system in non-nuclear industries. The primary acceptance considerations during operations were found to be system availability and system calibration. Additional research was recommended to more accurately define the characteristics of a user-acceptable system for nuclear power plant operators.

APPLICATION

This report describes factors related to user acceptance of computerized aids used in the nuclear power plant control room.

Friar, D.E., Fowler, D.R. & Brown, W.R. (1981, November). Development of a basic questionnaire for human factors application in nuclear power plant control rooms. Proceedings of the American Nuclear Society 1981 Winter Meeting, San Francisco, CA.

ABSTRACT

This paper analyzes the efforts of a study team in developing an assessment instrument. The principles for development of any questionnaire or control room survey are outlined first, and then some of the actual processes used in the Fast Flux Test Facility reactor at Richland, Washington, are described.

APPLICATION

One project goal was to provide other human factors specialists in the nuclear industry with a starting point for their own plant-specific questionnaires.

Frogner, B. & Rao, H.S. (1978). Control of nuclear power plants. IEEE Trans. Autom. Control, 3, 405-417.

ABSTRACT

The authors discuss applications, problems, trends, and their perspectives in the control of nuclear power plants, including interactions and objectives involved in obtaining operational flexibility and safety. Areas where researchers developing control methods can contribute toward improved control design are outlined.

APPLICATION

Although this document outlines areas for further research contributions, the problems discussed should be of assistance to those involved in the control design of nuclear power plants.

Fuchs, F., Engelschall, J. & Imlay, G. (1981). Human engineering guidelines for use in preparing emergency operating procedures for nuclear power plants (NUREG/CR-1999). Washington, DC: Nuclear Regulatory Commission.

ABSTRACT

This report presents recommendations aimed at improving the usability of emergency procedures used in nuclear power plants. The recommendations are based on established presentation principles and a review of typical deficiencies in current nuclear power plant emergency procedures. In support of the recommendations, a summary of these deficiencies and a discussion of the kinds of operator errors affected by procedures are included. The major recommendations are as follows:

1. Adopt a dual-level procedure design.
2. Require a written specification governing procedure design.
3. Employ human factors provisions in the design specification.
4. Require a written specification governing the procedure development process.
5. Continue to make maximum use of the analytical methods now employed.
6. Provide a means to help the plants comply with the specifications.

APPLICATION

A model procedure is included to illustrate how the above recommendations can be implemented. A listing is offered of the kinds of human factors provisions that should be employed in the design specification.

Fuchs, F., Engelschall, J. & Imlay, G. (1981). Evaluation of emergency operating procedures for nuclear plants (NUREG/CR-1875). Washington, DC: Nuclear Regulatory Commission.

ABSTRACT

This report documents the first of two tasks performed for the NRC relative to emergency operating procedures for nuclear power plants with a special emphasis on Loss of Coolant Accident (LOCA) procedures. Emergency procedures from nine plants have been evaluated. The recommendations regarding each plant's emergency procedures were made in separate reports. In this report, an analysis is made of problems common to emergency procedures in all nine plants. Recommendations are advanced for improvement of presentation style, level of detail, and administrative control.

APPLICATION

This document is useful to plants upgrading emergency procedures or writing EOPs for the first time. It provides information and recommendations for common procedural format, style, and content problems.

Fullerton, A.M., Peelle, E. & Reed, J.H. (1982). An evaluation of the nuclear plant operator licensing examination: Final report (NUREG/CR-3458). Washington, DC: Nuclear Regulatory Commission.

ABSTRACT

This report contains findings and conclusions about the Nuclear Regulatory Commission's nuclear power plant operator licensing examination based on six months of field work in late 1981 and early 1982. This report includes chapters which describe and evaluate the examination systems as they existed at the time of the field work. There are also discussions of the concepts of validity and reliability as they relate to the control room operator examination, operator performance measures, and performance-shaping factors. The last half of the report focuses on what could and should be done to the operator licensing system. The report argues that any new examination must be based on task analysis and should incorporate methods for measuring operators' problem-solving ability in ill-defined situations. It is argued that the NRC needs to clarify whether their licensing examination is to be a test of minimal competence or a master test, whether the examination is to serve the selection function, and whether separate licensing tests are needed for ROs and SROs. The last chapter details a model of a new licensing process. Features of the process include validated selection procedures, a computerized basic knowledge examination, an apprenticeship period with documentation of performance, and a computerized, tailored test to assess problem-solving ability and system understanding.

APPLICATION

This report can guide those interested in the validity and reliability of the NRC's nuclear power plant operator licensing examination.

Gertman, D.I., Blackman, H.S., Banks, W.W. & Petersen, R.L. (1982). CRT display evaluation: The multidimensional rating of CRT-generated displays (NUREG/CR-2942). Washington, DC: Nuclear Regulatory Commission.

ABSTRACT

This report is one in a series evaluating various methods for determining the effectiveness of display formats and contains results from multidimensional rating of three cathode ray tube displays. Each display contained information regarding the status of nine safety parameters critical to safe operations at the Loss of Fluid Test (LOFT) reactor located at the Idaho National Engineering Laboratory (INEL). Certified LOFT operators evaluated three formats — bars, stars, and meters — as part of a multimethod display evaluation ongoing at INEL. Each of the six cognitive dimensions embedded in the rating scale are discussed in terms of their internal consistency and ability to differentiate between each of the three formats.

APPLICATION

This report provides information which would be applicable in determining the effectiveness of various display formats and cathode ray tube displays. Information contained provides the status of nine safety parameters critical to safe operations at the Idaho National Engineering Laboratory reactor.

Gertman, D.I., Blackman, H.S. & Banks, W.W. (1982). CRT display evaluation: The multidimensional rating of CRT-generated displays (Report No. EGG-SSDS-5878). Washington, DC: Nuclear Regulatory Commission.

ABSTRACT

This report contains results of a multidimensional rating of three cathode ray tube (CRT) generated displays. Each display contained information regarding the status of nine safety parameters critical to safe operation of the Loss of Fluid Test Reactor (LOFT), located at the Idaho National Engineering Laboratory (INEL). Certified LOFT operators evaluated three format types (bars, stars, and meters) as part of a multimethod approach to display evaluation. Six cognitive dimensions embedded in the rating scale are discussed in terms of their internal consistency and ability to differentiate between each of the three format types. Preliminary findings suggest that two of the six dimensions, content integration (CI) and cognitive processing (CP), were able to discriminate between format types while satisfying the criteria of internal consistency.

APPLICATION

Findings of this research are applicable to the evaluation and use of CRT-based displays, and to the use of displays to indicate the status of safety-related plant functions.

Gertman, D.I., Blackman, H.S., Gilmore, W.E., II & French, D.L. (1983). ATR task training requirements and analysis (Report No. EEG-REP-6273). Idaho Falls, ID: EG&G Idaho, Inc.

ABSTRACT

Task analysis techniques were used to assist in identifying improvements needed in the training curriculum for selected positions at the Advanced Test Reactor (ATR). Six positions were examined — Experiment Power Reactor Operator, Experiment (EPRO-EX); Experiment Power Reactor Operator, Console (EPRO-CO); Senior Reactor Engineer (SRE); Assistant Shift Operator (AS); Shift Supervisor (SS); and Process Control Operator (PCO). A complete position task listing and a core of tasks defined in terms of (a) level of difficulty to perform, (b) severity of consequence if performed improperly, and (c) associated error probability were identified for each position. The systems, academic, and administrative knowledge needed by job incumbents to perform each task was noted. Strategies for teaching the knowledge associated with these tasks are presented.

APPLICATION

This report may prove useful to individuals involved with job or task analysis activities. It would be especially useful to DOE personnel.

Gertner, A., Israeli, R. & Cassuto, Y. (1984). Water and electrolyte balance in workers exposed to a hot environment during their work shift. Ergonomics, 27, 125-134.

ABSTRACT

This report investigated water and electrolyte balance in naturally heat-acclimatized workers having free access to water and performing light to moderate work in a warm environment during their regular 8-hour work shift. The study was conducted at the metal workshops of two plants located in the south of Israel in midsummer. Thirty-two workers were studied in Sdom, an extreme desert, and 13 in Beer Sheva, a semi-arid zone. The average WBGT at the work area ranged from 26°C at the beginning of the work shift to 29°C at the end in Sdom, and 24°C to 25°C, respectively, in Beer Sheva. Venous blood samples and body weights were taken before and after the work shifts. Three times during the work shifts, oral and skin temperatures were measured. The mean weighted skin temperatures increased 3.8°C in Sdom and 1.4°C in Beer Sheva during the work shifts, with a slight increase in oral temperatures. No weight loss was detected at the end of the work shifts. Hematocrit values decreased at the end of the work shifts while the other variables measured in the blood and serum were unchanged. Blood and plasma volumes increased during the work shifts. The data indicate that water and electrolyte balance was maintained. It is concluded that when a naturally heat-acclimatized individual performs light to moderate work (choosing his own work regimen) during his work shift in a warm environment, while having free access to drinking water and electrolytes, water and electrolyte balance is maintained.

APPLICATION

This paper presents information on the influence of heat stress on workers. Recommendations are given.

Goldhaber, G.M., Rogers, D.P., Lesnick, S. & Porter, D.T. (1979). Auditing organizational communications systems: The ICA communication audit. Dubuque, IA: Kendall/Hunt Publishing Company.

ABSTRACT

Chapter 4, Interpreting the Audit, presents five audit tools with sample data and how to interpret these data. An interview guide, a questionnaire survey, and critical incidents are provided as instruments of measurement of organizational communications.

APPLICATION

This book describes an approach for assessing organizational communication through interviews and questionnaires that could be modified (with copyright permission) for use with nuclear facilities.

Gonzalez, W.R. & Smith, D.L. (1984). A practical look at control panel enhancement. Nuclear Safety, 25, 227-237.

ABSTRACT

The accident at Three Mile Island has caused attention to be focused on human factors engineering concerns in the design of nuclear power plant control rooms and in control panels in particular. Examples from a control room review and enhancement task are described and discussed with reference to the need for a careful interpretation of Section 6 of NUREG-0700 which offers guidance for evaluation of control rooms but with very little retrofit information. Two Electric Power Research Institute studies that provide limited retrofit guidance are noted, and recommendations about further research are made.

APPLICATION

This report provides guidance and information which may be used in the area of human factors engineering in relation to nuclear power plant control room panels.

Grandjean, E. (1980). Fitting the task to the man: An ergonomic approach (3rd ed.). London: Taylor & Francis.

ABSTRACT

Emphasis is placed on the factors that affect people at work. This book provides a summary of some important European ergonomics research that has not been available in English. The level of treatment is generally introductory.

APPLICATION

People who are involved in workplace or equipment design, human factors engineering or related fields will find this book to be a practical and useful guide.

Grandjean, E. & Vigliani, E. (Eds.). (1980). Ergonomic aspects of visual display terminals. London: Taylor & Francis.

ABSTRACT

Users of VDTs have encountered problems of many types, including physiological complaints due to constrained postures as well as to eye strain, and psychological problems related to use of new working methods. In this book, the proceedings of an international workshop held in Milan in March 1980, these problems and methods for solving them are discussed. The contributions fall into the following eight sections: (1) physical characteristics of VDTs, (2) visual functions, (3) visual impairments, (4) performance at VDTs, (5) postural problems, (6) psychosocial aspects, (7) practical experience, and (8) ergonomic design and guidelines.

APPLICATION

VDTs are being installed in an ever-increasing variety of workplaces: manufacturing, industry, commerce, and administration. Those interested in the design of VDTs or the effects they have on workers will be interested in this book.

Green, S.R. (1984). Realistic simulation of severe accidents in BWRs computer modeling requirements (NUREG/CR-2940). Washington, DC: Nuclear Regulatory Commission.

ABSTRACT

This report documents the results of an assessment performed at Oak Ridge National Laboratory to determine the reactor and containment hardware, systems, and phenomena which must be modeled in realistic boiling water reactor severe accident analysis computer codes. The scope of the assessment is limited to BWR-4, 5, and 6 reactors and Mark I, II, and III containment systems. The report presents a concise review of the subject reactor and containment designs, together with a description of the reactor and containment systems which have the capacity to impact the outcome of severe accidents. The results of recent BWR probabilistic risk assessments are briefly discussed, and a detailed visualization of a BWR core melt accident is presented. Recommendations are made regarding the type of phenomena which should be modeled and the level of modeling sophistication required for various stages of the core melt accident. Finally, the current availability of the necessary models is discussed along with the associated model development priorities.

APPLICATION

This report is intended for review and assessment of reactor containment systems and designs. BWR risk assessment is presented along with a detailed core meltdown scenario.

Griffon, M. (1979). Human factors methods for analyses of incidents for research upon human failures and their causes (NRC Translation 643). Washington, DC: Nuclear Regulatory Commission.

ABSTRACT

The incident analysis method is divided into two phases.

1. Search for failure
2. Search for causes of human failures.

Failure is defined as finding a gap between the executed task and the task which would have been executed to avoid the occurrence of the incident. The method is applied to an incident of handling.

APPLICATION

In the long-term, this method of analysis should be used in a systematic manner for all incidents caused by human failures of execution.

Haas, P.M. & Bott, T.F. (1980, April). Criteria for safety-related nuclear power plant operator actions: A preliminary assessment of available data. Paper presented at 6th Advances in Reliability Technology Symposium and 3rd European Reliability Data Bank Seminar, Bradford, UK.

ABSTRACT

In the U.S., an effort has been underway for a number of years to develop a design standard to define when required manual operator action can be accepted as part of a nuclear plant design basis. To provide the necessary data base to support such standards and the necessary quantitative assessment of operator reliability, the NRC sponsored a study at Oak Ridge National Laboratory to develop the data base. A program of research using full-scope nuclear plant simulators and results that are correlated to field data was suggested. That program was recently initiated. The approach, results, and conclusions of the preliminary assessment are reported and the planned research program of simulator studies is summarized.

APPLICATION

This report would be helpful in preparing a data base of simulator studies to provide quantitative guidelines to develop a design standard for safety-related nuclear plant operator actions.

Haas, P.M., Selby, D.L., Hanley, M.J. & Mercer, R.T. (1983). Evaluation of training programs and entry level qualifications for nuclear power plant control room personnel based on the systems approach to training (NUREG/CR-3414, ORNL-TM-8848). Washington, DC: Nuclear Regulatory Commission.

ABSTRACT

This report summarizes results of research sponsored by the U.S. Nuclear Regulatory Commission (NRC) Office of Nuclear Regulatory Research to initiate the use of the Systems Approach to Training in the evaluation of training programs and entry level qualifications for nuclear power plant (NPP) personnel. Variables (performance shaping factors) of potential importance to personnel selection and training are identified and research to more rigorously define an operationally useful taxonomy of these variables is recommended.

APPLICATION

A model of the Systems Approach to Training for use in the nuclear industry is presented. Checklists based on this model to assess training programs are also proposed.

Haas, W.P. (1982). Upgrading of quality assurance programmatic guidance for operating nuclear power plants. Nuclear Safety, 23, 277-287.

ABSTRACT

As a result of analysis of the accident at Three Mile Island 2 (TMI-2) and experiences at several construction sites for nuclear power plants, the Nuclear Regulatory Commission (NRC) staff has concluded that certain quality assurance (QA) programmatic modifications relative to existing guidelines should be made. These modifications are directed toward upgrading and strengthening the QA function at operating nuclear power plants to improve its effectiveness in identifying and correcting operational deficiencies to protect the public health and safety. The NRC has developed upgraded guidelines in specific QA programmatic areas and has initiated their implementation at TMI-1 (restart) and at several other operating plants located near densely populated areas. Plans are to implement the new guidelines at all nuclear plants under design and construction and at recently built plants as well.

APPLICATION

Since quality assurance is of utmost importance in the nuclear power field, this paper contains some of the NRC's upgraded guidelines in specific QA programmatic areas.

Hall, R.E. (1982). Post-event human decision errors: Operator action tree/time reliability correlation (NUREG/CR-3010). Washington, DC: Nuclear Regulatory Commission.

ABSTRACT

This report documents an interim framework for the quantification of the probability of errors of decision on the part of nuclear power plant operators after the initiation of an accident. The framework can easily be incorporated into an event tree/fault tree analysis. The method presented consists of a structure called the operator action tree and a time reliability correlation which assumes the time available for making a decision to be the dominating factor in situations requiring cognitive human response. This limited approach decreases the magnitude and complexity of the decision-modeling task. Specifically, in the past, some human performance models have attempted prediction by trying to emulate sequences of human actions, or by identifying and modeling the information-processing approach applicable to the task. Although such modeling approaches can provide considerably greater insight into individual human behavior and the reasons for that behavior, this type of modeling for the full spectrum of relevant nuclear power plant tasks is extremely ambitious and goes beyond the requirements. The model developed here is directed at describing the statistical performance of a representative group of hypothetical individuals responding to generalized situations.

This document has the purpose of integrating and presenting work that has been under independent consideration and development by the three authors, and as such it represents an outgrowth of one recommendation of the 1981 IEEE Standards Workshop on Human Factors and Nuclear Safety held at Myrtle Beach, SC. In order to bring together these ideas into the interim approach represented by this document, BNL contracted to the NUS Corporation and SAI for the services of Mr. J. Wreathall and Mr. J. Fragola, respectively. As a result of these contracts, two reports have been produced which describe the operator action trees method (NUS #4159) and the time-reliability correlation (SAI# NY-R82-7-8(3)). These reports have been integrated into this document together with the separate development work that has been carried out by Mr. R.E. Hall of Brookhaven National Laboratory. The work described in the NUS Corporation and SAI reports is an outgrowth of a week-long meeting between the three authors held at Brookhaven National Laboratory and is representative of this 6-man-week effort of integration.

APPLICATION

This report describes an operator action tree method and time reliability correlation. This information would be useful to persons interested in the quantification of the probability of errors of decision of nuclear power plant operators after the initiation of an accident.

Hartley, C.S., Levy, I.S. & Fecht, B.A. (1984). Potential human factors deficiencies in the design of local control stations and operator interfaces in nuclear power plants (NUREG/CR-3696). Washington, DC: Nuclear Regulatory Commission.

ABSTRACT

The Pacific Northwest Laboratory has completed a project to identify human factors deficiencies in safety-significant control stations outside the control room of a nuclear power plant and to determine whether NUREG-0700, "Guidelines for Control Room Design Reviews," would be sufficient for reviewing those local control stations (LCSs). The project accomplished this task by first reviewing existing data pertaining to human factors deficiencies in LCSs involved in significant safety actions; second, surveying LCS environments and design features at several operating nuclear power plants; and third, assessing the results of that survey relative to the contents of NUREG-0700. The study's conclusions are (1) a definitive list of safety-significant local control stations cannot be specified because power plant designs vary significantly; (2) most, if not all, local control stations have design deficiencies that could be corrected by applying human factors engineering principles; and (3) NUREG-0700 is generally applicable to LCSs but guidance is needed to address the design of manually operated valves and the design requirements of LCSs in extreme environmental conditions. Finally, the study recommends an approach for improving present LCSs to reduce the likelihood that operator error will occur.

APPLICATION

This report provides a review of human factors deficiencies in control stations outside of the control room. Safety considerations are examined in conjunction with operator procedures. Human factors engineers and engineering psychologists may be able to utilize the information within this report.

Helander, M. (Ed.).(1981). Human factors/ergonomics for building and construction. New York: John Wiley & Sons.

ABSTRACT

Many of the factors that contribute to worker dissatisfaction and declining productivity in the construction industry directly involve problems in human elements, ergonomics, and management. Reflecting the growing interactions between engineers and social scientists, this book is the first work to apply advances in the study of human factors to the management of workers and work activities in the construction industry. Chapters of this book include: (1) accidents and construction site safety, (2) company and work organization, (3) productivity measurement and improvement, (4) work satisfaction and improvement, (5) the effect of environmental conditions on productivity, (6) ergonomic design of construction machinery, (7) physical and mental workload, (8) the effectiveness of training programs, and (9) affirmative action, minority rights and the construction industry.

APPLICATION

This book provides civil engineers, managers, and safety personnel with an improved understanding of the importance of human factors in construction work, and offers practical guidelines, specifically developed for the construction and building industry, for dealing with human problems in the work place.

Helander, M.G. (1982). The VDT design handbook (Report No. CRG-TR-82-014). Piscataway, NJ: Bell Laboratories.

ABSTRACT

This handbook addresses the design of visual display terminal (VDT) workstations that use monochromatic cathode ray tubes (CRT) similar to the kind used in television sets. The handbook is intended for persons within the Bell system who work with VDTs or who are interested in the human factors design of VDT workstations. The information is particularly important for the following situations: as a guideline for purchasing new equipment; for specification of the design of work places and illumination systems for new offices or offices that are remodelled; to aid in the understanding of some important work environment problems and to promote communication of the problems.

It is the ambition of these guidelines to ease the understanding of human factors design principles and inspire improvements in the working environment.

APPLICATION

While this report was prepared for Bell Labs, anyone interested in VDTs or VDT workstations would find the information beneficial.

Helander, M.G., Billingsley, P.A. & Schurick, J.M. (1984). In A.S. Neal & L. Strother (Eds.), An evaluation of human factors research on visual display terminals in the workplace (pp. 55-130). Santa Monica, CA: The Human Factors Society.

ABSTRACT

This report describes a critical review of 82 human factors research studies on visual display terminals (VDTs). The areas of interest include visual discomfort (28 studies), anthropometry and biomechanics (16 studies), work organization (9 studies), character and display design (21 studies), and lighting and reflectance (9 studies). The findings are summarized for each section individually.

Lack of scientific rigor has reduced the value of many of these studies. Especially frequent were flaws in experimental design and subject selection, both of which threaten the validity of results. In addition, the choice of experimental settings and dependent and independent variables often made it difficult to generalize the results beyond the conditions of the particular study. Admittedly, some of the research issues are difficult to study and would require substantial funding to investigate properly. Yet many studies would have gained much if appropriate field research methodologies had been used.

The studies on visual fatigue and postural fatigue did not provide any affirmative answers to the issue of whether such fatigue is more frequent for VDT work than for tasks performed without a VDT. The studies on work organization indicate that the work organization and job design factors may be more important than the VDT. The studies of workstation design, office lighting systems, and screen design provide some suggestions that are useful for the design of VDT workstations.

APPLICATION

This report would be of interest to anyone in search of recent research on VDTs in the workplace.

Hollnagel, E. (1981). The methodology of man-machine systems: Problems of verification and validation (Report No. RISO-M-2313). Roskilde, Denmark: RISO National Laboratory.

ABSTRACT

This paper provides an elementary discussion of the problems of verification and validation in the context of the empirical evaluation of designs for man-machine systems. After a definition of the basic terms, a breakdown of the major parts of the process of evaluation is given, with the purpose of indicating where problems may occur. This is followed by a discussion of verification and validation as two distinct concepts. Finally, some of the practical problems of ascertaining validity are discussed. The general conclusion is that rather than rely blindly on a well-established procedure or rule, one should pay attention to the meaningfulness of the aspects which are selected for observation, and the degree of systematism of the methods of observation and analysis. A qualitative approach is thus seen as complementary to a quantitative approach, rather than antithetical to it.

APPLICATION

This report could be useful to individuals involved in procedure generation projects or control room design reviews.

Hollnagel, E., Pedersen, O.M. & Rasmussen, J. (1981). Notes on human performance analysis (Report No. RISO-M-2285). Roskilde, Denmark: RISO National Laboratory.

ABSTRACT

This paper contains a framework for the integration of observation and analysis of human performance in nuclear environments — real or simulated. It identifies four main sources of data, and describes the characteristic data types and methods of analysis for each source in relation to a common conceptual background. The general conclusion is that it is highly useful to combine the knowledge and experience from different contexts into a coherent picture of how nuclear operators perform under varying circumstances.

APPLICATION

This paper given a compact report on the analysis of both research and training simulator performance and also analyzes routine event reports and complex incidents, based on in-plant interviews.

Hopkins, C.O. & Snyder, H.L. (1982). Critical human factors issues in nuclear power generation and a recommended comprehensive long-range plan. Proceedings of the Human Factors Society - 26th Annual Meeting, 692-697.

ABSTRACT

A comprehensive long-range human factors plan for nuclear reactor regulation was developed for the U.S. Nuclear Regulatory Commission by a Study Team of the Human Factors Society. This team identified and analyzed areas of human factors concern in nuclear power generation. It reviewed and evaluated current and planned human factors activities and programs throughout industry and the NRC. The result was a recommended comprehensive human factors plan for the next ten years.

APPLICATION

This report provides information which can be used by utilities or vendors to develop their own long-range plans of applying human factors to nuclear power generation.

Hopkins, C.O., Snyder, H.L., Price, H.E., Hornick, R.J., Mackie, R.R., Smillie, R.J. & Sugarman, R.C. (1982). Critical human factors issues in nuclear power regulation and a recommended comprehensive human factors long-range plan: Volumes 1, 2, 3, executive summary (NUREG/CR-2833). Washington, DC: Nuclear Regulatory Commission.

ABSTRACT

The report is presented in three volumes. Volume 1 contains an Executive Summary of the 18-month effort and its conclusions. Volume 2 summarizes all known nuclear human factors activity, evaluating this activity wherever adequate information is available, and describes the recommended long-range (10-year) plan for human factors in regulation. Volume 3 elaborates upon each of the human factors issues and areas of concern that have led to recommendations in the long-range plan.

APPLICATION

These reports provide information which may be used in the nuclear engineering and human factors areas.

Hottman, S.B. & Bateman, R.P. (1982). Task analysis of spent nuclear fuel operations technicians. Proceedings of the Human Factors Society - 26th Annual Meeting, 873-877.

ABSTRACT

This paper presents the results of a task analysis of operations technicians at an independent spent fuel storage installation (ISFSI). Supervisors at the ISFSI were interviewed and a preliminary job analysis was used to determine required operator skills. Training, safety, operating documents and checklists were reviewed and task inventory forms were developed with the help of ISFSI supervisors. Operations technicians were then interviewed and the task inventory forms filled out with information on task frequency, difficulty, hazard, time to complete, and error potential. These data were analyzed to determine required operator skills and proficiency levels necessary for safe ISFSI operation. The training and testing for certification necessary to verify the skills and proficiency levels were inferred from the data base and the Morris operation records.

APPLICATION

This paper contains information on job and task analysis. Methodology and results of a task analysis at an independent fuel storage installation are given.

Hottman, S.B., Bateman, R.P. & Biers, D.W. (1982). Analysis of training and certification of operations technicians at independent spent fuel storage installations (NUREG/CR-2712). Washington, DC: Nuclear Regulatory Commission.

ABSTRACT

This document presents the results of a task analysis and recommendations for the training and certification of operations technicians at independent spent fuel storage installations. Its purpose is to provide a technical basis for initial and continuation training for operations technicians at Independent Spent Fuel Storage Installations (ISFSIs). It also provides guidance for testing operations technicians to ensure that training objectives have been achieved.

APPLICATION

This report provides information which is pertinent to the training and certification of operations technicians at independent spent nuclear fuel storage installation.

Hsu, Y.Y. (1981). Some possible ways to improve nuclear power plant instrumentation. Nuclear Safety, 22(6), 728-737.

ABSTRACT

This article examines the adequacy of nuclear power plant instrumentation on the basis of the lessons learned from the accident at Three Mile Island 2 and from some of the available advanced technology. The examination identifies two areas that could be improved — unambiguous indication and reliable data collection. It suggests that these two areas can be improved by (1) direct measurement of key parameters, (2) grouping of information, (3) disturbance analysis, (4) self-verification of sensors, and (5) ability of the sensors to survive in a hostile environment and to measure an extended range. Also reported are some of the ongoing research programs, including projects on in-vessel liquid-level measurement and on-line reactor surveillance systems, at the Nuclear Regulatory Commission.

APPLICATION

This report contains information on improving nuclear power plant instrumentation design and operation by unambiguous indication and reliable data collection.

Human engineering guide to control room evaluation, Volumes I & II. Contributors: Stuart O. Parsons; MPR Associates, Inc.; General Electric; S.H. Weiss; General Physics Corporation; BWR Owners Group; INPO; U.S. Nuclear Regulatory Commission; and General Atomic Group.

ABSTRACT

The following documents are included in the collection: HFE Control Room Review; Guidelines for Control Room Review; Control Room Survey Project; MIT Course, Draft HE Checklist; BWR Owners Group Checklist; INPO Checklist; Computer Checklist; and HF Review Plan and Checklists.

APPLICATION

These documents present various guidelines and checklists for use by NRC and the nuclear industry for control room design review.

Illuminating Engineering Society. (1973). American national standard practice for industrial lighting (A11.1-1973). New York: Author.

ABSTRACT

This standard provides criteria for industrial lighting requirements in various applications. Luminescence measured in foot-candles and Dekalux is applied in terms of contrast sensitivity, reflected glare, physical characteristics of the eye, quality of illuminations, and daylight applications when advantageous.

APPLICATION

This study is intended for application in industrial lighting requirements where specific levels have been determined for various tasks. Human factors engineers and industrial psychologists may use this report in establishing a benchmark to evaluate lighting needs. This information may be of use during control room design review lighting surveys.

Institute of Electrical and Electronics Engineers. (1980). IEEE standard criteria for safety systems for nuclear power generating stations (IEEE Standard 603-1980). New York: Author.

ABSTRACT

This standard establishes minimum functional design criteria for the power, instrumentation, and control portions of nuclear power generating station safety systems. These criteria are established to provide a means for promoting safe practices for design and evaluation of safety system performance and reliability. However, adhering to these criteria will not necessarily fully establish the adequacy of any safety system's functional performance and reliability; nonetheless, omission of any of these criteria will, in most instances, be an indication of safety system inadequacy.

APPLICATION

The criteria established by this standard apply to those systems defined as safety systems and do not necessarily apply to all of the safety-related systems, structures, and equipment required for complete plant safety. Although the scope is limited to safety systems, many of the principles may have applicability to equipment provided for safe shutdown, post-accident monitoring display instrumentation, preventive interlock features, or any other systems, structures, or equipment related to safety, or all of the above.

To determine those systems subject to these criteria, an analysis of the overall plant response to postulated design basis events must be performed. A detailed presentation of analytical techniques that can be used in such an analysis is contained in ANSI/ANS 4.1-1978, Criteria for the Preparation of Design Bases for Systems that Perform Protective Functions in Nuclear Power Generating Stations. Good engineering judgement must be exercised in this analysis to assure that adequate margins exist in the design without imposing unduly restrictive criteria such that the goal of protecting the health and safety of the public is replaced by one of protecting every plant component.

Institute of Electrical and Electronics Engineers. (1980). IEEE trial-use standard criteria for the design of the control room complex for a nuclear power generating station (ANSI/IEEE Standard 567). New York: Author.

ABSTRACT

This standard provides criteria for the design of the control room complex for a nuclear power generating station. The emphasis is on the control room and its physical housing itself. The control room provides an area where normal operations as well as emergency operations are initiated. In this capacity it is imperative that standards are utilized and meet safety features which protect personnel.

APPLICATION

This report provides guidelines and criteria for the control room complex in a nuclear power generating station.

Institute of Electrical and Electronics Engineers. (1977). IEEE recommended practice for the design of display and control facilities for central control rooms of nuclear power generating stations (IEEE Standard 566-1977). New York: Author.

ABSTRACT

This document establishes guidelines to be used by power plant system designers in selecting information and control devices to be made available in the central control room, and in determining how and where they shall be made available so that they can most reliably and quickly be used by the operator. The guide addresses the functional requirements of information systems, controls, and displays, but not the selection of specific devices or equipment. It does not apply to the physical design of the control room enclosure or structures mounted therein.

APPLICATION

This document provides uniform guidelines for the functional selection, coordination, and organization of control and information systems in a nuclear power plant central control room.

Institute of Electrical and Electronics Engineers. (1980). Draft revision of IEEE Standard 560 (1977) — Criteria for design of nuclear power facility control rooms. New York: Author, Nuclear Power Engineering Committee.

ABSTRACT

This document establishes criteria to be used by power plant system, equipment, and main control room designers in selecting information and control features to be made available to plant operators in the main control room, and the methods to be used to provide such features. These criteria reflect the application of human engineering principles as they apply to power plant man-machine interfaces during normal and abnormal plant conditions. This includes the requirements of iterative systematic procedures to verify and validate the design process.

APPLICATION

The purpose of this document is to provide criteria for the functional selection, coordination, and organization of controls and displays in a nuclear power plant control room so as to optimize operator performance and minimize the potential for operator error.

Institute of Nuclear Power Operations. (1982). The accreditation of training in the nuclear power industry: Criteria and procedures (Report No. INPO 82-011). Atlanta, GA: Author.

ABSTRACT

The evaluation of utility training involves accreditation and plant evaluations. Accreditation as described in this document is intended to systematically evaluate and subsequently improve the training process used in individual utility training programs. Accreditation is complemented by INPO plant evaluations, which focus more directly on the performance of personnel in the plant, to ensure that training is producing the desired results and that plants are safely operated.

APPLICATION

An accreditation self-evaluation process is included for use by a utility to compare its training and organization programs to INPO Accreditation Criteria for the purpose of identifying strengths and weaknesses and problems and solutions.

Institute of Nuclear Power Operations. (1982). INPO/TVA pilot systems review report. Atlanta, GA: Author.

ABSTRACT

This report of a pilot systems review project conducted by INPO and TVA is an attempt to develop an alternative to the guidelines for control room design review (CRDR) published by the U.S. NRC (NUREG-0700). The objectives of the project were (1) to define the scope of the CRDR necessary to meet post-TMI requirements, (2) to define the depth of required analyses, (3) to provide examples of common human engineering techniques used to analyze system operations, (4) to estimate personnel/equipment resources required for the conduct of the CRDR, and (5) to attempt to integrate the CRDR with other TMI-related requirements. The approach utilized in this review emphasizes the improvement of plant operations under emergency conditions. Unlike NUREG-0700, it does not require significant functional analysis of operator tasks and system functions under emergency conditions; no analysis is performed for normal operations. Another difference is the omission of a control room inventory. A detailed analysis was conducted of two emergency resource systems, one simple and the other complex.

APPLICATION

This pilot project represents one approach to the conduct of a nuclear power plant control room design review, keyed to ensuring safe plant operation under emergency conditions.

Institute of Nuclear Power Operations. (1984). Training system development manual. Atlanta, GA: Author.

ABSTRACT

The purpose of this manual is to provide guidance on applying the systems approach to training in the nuclear power industry. It has been designed for use by training managers, training supervisors, and the training staff at nuclear power plants and training centers. It describes an approach for establishing and maintaining training and qualification systems based on actual job performance requirements. The manual illustrates the application of accepted management principles to the training process, with its success dependent on the effective management of the activities that are described.

APPLICATION

Implementing a training system development process requires two things — management commitment and qualified training personnel. Training managers and supervisors should adhere to the principles of performance-based training. In order to manage or supervise performance-based training effectively, it is recommended that they have a working knowledge of this manual.

Institutt for Energiteknikk. (1981). Computerized operation manual for safety technical specifications (HWR 30). Halden, Norway: Author, OECD Halden Reactor Project.

ABSTRACT

The present report is part of the series of Halden Work Reports (HWRs) which primarily are addressed to the Halden Programme Group (the technical steering body of the Halden Project) as a basis for its continuous review of the Project's research programs. The OECD Halden Reactor Project has developed a concept for computer assistance in the use of operational manuals for safety technical specifications. A prototype of a computerized operational manual was developed on the basis of this concept. Such a computerized operational manual was installed in the FORSMARK-1 nuclear power plant in Sweden. This pilot installation, called the CSTS system (acronym for Computerized Safety Technical Specifications), was used for an on-site experimental investigation in order to test the main ideas of such a computerized off-line system and to gain some useful feedback from practice.

For this experiment parts of the safety systems were selected. A variety of user options were included.

APPLICATION

With this concept, the operator is given a quick and efficient comprehension of the consequences of changes in component status. In addition, the CSTS system makes it possible to simulate faults in connection with planning of maintenance work. The system can be used for training and education of operation staff.

Instrument Society of America. (1979). Annunciator sequence and specifications (Report No. ISA-S18.1). Research Triangle Park, NC: Author.

ABSTRACT

This report provides information which may be applied in the standardization of annunciator sequences and specifications. Various areas are examined throughout the whole system, and defined in terms of terminology, sequencing, order of sequencing, type, and application of various annunciators. The various types include illuminated, drop type, light boxes, recording, and seismic annunciators. Standardization of the varied types in relation to function, design and audible variance levels is examined.

APPLICATION

This report is useful in control rooms or areas where annunciation is required. The varied listing provides brief guidelines toward some measure of uniformity.

Joyce, R.P., Chenzoff, A.P., Mulligan, J.F., & Mallory, W.J. (1973). Fully proceduralized job performance aids: Volume I - Draft military specifications for organizational and intermediate maintenance (AFHRL-TR-73-43). Wright-Patterson AFB, OH: Air Force Human Resources Laboratory. (AD-775 702)

ABSTRACT

This volume specifies a model for specifications for preparation of Fully Proceduralized Job Performance Aids for the maintenance of Air Force equipment. The model has a unique feature of requiring a task analysis yielding certain intermediate products necessary for the development of maintenance data to be prepared in a standard format and submitted for review by the Procuring Agency. The aids to be developed are for the organizational and intermediate maintenance function.

APPLICATION

This report is useful for aiding personnel with the development of job performance aids, especially in the maintenance area.

Kammann, R. (1979). The comprehensibility of printed instructions and the flowchart alternative. Human Factors, 17, 183-191.

ABSTRACT

A few recent studies of open-book comprehension for printed instructions lead to the rule of thumb that such instructions will be understood correctly about two-thirds of the time. In the experiment reported here, two different flowchart formats were compared with standard paragraph instructions and were found to be superior in comprehension accuracy and speed. The two-thirds rule and the flowchart effect were both sustained in comprehension testing in a subsequent field trial.

APPLICATION

This report provides information which can be used in determining instruction procedures through either written instructions or flowcharts.

Kershner, R.L., Gebhard, J.W., Silverman, E.B., & Pannel, G. (1982). An evaluation of nuclear power plant operator performance using a safety parameter display system. Proceedings of the Human Factors Society - 26th Annual Meeting, 789-793.

ABSTRACT

An applied experimental project is presently underway to evaluate the Analog Safety Parameter Display System (ASPDS) and the Engineered Safety Features (ESF) developed by the Virginia Electric and Power Company (VEPCO). These systems and displays were designed in response to the U.S. Nuclear Regulatory Commission guidelines to aid reactor operators in the efficient performance of their duties. Human performance during real-time control room operations with and without the ASPDS-ESF configuration were compared to test the efficacy of the system. The data for all events is presently undergoing analysis; a final report will be available upon completion of this analysis project.

APPLICATION

Some background information for safety parameter display systems (SPDS) is presented here.

Kisner, R.A., & Frey, P.R. (1981). Summary of work on nuclear power plant crew function and organization (NUREG/CR-2587). Washington, DC: Nuclear Regulatory Commission.

ABSTRACT

This summary attempts to bring together in one reading the work on the nuclear power plant operator's role carried out by Oak Ridge National Laboratory (ORNL) and several of its subcontractors. This work was a part of the research project, "Operational Aids for Reactor Operators," administered by ORNL and sponsored by the Nuclear Regulatory Commission (NRC). A list of these subcontractors is given with their respective contributing reports.

APPLICATION

This report discusses the role of the operator. Operations, training or staffing personnel may find the information useful.

Knuth, D., & Boyd, R. (1981). An independent safety assessment of Department of Energy nuclear reactor facilities emergency planning and response (Report No. DOE/US-0013). Washington, DC: Department of Energy.

ABSTRACT

The Department of Energy (DOE) has formed a Nuclear Facilities Personnel Qualification and Training (NFPQT) Committee to assess the implications of the recommendations contained in the President's Commission Report on the Three Mile Island (TMI) Accident (the Kemeny Commission report) that are applicable to DOE's nuclear reactor operations. Thirteen DOE nuclear reactors were reviewed. The emergency planning and response assessments of the facilities are based on information provided by the individual operator organizations and/or cognizant DOE Field Offices. This report indicates how these 13 reactor facilities measure up in light of the Kemeny and other TMI-related studies and recommendations, particularly those that have resulted in upgraded Nuclear Regulatory Commission (NRC) requirements in the areas of emergency planning and response.

APPLICATION

This report assesses the DOE's nuclear reactor operations against the recommendations contained in the President's Commission report on the TMI-2 accident.

Kohl, G.A. (1983). Effects of shape and size of knobs on maximal hand-turning forces applies by females. The Bell Systems Technical Journal, 62, 1705.

ABSTRACT

Outside plant craftspeople use knobs to apply turning forces on clamp mechanisms that hold field equipment temporarily in place. A study was performed to develop a set of data that provide guidance for determining knob size and shape characteristics most appropriate for various outside plant working conditions. Forty female participants applied maximal isometric turning force to each member of a set of twenty experimental knobs that systemtically varied in shape and size. In half the trails the participants applied force with greased hands and in the other half used nonslip compound. In addition, two arm-wrist positions were observed. In general, triangular knobs allow more hand torque to be generated and require significantly less material than square, pentagonal, hexagonal, or circular knobs of comparable size. However, this effect depends upon the arm-wrist position and grip conditions. A 3.5-inch turning diameter is desirable when both cost and performance are considered.

APPLICATION

With the increasing number of women performing jobs previously held by males, strength and size specifications for "tools of the trade" must be altered to accommodate both sexes. Here, the effects of shape and size of knobs on maximal hand-turning forces applied by females are considered.

Koukol, J.F., Lapin, E.E., Leverton, W.F., & Pickering, W.F. (1980). Application of aerospace failure-reporting systems to power plants (Report No. EPRI-NSAC-4). Palo Alto, CA: Electric Power Research Institutes, Nuclear Safety Analysis Center.

ABSTRACT

This report provides the details of discrepancy/failure reporting systems used in NASA and DOD space projects. It describes how these data systems fit into the framework of a broad-based reliability program to ensure the success of complex systems. It is expected that some elements of the failure-reporting systems, which have been used so successfully by the aerospace industry, could be adopted by the nuclear power industry. The output from these reporting systems is an essential element of NSAC's efforts to continually upgrade nuclear safety through cumulative learning from plant-operating experience.

APPLICATION

The report would be of interest to anyone involved in implementing or administering reliability-related programs, particularly in the area of data systems.

Kubokawa, C., Woodson, W., & Selby, P. (1969). Databook for human factors engineers. Volume I: Human engineering data. Volume II: Common formulas, metrics, definitions (NASA Report No. CR114272). Washington, DC: National Aeronautics and Space Administration. (NTIS No. N71-25943)

ABSTRACT

The information collected in this databook represents data most often used by practicing human factors specialists as determined by a survey of well-known practitioners of human engineering. The purpose of this handbook is to provide a convenient method for taking the most used reference information directly to a job remote from the specialist's regular bookshelf. Although it is recognized that such a collection may not be as complete as desired, an attempt has been made to cover as many topics as feasible within the context of a handbook. The included materials have been taken directly from other sources and in a few cases represent original data.

Volume I of the two-volume series contains typical human engineering data useful in determining optimum design characteristics of equipment operated or maintained by human operators and/or maintenance personnel. Volume II contains formulas, nomographs, metrics, conversion tables, symbols, definitions and abbreviations and/or acronyms which may be required at some time during the project activities of typical human engineering specialists. This information, although available from other sources, often requires that the human engineer search through numerous texts, handbooks, specifications or guides in order to find what he needs.

APPLICATION

This is a comprehensive source of human engineering data useful to designers or human factors specialists. The data contained is useful for applying to operational or maintenance tasks. Topics include anthropometry, equipment and component design, environmental conditions, human metabolic factors and human behavioral factors.

Larsen, D.G. & Robb, T.C. LOFT advanced control room operator diagnostic and display system (ODDS). Idaho Falls, ID: EG&G Idaho, Inc.

ABSTRACT

The Loss-of-Fluid Test (LOFT) Reactor Facility in Idaho includes a highly instrumented nuclear reactor operated by the Department of Energy for the purpose of establishing nuclear safety requirements. The results of the development and installation into LOFT of an Operator Diagnostic and Display System (ODDS) are presented herein. ODDS is a computer-based graphics display system centered around a PRIME 550 computer with several RAMTEK color graphic display units located within the control room and available to the reactor operators. Use of computer-based color graphics to aid the reactor operator is discussed. A detailed hardware description of the LOFT data system and the ODDS is presented. Methods and problems of backfitting the ODDS equipment into the LOFT plant are discussed.

APPLICATION

This report would be of interest to anyone involved in establishing and operating safety-related programs, particularly those involving color graphic display units within the control room.

Letbetter, D.G. (1982). Design criteria for safer manual lifting by men and women. Proceedings of the Human Factors Society - 26th Annual Meeting, 503-507.

ABSTRACT

Simplified design criteria are provided for two-handed, manual lifting by standing men and women, without selective assignment of personnel to specific material handling tasks. Based on a 1981 NIOSH report, application of these criteria requires no knowledge of human anatomy, anthropometry, biomechanics, psychophysics, muscle fatigue, cardiovascular capacity, or metabolic endurance. A person who can read and use simple graphs can quickly determine the maximum weight of a listed object. The information needed is the horizontal grasp distance and the initial grasp height and lift distance of the object, plus the frequency and duration of lifting.

APPLICATION

This paper gives easy-to-read graphs for those who want to calculate the maximum weight a person can safely lift using two hands.

Lindell, M.K. (1983). Analysis of emergency staffing for nuclear power plants. Proceedings of the Human Factors Society - 27th Annual Meeting, 1, 184-186.

ABSTRACT

Determination of staffing requirements for response to nuclear plant emergencies should be based upon task analysis in order to ensure that emergency functions can be performed in any type of accident. The method of analysis must recognize the differences between personnel performance in normal and emergency conditions and the limited information available for analysis of emergency tasks. A four-phase method is described that consists of generic analysis (identification of general emergency functions and tasks), situational analysis (definition of the characteristics of the classes of emergencies that can occur), quantitative analysis (determination of workloads, by position) and sensitivity analysis (examination of the degree to which changes in assumptions produce changes in required staffing levels).

APPLICATION

This report would be a useful guide for those interested in the staffing procedures for emergency situations in nuclear power plants.

Lineberry, C.S. & Bullock, D.H. (1980). Job aids. Englewood Cliffs, NJ: Educational Technology Publications.

ABSTRACT

This volume examines the job aid options available to educators and trainers. Guidelines are offered on when, where, and how to use aids, and especially the explanation of the variety of forms that job aids can take.

APPLICATION

This book would be useful for those involved in training or other areas where job performance aids are used.

Luma, S.F., Guidetti, R.P. & Rowland, J. (1981, November). Palo Verde nuclear generating station control room human factors study. Proceedings of the American Nuclear Society - Winter Meeting, San Francisco.

ABSTRACT

This report provides the results of a study made of the Palo Verde nuclear generating station control room. The objective of the study was to identify control room human factors discrepancies using NUREG/CR-1580 guidelines. The study focused on the need to involve plant systems, control room designers, utility technical management, and human factors specialists.

APPLICATION

This report is intended to be used by engineering staff and human factors specialists interested in control room design review activities.

Lutman, R.N., Petrick, W.P. & Hallam, J.W. (1982). A primer on colorgraphic display systems for nuclear power plants (Report No. EPRI-NSAC-45). Palo Alto, CA: Electric Power Research Institute, Nuclear Safety Analysis Center.

ABSTRACT

This primer provides an overview of the technical issues relative to the application of colorgraphic display systems in nuclear power plants. Key sections include the Nuclear Regulatory Commission's (NRC) Emergency Response Facility (ERF) requirements, hardware selection criteria and evaluation, theory of operation, host and device independence factors, software engineering, human factors engineering, and serial and parallel interfaces. Current technology is in a state of rapid evolution and this primer provides an up-to-date assessment of key issues.

APPLICATION

This primer is intended to be a reference source for utility engineers responsible for the system design and software engineering for modern, high-performance, computer-based grephic display systems.

Luxenberg, H.R. & Kuehn, R.L. (1968). Display systems engineering. New York: McGraw Hill.

ABSTRACT

This book contains background material which may be read by the practicing scientist or engineer seeking an introduction to display systems or by the worker already skilled in the area. The book includes much of the essential theoretical foundations of display systems, and technological reductions to practice.

Topics include photometry, colorimetry, image analysis, optics, CRTs, recording media, film-based production systems, lights, lasers, and laser holography.

APPLICATION

This book contains background material pertinent to displays. Theoretical foundations are presented also.

Mackay, C.J., & Bishop, C.M. (1984). Occupational health of women at work: some human-factors considerations. Ergonomics, 27, 489-498.

ABSTRACT

Although still concentrated in a narrow range of activities (as compared to men), women are increasing their share of the overall labor force and there is a growing trend toward employment in occupations previously dominated by males. The health of women at work may benefit from the self-esteem and sense of accomplishment which work can bring or may suffer from the stresses of which work may impose. This paper discusses such effects on the physical and mental well-being of women at work from a number of perspectives.

APPLICATION

Given the increasing number of women in the workforce, this article reviews possible human factors considerations in the areas of occupational health hazards, anthropometric differences, muscular strength/endurance, and mental health.

Maddox, M.E. (1983). The interpretation of human factors design criteria for nuclear power plant control room reviews. Proceedings of the Human Factors Society - 27th Annual Meeting, 1, 23-27.

ABSTRACT

As a result of the Three Mile Island-Unit 2 (TMI) accident and subsequent investigations, all U.S. nuclear utilities are being required to review the control rooms in their nuclear generating plants for human factors design adequacy. This paper presents a description of the ongoing process of applying human factors design criteria from the military and aerospace arena to the review and backfit activities in the nuclear utility industry.

APPLICATION

Helpful in realizing a fundamental problem with guidance issued by the NRC and others is that much of the design guidance is not directly applicable to a review and backfit process such as control room and design reviews.

Maddox, M.E., & Brickey, M.C. (1983). The integration of human factors methodology into nuclear power plant control room reviews. Proceedings of the Human Factors Society - 26th Annual Meeting, 654-658.

ABSTRACT

This paper briefly reviews the evolution of the Nuclear Regulatory Commission (NRC) requirements since the Three Mile Island accident, and it describes a utility pilot study to demonstrate the usefulness of human factors methods in meeting these requirements. This utility pilot study suggests that those human engineering problems likely to affect the ability of control room operators to complete emergency procedures should be assigned the highest level of priority for mitigation.

APPLICATION

This paper was written to lessen confusion among the utilities and the NRC regarding control room design reviews.

Mallory, K., Fleger, S., Johnson, J., Avery, L., Walker, R., Baker, C., & Malone, T. (1980). Human engineering guide to control room evaluation. I. Control room evaluation process. II. Human engineering guidelines (draft report NUREG/CR-1580). Washington, DC: Nuclear Regulatory Commission.

ABSTRACT

Task I.D, Control Room Design, of NUREG-0660, the NRC Action Plan developed as a result of the TMI-2 Accident, specifies that the Commission's Office of Nuclear Reactor Regulation will require that operating reactor licensees and applicants for operating licenses perform a detailed control room design review to identify and correct design deficiencies. The two-part report is a draft revision of the guidelines to be used in the detailed control room reviews. The guidelines and procedures of this report are based on human factors evaluations of nine nuclear power plant control rooms.

APPLICATION

The report is a suggested set of guidelines and procedures for control room evaluation, and as such does not directly address all of the design review factors specified in Task I.D of NUREG-0660.

Martin, J. (1973). Design of man-computer dialogues. Englewood Cliffs, N.J: Prentice-Hall, Inc.

ABSTRACT

This book is based on a course given at the IBM Systems Research Institute. Man and computer must be able to communicate with each other. The computer designer needs to take into consideration man's limitations in relation to technological innovations. The book addresses the topics of alphanumeric dialogues, sound and graphic dialogues, psychological considerations, operators without training, and implementation considerations.

APPLICATION

This book discusses problems and solutions for naive users of computer-based systems. The intent of the material is to make software/hardware specialists aware of user-induced design constraints.

Matule, R. (1981). Effects of visual display units on the eyes: A bibliography (1972-1980). Human Factors, 23, 581-586.

ABSTRACT

Visual display units (VDUs) have been reported to cause such difficulties as eyestrain, visual discomfort, and visual fatigue. In addition, there are effects on visual accommodation as well as effects arising from contrast and glare sensitivity. This bibliography brings together in one place the widely dispersed literature on the effects of VDUs on the eyes.

APPLICATION

This bibliography provides various perspectives on the current research done on visual display units. It is a fairly comprehensive listing of recent articles concerning visual display units.

McCormick, E.J., & Sanders, M.S. (1982). Human factors in engineering and design (5th ed). New York: McGraw-Hill.

ABSTRACT

This text is intended as a survey of the human factors field. Its major thesis is that the man made features and facilities of our civilization should be designed with due consideration to the human use thereof. Topics include information input, human output and control, work space and arrangement, environments, basic human abilities and characteristics, and the effects of design features on human performance and human welfare.

APPLICATION

This textbook provides basic information on a variety of human factors engineering topics. Much emphasis is placed on the design effort.

McKeithan, B.G., & Kfoury, N.S. (1983). Increasing electric power plant productivity through maintenance management. Proceedings of the Human Factors Society -27th Annual Meeting, 1, 576-580.

ABSTRACT

A literature search highlighting power plant maintenance objectives and problem areas was conducted. A method for performing a Human Factors Engineering Assessment of a plant maintenance department is suggested, in conjunction with various maintenance management techniques including time control, maintenance standards, maintenance prioritization, reliability management, information management automation, and the establishment of a Maintenance Planner position.

APPLICATION

This report would be of interest to persons developing or updating a plant maintenance department.

Meese, G.B., Kok, R., Lewis, M.I. & Wyon, D.P. (1984). A laboratory study of the effects of moderate thermal stress on the performance of factory workers. Ergonomics, 27, 19-43.

ABSTRACT

Nearly 1000 black and white, male and female factory workers were exposed in single-sex groups of four, each group working a full shift and attending for one day only, to air temperatures of 6, 12, 18, 24°C (cold series) and 20, 26, 32, 38°C (hot series). All exposures were at low humidity. Clothing levels were fixed for the cold series and the hot series. The exposures took place in a mobile climate chamber on the factory site and the workers performed a series of tasks to simulate factory work. Significant effects of temperature were recorded and the implications for factory design are noted.

APPLICATION

Persons interested in the effect of thermal comfort on performance may find this paper of use.

Meijer, C.H., & Gill, W.J. (1980, June). Operational aids to improve the man-machine interaction in a nuclear power plant. Proceedings of the American Nuclear Society Annual Meeting, Las Vegas, NV.

ABSTRACT

This paper addresses the Combustion-Engineering, Inc., (C-E) approach to meet some of the latest needs with operator aids to improve the man-machine interfaces to monitor, control, and diagnose the plant during its normal and abnormal operation. In particular, the principles of a Critical Function Monitoring System (CFMS) are discussed in detail. CFMS is an aid to the plant operator to monitor and control a finite set of critical plant safety functions.

APPLICATION

For operating plants and plants in advanced stages of construction, C-E recommends installation of the CFMS in the control room as a separate, independent unit. For plants being designed or in early stages of construction, C-E views the integration of the CFMS into their NUPLEX 80™ control room as the most ideal concept.

Meijer, C.H., & Safryn, F.J. (1981). The treatment of alarms in power plants - a practical discussion (C-E Document No. 1PDR-81-004). Windsor, CT: Combustion Engineering.

ABSTRACT

This paper discusses a practical approach to the treatment of alarms in a power plant. It addresses the Man-Process Interaction with alarms, the functional design criteria/goals for alarm systems and practical methods of alarm handling in currently operating as well as future plants.

APPLICATION

Those interested in a practical approach to the treatment of alarms in a power plant will find this of value.

Meister, D. (1984). Human Reliability. In A.S. Neal & L. Strother (Eds.), Human factors review: 1984 (pp. 13-54). Santa Monica, CA: The Human Factors Society.

ABSTRACT

This survey reviews and assesses the human reliability (HR) literature under the following headings: Definition, Historical Review, The Importance of HR, HR Methodologies, Theoretical Assumptions, HR Studies, Taxonomic Factors, Data Bases, Critique of HR, and Status and Future of HR. The review emphasizes the period from 1970 to the present. The relevance of HR to the human factors discipline is stressed.

APPLICATION

Those interested in human reliability literature would find this review useful.

Meister, D., & Rabideau, G.F. (1965). Human factors evaluation in system development. New York: John Wiley & Sons.

ABSTRACT

This is a book about how human factors evaluation is performed during system development, with all of the limitations and potentialities inherent in the system development situation. Topics include the system and system development, analysis and evaluation, human engineering evaluation of system products, system performance evaluation parameters, planning the performance evaluation, data collection and data analysis methods, and human factors evaluation of production processes.

APPLICATION

This book should be of use to anyone interested in examining the processes by which complex man-machine systems are developed and evaluated, including human engineers, and design and test engineers.

Melber, B.D., & Schreiber, R.E. (1983). Engineering expertise on shift in nuclear power plants: The foreign experience (NUREG/CR-2952). Washington, DC: Nuclear Regulatory Commission.

ABSTRACT

This report describes the practices of selected foreign countries with providing engineering expertise on shift in nuclear power plants. The extent to which engineering expertise is made available and the alternative models of providing such expertise are presented. The implications of foreign practices for U.S. consideration of alternatives are discussed, with reference to the shift technical advisor (STA) position and to a proposed shift engineer position. The procedure used to obtain information on foreign practices was primarily a review of the literature, including publications, presentations, and government and utility reports. There are two approaches that are in use to make engineering expertise available on shift: (1) employing a graduate engineer in a line management operations position, and (2) creating a specific engineering position for the purpose of providing expertise to the operations staff. The comparisons of these two models did not indicate that one system inherently functions more effectively than the other. However, the alternative models are likely to affect crew relationships and performance; labor supply, recruitment, and retention; and system implementation problems.

APPLICATION

Alternatives to the shift technical advisor position, as currently practiced in foreign countries, are discussed. This report may prove interesting to operations personnel as well as staffing personnel.

Merritt, R. (1980). Annunciators meet a new standard. Instruments & Control Systems, 31-35.

ABSTRACT

This article provides an up-to-date look at annunciators and their development since the accident at the Three Mile Island nuclear facility. A review of existing functions and sequence diagrams is presented. New technology in the field is discussed in conjunction with application and human factors principles.

APPLICATION

This article is intended to be of use to engineers and technical support personnel. Various applications are presented which illustrate the diversity of annunciators in applications relating to human factors.

Moraal, J., & Kraiss, K.F. (Eds.). (1981). Manned systems design: Methods, equipment and applications. New York: Plenum Press.

ABSTRACT

This book presents an overview of the current status of various analytical and experimental methods relevant to this subject area. Contained in the book are the proceedings of a conference with the same title. The papers are organized in four sections: concepts and strategies, analytical approaches, measurement of performance, and simulator design and evaluation.

APPLICATION

This book contributes to a better understanding of this field of research and is a requisite volume for researchers and workers in industrial psychology and biomedical, nuclear, aerospace and chemical engineering.

Moray, N. (Ed.). (1979). Mental workload, its theory and measurement. New York: Plenum Press.

ABSTRACT

Concentration and efficiency of performance are directly related to the concept of mental workload. The problems of too heavy or too light a load have been repeatedly analyzed, generating an enormous amount of information in numerous models. This volume represents an interdisciplinary attempt to synthesize this material into a coherent summary that is both theoretically sound and practically applicable. Strengths and weaknesses of contemporary approaches to workload are described and new methods of measurement are critically assessed.

APPLICATION

Mental workload, from both the academic and applied viewpoints, are examined here for those whose work involves applying models of human behavior.

Morgan, C.T., Cook, J.S., III, Chapanis, A., & Lund, M.W. (1963). Human engineering guide to equipment design. New York: McGraw-Hill.

ABSTRACT

The primary emphasis in this handbook is on recommended design principles and practices in relation to general design problems rather than on the compilation of research data.

APPLICATION

This book is to be used as a human factors engineering handbook which the designer can use to assist in design problems.

Morgenstern, M.H., Clausen, M.H., Foley, L.O., Levy, G.W., Myers, L.B., Rankin, W.L., & Shikiar, R. (1981). Guidelines for preparing emergency procedures for nuclear power plants (NUREG/CR-1977). Washington, DC: Nuclear Regulatory Commission.

ABSTRACT

In response to the Three Mile Island (TMI) accident and the subsequent evaluation, the U.S. Nuclear Regulatory Commission (NRC) has published the TMI Action Plan. This Action Plan identifies the need to provide Emergency Operating Procedures that treat the lower consequence/higher probability emergencies which had not been addressed in the past, and the need to incorporate good human factors practices in these procedures.

APPLICATION

This document provides input for use in developing guidelines for writing Emergency Operating Procedures for nuclear power plants.

Morse, G.L. & Swift, R.L. (1982, April). Working safely in confined spaces. Plant Engineering, 94-97.

ABSTRACT

Although testing the environment to be entered is necessary to ensure safe entry and work in confined spaces, it is only one part of a total program. After the environment has been evaluated and the hazards identified, employees should follow certain procedures for entering and working within the space. This article outlines those procedures.

APPLICATION

This article is of use to those interested in implementing a safety plan for entering and working in confined spaces.

Myers, L.B., & Bell, A.J. (1984). Methods for implementing revisions to emergency operating procedures (NUREG/CR-3632). Washington DC: Nuclear Regulatory Commission.

ABSTRACT

This report identifies factors which influence the effectiveness of training and implementation of revised emergency operating procedures (EOPs). The possible effects of negative transfer of training are discussed. The report includes a summary of existing methods for implementing revisions to procedures based on interviews with plant personnel, a review of the training literature applicable to the effect of previously learned procedures on learning and performance with revised procedures (i.e. negative transfer), and recommendations of methods and schedules for implementing revised EOPs.

APPLICATION

The information and results of this study are useful for facilities developing and reviewing EOP implementation programs.

Naval Air Systems Command. (1980). Technical manual preparation guide for technical writers, editors, and illustrators - management and procedures manual (NAVAIR 00-25-700). Warminster, PA: Author.

ABSTRACT

This is a guide to assist technical manual personnel in the development of comprehensive and usable technical manuals. The manual identifies goals and objectives for obtaining improved Navy Technical Manual usability. The guide includes technical manual design and development phases, task development and technical manual organization, technical writing guidelines, illustration guidelines, and comprehensibility assurance criteria.

APPLICATION

The guide would be of interest for use by all technical manual preparing activities. It includes methods and procedures essential for the development or update maintenance of usable and comprehensive documents.

Nelson, W.R. (1984). Response trees and expert systems for nuclear reactor operations (NUREG/CR-3631). Washington, DC: Nuclear Regulatory Commission.

ABSTRACT

The United States Nuclear Regulatory Commission is sponsoring a project performed by EG&G Idaho, Inc., at the Idaho National Engineering Laboratory (INEL) to evaluate different display concepts for use in nuclear reactor control rooms. Included in this project is the evaluation of the response tree computer-based decision aid and its associated displays. This report serves as an overview of the response tree methodology and how it has been implemented as a computer-based decision aid utilizing color graphic displays. A qualitative assessment of the applicability of the response tree aid in the reactor control room is also made. Experience gained in evaluating the response tree aid is generalized to address a larger category of computer aids, those known as knowledge-based expert systems. General characteristics of expert systems are discussed, as well as examples of their application in other domains. A survey of ongoing work on expert systems in the nuclear industry is presented, and an assessment of their potential applicability is made. Finally, recommendations for the design and evaluation of computer-based decision aids are presented.

APPLICATION

This paper is a helpful report to persons working in the areas of display design and evaluation.

Nelson, W.R., Clark, M.T. & Banks, W.W. (1981). Applications of functional analysis to nuclear reactor operations (NUREG/CR-1995). Washington, DC: Nuclear Regulatory Commission.

ABSTRACT

The Loss-of-Fluid Test (LOFT) facility is used to demonstrate a functional analysis methodology. Two groups of procedures (for normal cooldown and emergency decay heat removal) from the LOFT Plant Operating Manual (POM) are analyzed using the methodology. Example improvements to the procedures are presented, as well as general guidelines for upgrading operating procedures. Recommendations are made for potential applications of functional analysis in the nuclear industry.

APPLICATION

This report investigates functional analysis techniques that can be used in the nuclear industry. Particular emphasis is given to the development and upgrading of operating procedures.

Nuclear Regulatory Commission.(1973). Reactor safety study: An assessment of accident risks in U.S. commercial nuclear power plants (NUREG-75/014). Washington, DC: Author.

ABSTRACT

The Reactor Safety Study is a report describing the estimated accident risks to the public commercial nuclear power plants of the type now in use. The study was directed by Professor Norman C. Rasmussen of the Massachusetts Institute of Technology. The study compares the estimated risks from nuclear power plants to those which result from other man-caused and natural events. The appendices to the report describe the methodologies employed, the analyses conducted and the results obtained. Included are detailed descriptions of the models developed to estimate the health effects and property damages which could be expected to result from nuclear power plant accidents.

APPLICATION

This report is useful in providing a comparison of potential risks at the nuclear level versus other man-made or natural events. This report would be applicable in the area of safety precaution and emergency response to nuclear and natural disasters.

Nuclear Regulatory Commission. (1979). TMI-2 lessons learned task force: Final report (NUREG-0585). Washington, DC: Author.

ABSTRACT

In its final report reviewing the Three Mile Island accident, the TMI-2 Lessons Learned Task Force suggests changes in several fundamental aspects of basic safety policy for nuclear power plants. Changes in nuclear power plant design and operations in the regulatory process are discussed in terms of general goals. The appendix sets forth specific recommendations for reaching these goals.

APPLICATION

This report is one of the first in-depth responses of the NRC to the impact of the TMI-2 accident on safety policy. It presents recommendations for improvements in licensing practices, personnel qualifications, staffing and manning procedures, performance verification/evaluation, control room human factors, and design assessment.

Nuclear Regulatory Commission. (1980). Clarification of TMI action plan requirements (NUREG-0737). Washington, DC: Author.

ABSTRACT

This document is a letter of licensees of operating power reactors and applicants for operating licenses forwarding post-TMI requirements which have been approved for implementation. Following the accident at Three Mile Island Unit 2, the NRC staff developed the Action Plan, NUREG-0660, to provide a comprehensive and integrated plan to improve safety at power reactors. Specific items from NUREG-0660 have been approved by the NRC for implementation at reactors. It should be noted that the total set of TMI-related actions have been collected in NUREG-0660, but only those items that the NRC has approved for implementation to date are included in this document (NUREG-0737).

APPLICATION

This report includes requirements information about schedules, applicability, method of implementation review, submittal dates, and clarification of technical positions for licensees of operating power reactors and applicants for operating licenses.

Nuclear Regulatory Commission. (1980). Criteria for preparation and evaluation of radiological emergency response plans and preparedness in support of nuclear power plants (NUREG-0654). Washington, DC: Author.

ABSTRACT

This document is concerned with accidents at fixed commercial nuclear power reactors which might have impact on public health and safety. The purpose is to provide a common reference and guidance source for (1) state and local governments and nuclear facility operators; and (2) Federal Emergency Management Agency, NRC, and other Federal agency personnel in the development of emergency response plans and preparedness in support of nuclear power plants.

APPLICATION

Many of the planning elements contained in this guide may be useful for planners in the vicinity of test and research reactors, fuel processing plants, or other facilities using or producing large quantities of radioactive material.

Nuclear Regulatory Commission. (1980). Inspection and enforcement manual. Washington, DC: Author, Office of Inspection and Enforcement.

ABSTRACT

This manual contains basic policies and procedures that have overall applicability to inspection and enforcement programs. Also included is a categorized source of information covering all phases of inspection and enforcement operations.

APPLICATION

Policy, procedures, inspection objectives, required scopes of inspection, and guidance developed for the Office of Inspection and Enforcement are provided.

Nuclear Regulatory Commission. (1980). NRC action plan developed as a result of TMI-2 accident, Volume 1 (NUREG-0660). Washington, DC: Author.

ABSTRACT

This Action Plan was developed to provide a comprehensive and integrated plan for the actions now judged necessary by the Nuclear Regulatory Commission to correct or improve the regulation and operation of nuclear facilities based on the experience from the accident at TMI-2 and the official studies and investigations of the accident. Activities and programs of the NRC not related to the accident at TMI-2 are not described in this Action Plan; they are contained in the NRC Operating Plan. The schedules and resources presented in this Action Plan and the NRC Operating Plan have been adjusted to try to optimize the increase in safety consistent with the resources available to the agency in fiscal years 1980 and 1981.

APPLICATION

This plan contains the recommendations for specific changes in operational safety; siting and design; emergency preparedness; practices and procedures; and NRC policy, organization, and management following the TMI-2 accident. The plan also contains estimates of the resources and schedule for NRC and the industry to accomplish the actions.

Nuclear Regulatory Commission. (1981). Functional criteria for emergency response facilities (NUREG-0696). Washington, DC: Author.

ABSTRACT

This report describes the facilities and systems to be used by nuclear power plant licensees to improve responses to emergency situations. The facilities include the technical support center (TSC), on-site operational support center (OSC), and near-site emergency operations facility (EOF), as well as a brief discussion of the emergency response function of the control room. The data systems described are the safety parameter display system (SPDS) and nuclear data link (NDL). Together, these facilities and systems make up the total emergency response facilities (ERFs). Licensees should follow the guidance provided both in this report and in NUREG-0654 (FEMA-REP-1), Revision 1 for design and implementation of the ERFs.

APPLICATION

This document establishes criteria that the NRC staff intends to use in evaluating whether an applicant/licensee meets the requirements of 10 CFR 50, Appendix E, Article IV.E.8 and Appendix A, GDC 19. The use of criteria different from those set forth herein will be accepted only if the substitute criteria provide a basis for determining that the above-cited regulatory requirements have been met.

Nuclear Regulatory Commission. (1981). Guidelines for control room design reviews (NUREG-0700). Washington, DC: Author.

ABSTRACT

This regulation provides the guidance that the NRC staff believes should be followed to accomplish the control room design review described in NUREG-0660. The guidelines are based on NUREG/CR-1580 and NUREG-0659, with modifications as suggested and recommended in comments on these two documents. Compliance with these guidelines is not a requirement.

APPLICATION

Although NUREG-0700 is not a substitute for statutory requirements, the approaches, methods, and reporting procedures provided can help ensure adequate human factors engineering considerations are included in control room design reviews.

Nuclear Regulatory Commission. (1981). Human factors acceptance criteria for the safety parameter display system (draft report) (NUREG-0835). Washington, DC: Author.

ABSTRACT

This report contains human factors engineering design review acceptance criteria developed by the Human Factors Engineering Branch (HFEB) of the Nuclear Regulatory Commission (NRC) to use in evaluating designs of the Safety Parameter Display System (SPDS). These criteria were developed in response to the functional design criteria for the SPDS defined in NUREG-0696, Functional Criteria for Emergency Response Facilities.

General acceptance criteria for displays of plant safety status information by the SPDS are developed. In addition, specific SPDS review criteria corresponding to the SPDS functional criteria specified in NUREG-0696 are established.

These design review acceptance criteria define a basis for the NRC staff's human factors review of a Safety Parameter Display System. These review criteria do not impose any new functional design requirements.

APPLICATION

The purpose of this report is to identify design review acceptance criteria for the Safety Parameter Display System installed in the control room of a nuclear power plant. Use of computer-driven CRT displays is anticipated.

Nuclear Regulatory Commission. (1981). Staff supplement to the draft report on human engineering guide to control room evaluation (NUREG-0659). Washington, DC: Author.

ABSTRACT

This supplement to NUREG/CR-1580 was prepared by the NRC staff to provide (1) responses to comments on the draft guidelines, (2) sample checklists and corresponding human engineering guidelines/acceptability criteria for analyzing operator-control room interfaces, and (3) draft systems review guidelines.

APPLICATION

This document provides the planned procedures for evaluating licensee and applicant control room design reviews and for implementing control room design improvements.

Nuclear Regulatory Commission. (1982). Guidelines for the preparation of emergency operating procedures: Resolution of comments on NUREG-0799 (NUREG-0899). Washington, DC: Author.

ABSTRACT

The purpose of this document is to identify the elements necessary for utilities to prepare and implement a program of Emergency Operating Procedures (EOPs) for use by control room personnel to assist in mitigating the consequences of a broad range of accidents and multiple equipment failures. This document applies only to the EOPs so designated; it does not address emergency preparedness or emergency planning. It also represents the resolution of comments on NUREG-0799, "Draft Criteria for Preparation of Emergency Operating Procedures."

APPLICATION

This document applies only to Emergency Operating Procedures and specifically does not address emergency preparedness or emergency planning.

Nuclear Utility Task Action Committee. (1983). Control room design review implementation guideline (Report No. INPO 83-026). Atlanta, GA: Institute of Nuclear Power.

ABSTRACT

The implementation guideline is divided into two distinct but complementary parts. The first part, the guideline portion, lists specific functional areas that should be addressed in some form by utilities developing a CRDR program plan. The second part is an example CRDR implementation program plan provided as the appendix.

APPLICATION

This CRDR Implementation Guideline has been developed by the CRDR NUTAC to assist individual utilities in developing their CRDR program plans in response to NUREG-0737, Supplement 1.

Nuclear Utility Task Action Committee. (1983). Control room design review survey development guideline (Report No. INPO 83-042). Atlanta, GA: Institute of Nuclear Power.

ABSTRACT

The Survey Development Guideline is divided into three complementary parts. The introductory portion of the document describes the purpose and scope, defines the major terms used in the guideline, and describes briefly the methodology used, which is basically one of screening an existing set of items to find acceptable survey items.

The second portion contains an example set of the surveys, checklists, and questionnaires developed using this methodology. The purpose of this section is to illustrate the products produced by using the methodology and to assist member utilities by providing CRDR surveys, checklists, and questionnaires that can serve as examples around which each utility may develop instruments specifically tailored to their own control room survey. This is Appendix A to the document.

The third portion of the document is a set of appendixes (B through H) containing items not included among the control room survey items.

APPLICATION

This CRDR Survey Development Guideline has been developed by the CRDR Nuclear Utility Task Action Committee (NUTAC) to assist individual utilities in developing their CRDR program plans in response to NUREG-0737, Supplement 1.

Nuclear Utility Task Action Committee. (1983). Control room design review task analysis guideline (Report No. INPO 83-046). Atlanta, GA: Institute of Nuclear Power.

ABSTRACT

This document was written in response to a utility industry request for assistance in the area of human factors in general and the CRDR in particular.

It is intended for use by personnel performing a CRDR and is designed to assist utilities in understanding and implementing that portion of their CRDR that requires the use of task analysis. This document contains a discussion of the rudiments of tasks and task analysis. Followig the introductory discussion are descriptions of each phase required to implement the task analysis process in order to obtain the kinds of information necessary for the CRDR.

Appendixes to this document provide a sample task analysis procedure as it might be written by a utility, an example of the output of that procedure, and a reference list of NUREG-0700 Section 6 items that are most appropriately addressed during the CRDR task analysis.

APPLICATION

This CRDR Task Analysis Guideline has been developed by the CRDR NUTAC to assist individual utilities in developing their CRDR program plans in response to NUREG-0737, Supplement 1.

Nuclear Utility Task Action Committee. (1983). Human engineering principles for control room design review (Report No. INPO 83-036). Atlanta, GA: Institute of Nuclear Power.

ABSTRACT

The intended use for this document is to help assess whether particular aspects of a nuclear control room that have been identified as HEDs can still fulfill the design principle for that particular item. This document contains basic human engineering principles grouped into sections related to nuclear power plant control rooms. Each principle is followed by a short explanation, a list of references that can be consulted for detailed criteria related to that reference, and examples of methods that might be used to support that principle. A cross-reference guide to NUREG-0700, Section 6, is provided as an appendix to this document.

APPLICATION

This document was written in response to a utility industry request for assistance in the area of human factors in general and the CRDR in particular.

Oak Ridge National Laboratory. (1981). Specification and verification of nuclear power plant training simulator response characteristics. Part 1: Summary of current practices for nuclear and non-nuclear simulators (NUREG/CR-2353). Washington, DC: Nuclear Regulatory Commission.

ABSTRACT

This report reviews the methods and practices of the nuclear industry for specifying and verifying the performance characteristics of simulators used to train nuclear power plant operators. It also reviews the training simulator methods and practices of selected non-nuclear industries (in particular, the civilian and military aircraft industries) and compares them with those of the nuclear industry. In addition, it identifies non-nuclear methods that might be profitably adopted by the nuclear industry and perhaps included in a simulator standard endorsed by the Nuclear Regulatory Commission. Final conclusions and recommendations are discussed in a companion report (NUREG/CR-2353, Volume 2; ORNL/TM-7986).

APPLICATION

This report reviews methods and practices used for specifying and verifying performance characteristics of simulators used to train nuclear power plant operators. Non-nuclear industries may be able to utilize these procedures in other simulator applications.

Olsen, R.A. (Ed.). (1981). Handbook for design and use of visual display terminals. Sunnyvale, CA: Lockheed Missile & Space Company, Inc.

ABSTRACT

This handbook concentrates on workstations with video or other displays and a keyboard. It provides information on work environments and aids in the selection of display hardware. The needs of people using the displays are discussed, along with guidelines, rules, checklists, and tables for planning purposes. Further sources of information are also listed.

APPLICATION

This handbook is for people interested in effects of work on posture and health; supervisors with questions on workstation design; managers planning and coordinating work areas; buyers selecting or specifying furnishings; designers of consoles, panels, and displays; data processing systems and equipment designers; office managers and word processing supervisors; and training and personnel services representatives.

Olson, J., McLaughlin, S.D., Osborne, R.N. & Jackson, D.H. (1984). An initial empirical analysis of nuclear power plant organization and its effect on safety performance (NUREG/CR-3737). Washington, DC: Nuclear Regulatory Commission.

ABSTRACT

This report contains an analysis of the relationship between selected aspects of organizational stucture and the safety-related performance of nuclear power plants. The report starts by identifying and operationalizing certain key dimensions of organizational structure that may be expected to be related to plant safety performance. Next, indicators of plant safety performance are created by combining existing performance measures into more reliable indicators. Finally, the indicators of organizational structure are related to the indicators of plant safety performance using correlational and discriminant analysis. The overall results show that plants with better developed coordination mechanisms, shorter vertical hierarchies, and a greater number of departments tend to perform more safely.

APPLICATION

This study may provide nuclear power plant personnel with a better understanding of the relationship between organizational structure and safety-related performance.

Olson, J., Schreiber, R.E. & Melber, B.D. (1984). Alternative approaches to providing egineering expertise on shift (NUREG/CR-3785). Washington, DC: Nuclear Regulatory Commission.

ABSTRACT

This report represents the conclusions of a project studying the role of engineering expertise on shift in nuclear power plants. Using the present shift technical advisor (STA) position as the base case, several alternatives were analyzed. On-shift alternatives include the STA, the shift supervisor (SS), and the shift engineer (SE). The SE is degreed, experienced, trained and licensed as a Senior Reactor Operator. Some non-shift alternatives were also studied. These included a cadre of on-call engineers and specialists within continual contact and easy reach of the plant, a technical system of phone and data lines linking the plant with a facility similar to an on-site technical support center, and a safety parameter display system (SPDS) to augment technical upgrading of operator aids presently available. Potential problems considered in the analysis of implementation of these alternatives included job content constraints, problems of crew acceptance, and problems of labor supply and retention. Of the considered alternatives, the SE and SS options appear superior to the current STA approach. The SE option appears the easiest to implement and the most effective under varied plant conditions. The SE may also serve as liaison to off-site support facilities.

APPLICATION

The intent of this report was to study the role of engineering expertise on shifts in nuclear power plants. Areas of information were the shift engineer, shift technical advisor, and overall engineering expertise.

Onodera, K., Miki, M., Nukada, K., & Nakamura, H. (1982). Reliability management of nuclear power plant. 1982 Proceedings, Annual Reliability and Maintainability Symposium, 151-156.

ABSTRACT

Statistics show that the average frequency of forced shutdown of nuclear power plants is 6-8 times per plant year in the United States, 3-4 in West Germany and about 1 in Japan.

Although Japan seems to have reached a good frequency, plant manufacturers wish to improve this frequency by making more reliable plants.

This paper describes several activities of plant manufacturer Hitachi, Ltd., relating to the reliability management of nuclear power plants, such as standardization of design, reliability classification of equipment, and reliability assessment methods.

APPLICATION

Since plant shutdown means loss of money, all plant personnel interested in maintenance and reliability would find this article useful.

Parker, J.F., Jr., & West, V.R. (Eds.). (1973). Bioastronautics Data Book. Washington, DC: National Aeronautics and Space Administration.

ABSTRACT

This revision of the Bioastronautics Data Book was prepared in order to bring together the essentials of the large body of human research information generated in recent years and to present it in a form suitable for engineers and others concerned with the development and evaluation of modern systems. This is an updating and expansion of an earlier document prepared for the National Aeronautics and Space Administration in 1964 by Webb Associates. The revision was prepared under the guidance of Working Group 5 of the Committee on Hearing Bioacoustics and Biomechanics of the National Academy of Sciences.

APPLICATION

This book is designed to be a source of human research information generated in recent years. It deals with a substantial array of content areas within the broad domain of life sciences and presents primarily that information deemed of value for system design and evaluation.

Parris, H.L., & McConville, J.T. (1981). Anthropometric data base for power plant design (Report No. EPRI NP-1918-SR, Special Report). Palo Alto, CA: Electric Power Research Institute.

ABSTRACT

The primary study objective is to develop anthropometric data based upon the men and women who operate and maintain nuclear power plants. Age, stature, and weight information were obtained by a questionnaire survey of current operator and maintenance personnel, and the data extracted from the questionnaires were analyzed to derive body-size information for a number of anthropometric variables of interest to designers. Designers can significantly increase both the operational and maintenance efficiency of future power plant workplaces by utilizing the data contained in this report.

APPLICATION

The availability of such data will particularly help designers who in the past either have not systematically utilized any formal data or who have been forced to rely on the use of anthropometric data compiled for other populations.

Pauls, J.L. (1983). Stair safety and handrail studies: methods, findings and applications to building codes and standards. Proceedings of the Human Factors Society - 27th Annual Meeting, 2, 611-615.

ABSTRACT

Background information is provided on the problem of stair accidents and the solutions being recommended as a result of research into stair use and design. Changes in building codes and standards began appearing in 1980; more extensive changes are now being discussed and will appear between 1984 and 1990.

APPLICATION

Stair accidents are the leading cause of injuries in buildings. Those involved in stair design can find recommendations in this article.

Pen, R.W., Miller, D.C., & Feeher, C.E. (1981). Evaluation of proposed control room improvements through analysis of critical operator decisions (Report No. EPRI-NP-1982). Palo Alto, CA: Electric Power Research Institute.

ABSTRACT

Decision-making by nuclear power plant operators was studied in the context of four recent off-normal events in order to assess the potential impact of various control room improvements and innovations. Categories of improvements considered in the study included proposed changes in staff organization and training, controls and displays, and computerized support systems.

The evaluation methodology involved judgments by a panel of experts regarding the benefits of proposed improvements for specific operator decisions. It also included the explication of a model of operator decision-making and an analysis in terms of this model of how each improvement could help prevent or resolve decision-making errors.

The results indicated that time stress on the crew played an appreciable role in performance failures. The report concludes that it is unrealistic to expect that further training improvements alone can do much to address the multitude of potential situations that operators face. A combination of improvements will be necessary, integrated by a strong underlying operational concept that could be embodied in a computerized support system. The recommended approach would emphasize the detection and correction of errors when they occur, in addition to the prevention of errors.

APPLICATION

This report may prove interesting to those involved with current or future control room enhancement projects. The impact of different improvements upon operator decision-making is assessed.

Pine, S.M., Schulz, K.A., Edman, J.R., Hanson, T.G., Evans, T.G., Gonzales, W., Smith, D. & Seminara, J. (1982). Human engineering guide for enhancing nuclear control rooms (Report No. EPRI NP-2411). Palo Alto, CA: Electric Power Research Institute.

ABSTRACT

A guide documenting near-term human engineering approaches for enhancing existing nuclear control rooms and for correcting many commonly found discrepancies in control rooms is presented. Primary data collected during site visits to four PWR plants and the data collection procedure are reviewed; details of the guide are provided; and evaluation of the enhancement approaches via an extensive review cycle is described.

APPLICATION

The guide is cross-referenced to NUREG-0700 and is intended as a reference document for multidisciplinary design review teams.

Post, T., Price, H., & Diffley, C. (1976). A guide for selecting formats and media for presenting maintenance information (Contract No. N00600-76-C-1373). Bethesda, MD: Naval Ship Research and Development Center.

ABSTRACT

The research reported here developed a method for selecting formats and media for presenting maintenance information. The work was sponsored by the Navy Technical Information Presentation Project (NTIPP), an exploratory development program being conducted by the David W. Taylor Naval Ship Research and Development Laboratory, Carderock, Maryland.

The Navy plans to evaluate the product of this research in a shipboard setting. The evaluation will assess the feasibility of applying the method (does the guide provide adequate guidance for selecting formats and media?) and the utility of the selection (what are the benefits of presenting information in the formats and media indicated by the selection method?).

APPLICATION

Useful information for procedure or documentation development, especially in the area of maintenance, is presented in this report.

Potash, L.M. (1980). Analysis of licensee event report (LER) and noncompliance data related to licensee performance evaluation (Report No. EGG-SSDC-5223). Idaho Falls, ID: EG&G Idaho, Inc.

ABSTRACT

The Nuclear Regulatory Commission (NRC) Inspection Program (noncompliance data) and the Licensee Event Report (LER) Program were analyzed to improve the effectiveness of measures of regulatory performance, to describe the relationships between power plant characteristics and LERs and noncompliances, and to provide a critical analysis of the LER and NRC Inspection Program. In order to accomplish these objectives, computer printouts of LERs and noncompliance data describing events occurring between November 1, 1977, to October 30, 1978, were analyzed for 52 power plants. Recommendations are made for implementing a program for measuring regulatory performance. The possibility of abandoning the concept of regulatory performance and using noncompliances to identify specific problems that need correction is explored. A critical analysis of the LER and NRC Inspection Programs is also incorporated in this report, including a discussion of the new NRC Resident Inspector Program.

APPLICATION

This report would be useful to anyone interested in the effectiveness of regulatory performance.

Price, H.E., Maisano, R.E., & Van Cott, H.P. (1981). The allocation of functions in man-machine systems: A perspective and literature review (NUREG/CR-2623). Washington, DC: Nuclear Regulatory Commission.

ABSTRACT

This report reviews the literature relevant to allocation of functions and presents a procedure for the allocation process applicable to nuclear power plant control rooms. Methods and models that have been developed to aid the allocation process are considered, followed by examples of real-world applications. The resultant hypothesis of allocations is tested against environmental, system, and psychological constraints.

APPLICATION

This report provides an overview of the various literature available which is applicable to nuclear control room procedures and the allocation of function to system process. Evaluations and installations of automated and computer-based aids in nuclear power plants are also reviewed.

Price, H.E., Post, T.J., & Kolsrud, G. (1971). Development of information measurement techniques for quality assurance of Navy aircraft maintenance job aids. Part I: Research and development effort. Part II: In-process review test forms (Contract No. N62269-70-C-0395). Warminster, PA: Naval Air Development Command.

ABSTRACT

The purpose of this study was to develop paper and pencil tests to support in-process review of aviation maintenance job aids. Two types were developed, editorial and information content. Application of the tests should result in early detection of inadequacies and corrective feedback to technical writers.

APPLICATION

This report addresses the problem of studying the feasibility and development of information measurement techniques and for preparation of tests of technical publication during in-process review.

Pulliam, R., Price, H.E., Bongarra, J., Sawyer, C.R. & Kisner, R.A. (1983). A methodology for allocating nuclear power plant control functions to human or automatic control (NUREG/CR-3331). Washington, DC: Nuclear Regulatory Commission.

ABSTRACT

This report describes a general method for allocating control functions to man or machine during nuclear power plant (NPP) design, or for evaluating their allocation in an existing design.

The research examined some important characteristics of the systems design process, and the results make it clear that allocation of control functions is an intractable problem, one which increases in severity with the increasing complexity of systems. The method is reported in terms of specific steps which should be taken during the early stages of a new system design, and which will lead to an optimal allocation at the functional design level of detail.

The procedure described are not expected to provide an ultimate solution to the allocation-of-functions problem. However, these procedures can at least assure that allocation of control functions is considered during design in an orderly and rational way. They should substantially advance the general understanding of this problem and the ability of the design community to allocate control functions to humans or automation in complex systems.

APPLICATION

This report explores the problem of allocating functions to human or automatic control, with particular reference to nuclear power plant control rooms.

Ramos, S.C., et al. (1981). Methodology for evaluation of emergency response facilities (NUREG-0814). Washington, DC: Nuclear Regulatory Commission.

ABSTRACT

This draft report was prepared largely from the criteria in NUREG-0696 by NRC staff assisted by contractor personnel. This report is presented in draft form for public comment and interim use. It also will be used by the staff in this form for the initial reviews of the Emergency Response Facilities designs which are presently being submitted by nuclear power reactor operators. The staff will incorporate the experience gained from the preliminary reviews and the comments received into a final methodology document which will be used by the staff in its determination of the acceptability of ERFs proposed by nuclear power reactor licensees.

This document is issued for comment and to provide affected licensees an early insight into the approach the staff will use in reviewing Emergency Response Facility proposals.

APPLICATION

This report is intended for use in review of Emergency Response Facility designs.

Ramsey, H.R., & Atwood, M.E. (1979). Human factors in computer systems: A review of the literature (NTIS No. AD-A075679). Springfield, VA: National Technical Information Service.

ABSTRACT

Based on an extensive literature survey, this document presents a description and critical analysis of the state of the art in the area of human factors in computer systems. This review is concerned both with the status of human factors research in the area of user-computer interaction and with the current state of user-computer interaction technology and practices. The primary purpose of the review is to determine whether research and practice in this area have evolved sufficiently to support the development of a human factors guide to computer system design. It is concluded that insufficient data exist for the development of a "quantitative reference handbook" in this area, but that a "human factors design guide" — which discusses issues, alternatives, and methods in one context of the design process — is both feasible and needed.

APPLICATION

This report provides a review of human factors in user-computer interaction technology and practices. This data may be useful to persons upgrading computer systems or anticipating integrating a new system.

Ramsey, H.R., Atwood, M.E., & Kirshbaum, P.J. (Eds.). (1978). A critically annotated bibliography of the literature of human factors in computer systems (Contract No. N00014-76-C-0866). Washington, DC: Office of Naval Research. (NTIS No. AD-A058081)

ABSTRACT

This bibliography provides a very broad survey of literature dealing with human factors in relation to computer systems. References selected deal with human factors aspects of interactive computers, hardware, software, and procedures.

APPLICATION

This bibliography would be useful in any application where interaction between human factors principles and computerized systems occurs.

Rankin, W.L., Bolton, P.A., Shiklar, R., & Saari, L.M. (1984). Nuclear power plant simulators for operator licensing and training. Part I: The need for plant-reference simulators. Part II: The use of plant-reference simulators (NUREG/CR-3725). Washington, DC: Nuclear Regulatory Commission.

ABSTRACT

Part I of this report presents technical justification for the use of plant-reference simulators in the licensing and training of nuclear power plant operators and examines alternatives to the use of plant-reference simulators. The technical rationale is based on research on the use of simulators in other industries, psychological learning and testing principles, expert opinion, and user opinion. Strong technical justification exists for requiring plant-reference simulators for operator licensing purposes. Technical justification for the use of plant-reference simulators for operator training is less well grounded empirically, although expert opinion is that plant-reference simulators, when properly used, result in the most effective training. Part II discusses the central considerations in using plant-reference simulators for licensing examination of nuclear power plant operators and for incorporating simulators into nuclear power plant training programs. Recommendations are presented for the administration of simulator examinations in operator licensing that reflect the goal of maximizing both reliability and validity in the examination process. A series of organizational tasks that promote the acceptance, use, and effectiveness of simulator training as part of the onsite training program is delineated.

APPLICATION

These reports may be utilized by operator training and licensing personnel in administering the simulator training.

Rankin, W.L., Duvernoy, E.G., Morgenstern, M., Ames, K.R., & Eckenrode, R.J. (1983). Near term improvements for nuclear power plant control room annunciator systems (NUREG/CR-3217). Washington, DC: Nuclear Regulatory Commission.

ABSTRACT

This report sets forth a basic design philosophy with its associated functional criteria and design principles for present-day, hard-wired nuclear power plant control room annunciator systems. It also presents a variety of annunciator design features that are either necessary for or useful to the implementation of the design philosophy. The information contained in this report is synthesized from an extensive literature review, from inspection and analysis of control room annunciator systems in the nuclear industry and in related industries, and from discussions with a variety of individuals who are knowledgeable about annunciator systems, nuclear plant control rooms, or both. This information should help licensees and license applicants in improving their hard-wired control room annunciator systems as outlined by NUREG-0700.

APPLICATION

This report is intended for dissemination of current literature which would be applicable in control room human factors engineering. This information is helpful in licensing applications and control room applications.

Replogle, J.O. (1983). Hand torque strength with cylindrical handles. Proceedings of the Human Factors Society - 27th Annual Meeting, 412-416.

ABSTRACT

The relationship between the diameter of a smooth cylindrical handle and the torque that can be applied by the human hand has been analyzed. An analytical model has been derived for the maximum force that can be developed before the hand slips on the handle. The model has been tentatively verified by the torque measurements on 20 subjects using a series of smooth cylinders ranging from .95 to 8.89 cm.

APPLICATION

The results of this study are useful to those interested in selecting handle diameter when used in a torque situation.

Risø National Laboratory (Eds.). (1982). An annotated list of publications on man-machine systems and reliability and risk analysis. Roskilde, Denmark: Author.

ABSTRACT

This bibliography presents information as to publications available in the man-machine area of process plants. Emphasis is placed on human factors in conjunction with reliability and safety.

APPLICATION

This bibliography is intended for use in the human factors and risk analysis associated with men-machine interfaces.

Roberts, K.H., & O'Reilly, C.A., III. Measuring organizational communication. Journal of Applied Psychology, 59, 321-326.

ABSTRACT

Past research on organizational communication has not included systematic development of a measurement method that can be used to compare dimensions of communication within and across organizations. This research reports on initial attempts to develop such instrumentation. Seven samples, with a total of over 1,200 respondents, were used to develop a 35-item questionnaire measuring 16 facets of communication.

APPLICATION

The dimensions of communication (amount of information, timeliness of information, withholding, redundancy, and gatekeeping) that are covered in the Roberts and O'Reilly questionnaire have applicability for nuclear power plant operations as well. The categories of communication problem areas could be used in designing a survey to assess nuclear power plant communications in a single plant or to compare across several plants.

Rodgers, S.H. & Eggleton, E.M. (Eds.). (1983). Ergonomic design for people at work. Belmont, CA: Lifetime Learning.

ABSTRACT

The book gives practical approaches for the solution to many design problems. It includes examples and case studies based on real experience. Chapters include: Workplace Design, Equipment Design, Information Transfer and Environment.

APPLICATION

People who are involved in workplace or equipment design, human factors engineering or related fields will find this book to be a practical and useful guide.

Rogovin, M., Frampton, G.T., Jr., Cornell, E.K., DeYoung, R.C., Budnitz, R., & Norry, P. (1980). Three Mile Island: A report to the commission and to the public (NUREG/CR-1250, Volume 1). Washington, DC: Nuclear Regulatory Commission.

ABSTRACT

This report presents the results of the investigation by the law firm of Rogovin, Stern, & Huge to review and report on the accident at Three Mile Island. The principal objectives of the inquiry were to determine what happened and why, to assess the actions of utility and NRC personnel before and during the accident, and to identify deficiencies in the system and areas where further investigation might be warranted. This first volume contains a narrative description of the accident and a discussion of the major conclusions and recommendations.

APPLICATION

This work was designed to enable the NRC to fulfill its regulatory responsibilities by achieving the fullest possible understanding of the accident, both from a technical point of view and from the standpoint of how the NRC's own regulatory processes functioned.

Rogovin, M., & Frampton, G.T., Jr. (1980). Three Mile Island: A report to the commissioners and to the public (NUREG/CR-1250, Volume 2). Washington, DC: Nuclear Regulatory Commission.

ABSTRACT

This report presents the results of the investigation by the law firm of Rogovin, Stern, & Huge to review and report on the accident at Three Mile Island. The principal objectives of the inquiry were to determine what happened and why, to assess the actions of utility and NRC personnel before and during the accident, and to identify deficiencies in the system and areas where further investigation might be warranted.

This second volume is divided into three parts. Part 1 focuses on the pre-accident licensing and regulatory background. Part 2 focuses on the technical description of the accident. Part 3 contains descriptions and assessments of responses to the accident by (1) the utility, (2) the NRC and (3) State and Federal agencies; an analysis of information provided to the media during the accident; and a study prepared for the Special Inquiry group on safety management factors germane to the accident.

APPLICATION

This work was designed to enable the NRC to fulfill its regulatory responsibilities by achieving the fullest possible understanding of the accident, both from a technical point of view and from the standpoint of how the NRC's own regulatory processes functioned.

Roscoe, B.J. (1984). Nuclear power plant alarm prioritization (NPPAP) program status report January 1, 1983 to September 31, 1983 (NUREG/CR-3684). Washington, DC: Nuclear Regulatory Commission.

ABSTRACT

This report describes the status of a research project directed toward nuclear power plant alarm prioritization. Criteria for modified alarm activation are being developed and studied. Also being developed are measures to regulate the alarm rate at some desired level. The problem of alarm prioritization based upon maintenance of critical safety functions while maintaining complete alarm coverage of accidents is being addressed. The plant information needed to support the associated technical development areas is being compiled for a specific plant, categorized, and entered into a computer data base. Near-term recommendations for regulatory action on plant annunciator systems are presented.

APPLICATION

This report discusses the application of a prioritization scheme for annunciator systems and the problems encountered. This information would be useful to engineers, operations personnel or human factors specialists designing or upgrading alarm systems.

Rossiter, D., & Skolnick, S. (1980). Computer systems interface guidelines for nuclear plants. Palo Alto, CA: Electric Power Research Institute, Nuclear Safety Analysis Center.

ABSTRACT

This report provides guidance and general recommendations for upgrading nuclear plant process computer installations to meet NRC data system requirements. Principal technical, procurement, and operational considerations are developed in a programmatic framework to facilitate system improvements. The scope of these considerations is directed toward present requirements, but also allows for technological advances and expansion in applications, as well as changing regulatory requirements which may occur in the future.

APPLICATION

These guidelines and recommendations would be of interest to anyone involved in upgrading nuclear power plant process systems, particularly computer installations.

Sabri, Z.A. (1980, April). Human factors in nuclear power plant operation. Paper presented at the American Nuclear Society Thermal Reactor Safety Meeting, Knoxville, TN.

ABSTRACT

An extensive effort is being devoted to developing a comprehensive human factors program that encompasses establishment of a data base for human error prediction using past operation experience in commercial nuclear power plants. Some of the main results of such an effort are reported, including data retrieval and classification systems which have been developed to assist in estimation of operator error rates. Also, statistical methods are developed to relate operator error data to reactor type, age, and specific technical design features. Results reported in this paper are based on an analysis of LERs covering a six-year period for LWRs. Developments presently include a computer data management program, statistical model, and detailed error taxonomy.

APPLICATION

This report is intended to aid in establishing a data base for predicting operator errors in commercial nuclear power plants.

Salvendy, G. (Ed.). (1984). Human-computer interaction: Proceedings of the first USA-Japan conference on human-computer interaction. New York: Elsevier.

ABSTRACT

This book consists of 72 papers which were presented at the USA-Japan conference on human-computer interaction. The objective of the conference was to consolidate knowledge within the fields of human factors and computers in order to exchange information and new developments. The topics covered ranged from conceptual and theoretical issues in human-computer interaction to speech synthesis and recognition with computer interfaces. Papers were presented in the following areas: taxonomies, standardization, and evaluation of human-computer interaction; software design and use; artificial intelligence; ergonomics; and stress, health-psychological issues and visual functions in relation to CRT display tasks.

APPLICATION

This book is relevant to the areas of human factors in relation to computers and productivity in real-world applications.

Samanta, P.K., Swoboda, A.L. & Hall, R.E. (1981). Sensitivity of risk parameters to human errors in reactor safety study for a PWR (NUREG/CR-1879). Washington, DC: Nuclear Regulatory Commission.

ABSTRACT

Sensitivities of the risk parameters, emergency safety system unavailabilities, accident sequence probabilities, release category probabilities and core melt probabilities were investigated for changes in the human error rates within the general methodological framework of the Reactor Safety Study for a Pressurized Water Reactor (PWR). Impact of individual human errors were assessed both in terms of their structural importance to core melt and reliability importance on core melt probability.

APPLICATION

A discussion of human error and its consequences is presented. This report is of particular interest to individuals involved with risk assessment and human reliability.

Sawyer, C.R., Pain, R.F., Van Cott, H.C. & Banks, W.W. (1982). Nuclear control room modifications and the role of transfer of training principles: A review of issues and research (NUREG/CR-2828; EGG-2211). Washington, DC: Nuclear Regulatory Commission.

ABSTRACT

This report addresses issues and research related to the implementation of NUREG-0700 — specifically, transfer of training considerations associated with control room modifications, retrofits, and general upgrades. The purpose of the effort was to identify literature and data which would indicate any specific negative effects of instrumentation and control board changes on operator performance, especially under high stress conditions. An exhaustive search revealed that no definitive applied studies in this area had been carried out. However, a review of the theoretical and human performance literature, with emphasis upon the generalizability of transfer of training studies to control room modification scenarios, led to the following conclusions: (1) a judicious and systematic application of human factors engineering design criteria will not degrade operator performance in nuclear control rooms; (2) the application of human engineering design criteria appears to enhance operational effectiveness, increase system safety, and allow operators greater ease and efficiency in system control and information extraction; (3) close adherence to human engineering design criteria during control room retrofit creates a greater degree of acceptance by operators and plant managers; and (4) certain design changes could lead to negative transfer of training effects for operators.

APPLICATION

This research examines the potential impact of control room modifications and retrofits on user acceptance and performance, particularly from the point of view of transfer-of-training.

Schueller, W.L., II. (1983). The effect of handle shape on grip fatigue in manual lifting. Proceedings of the Human Factors Society - 27th Annual Meeting, 417-422.

ABSTRACT

This study investigated the effect which various handle shapes produced on grip fatigue. This was measured through the calculation of a time to fatigue using a spectral analysis of the surface EMG of the grip muscles and through the determination of maximal pull forces in the upward direction. Significant differences existed between the handles in the maximum pull test, but not in the times to fatigue.

APPLICATION

The results of this study are useful to those interested in selecting handle shape when used in a pulling situation.

Schroeder, L.R. & Fowler, D.R. Human factors engineering design guidelines: H. Developed for use in the nuclear industry. Richland, WA: United Nuclear Industries and Rockwell International.

ABSTRACT

This document consists of more than 80 pages of checklists covering the following human engineering design considerations in a nuclear power plant control room: preliminary design, controls and displays, control/display integration, panel layout, grouping of panels, integrating workstations and systems, and systems and environment.

APPLICATION

These guidelines were developed for use in the nuclear industry for control room design reviews.

Seeman, S.E., Colley, R.W. & Stratton, R.C. (1983). Optimization of the man-machine interface for LMFBRs. Nuclear Safety, 24, 506-512.

ABSTRACT

An effort is underway to optimize the roles of man and machine in control of liquid-metal-cooled fast breeder reactors. The work reported here describes two systems: (1) MIDAS, presently in use, is a large data base system developed for the Fast Flux Test Facility (FFTF) as an aid to operators in determining how to proceed with maintenance and repairs on plant components, and (2) the Procedure Prompting System is being developed to demonstrate a new methodology for automatically generating instructions to aid plant recovery in off-normal conditions. Methodology for this system has been demonstrated on a model of a small subsystem of FFTF.

APPLICATION

Persons interested in optimizing the man-machine interface for LMFBRs may find this paper of use.

Seidenstein, S., Williams, A.R., Goddard, C.J. & Chesney, M. (SRI). (1981). Human factors review of electric power dispatch control centers (Report No. EPRI-EL-1960, Volumes 1-6). Palo Alto, CA: Electric Power Research Institute.

ABSTRACT

Human factors is a systems-oriented interdisciplinary specialty concerned with influencing the design of systems, equipment, facilities, and operational environments to promote effective system operations through emphasis on efficient and reliable operator performance. Phase I of this project evaluated a sample of 13 contemporary electric power control centers by conducting site surveys; these surveys included checklists, guided interviews, photography, direct physical measurement, and technical discussions with operators, management, and supervisory personnel at each site.

The project evaluated the information available to the operator and the physical interface between the operator and power systems, as well as the operational setting in which tasks are performed. Guidelines for the application of human factors principles are given where applicable. Particular attention was given to the design of the cathode ray tube (CRT) interface, the data base, facility lighting, training, manning, and work stress. Several potential areas for further study are identified.

Subsequent phases of this project will study system operator information requirements and information interfaces between the operator and the system.

The results of this research project are presented in EL-1960, a six-volume report entitled Human Factors Review of Electric Power Dispatch Control Centers. The six volumes are:

- Volume 1: Survey Results Summary
- Volume 2: Detailed Survey Results
- Volume 3: Operator Information Needs Summary
- Volume 4: Operator Information Needs
- Volume 5: Information Management and Presentation Summary
- Volume 6: Information Management and Presentation.

APPLICATION

This project evaluated the information available to the operator and the physical interface between the operator and power systems, as well as the operational setting in which tasks are performed.

Selway, R.J., Jr. (1984, April). Quality circles in action. Paper presented at the Institute of Nuclear Power Operations Maintenance Superintendents Workshop, Altanta, GA.

ABSTRACT

Baltimore Gas & Electric's Performance Improvement Process has three components: measurement, accountability, and participation. The first two components use traditional approaches, such as performance indicators, work measurement, and operational audits. The third component, participation, besides using such approaches as suggestion systems and training programs, also employs quality circles, a structure and process for involving employees in the improvement process of work-related problems.

APPLICATION

This paper could be used as a reference document for nuclear facilities designing a formal employee performance improvement plan. It presents guidelines for developing and implementing quality circles.

Seminara, J. (1982). Human factors methods for assessing and enhancing power plant maintainability (Report No. EPRI NP-2360). Palo Alto, CA: Electric Power Research Institute.

ABSTRACT

This study — a follow-on effort to NP-1567, a human factors review of nine power plants with respect to maintainability — provides data-gathering tools for use by utilities in reviews of their own plants. These tools, which are applicable to both nuclear and fossil fuel plants, include an illustrated checklist; a structured interview; task analysis formats; communications, illumination, and safety surveys; and potential accident and damage analyses. Enhancement opportunities and strategies are discussed.

APPLICATION

The topics covered by this report can help anyone involved in assessing control room maintainability by standardizing interview methods and organizing actual reviews.

Seminara, J.L., Eckert, S.K., Seidenstein, S., Gonzalez, W.R., Stempson, R.L. & Parsons, S.O. (1979). Human factors methods for nuclear control room design (Report No. EPRI NP-1118-SY). Palo Alto, CA: Electric Power Research Institute.

ABSTRACT

The final report of this study is published in four volumes with this volume being the summary. In the study, human factors approaches were applied in the design of representative nuclear power plant control panels. First, methods for upgrading existing operational control panels were examined. Then, based on detailed human factors analyses of operator information and control requirements, design of reactor, feedwater, and turbine-generator control panels were developed to improve the operator-control board interface, thereby reducing the potential for operator errors.

APPLICATION

This summary report will be of interest to anyone involved in control room design or in operator performance. The full report will be of interest to anyone deeply involved in the design of power plant control rooms. Designers of other types of control rooms, such as dispatch centers or process plants, may also benefit from the report.

Seminara, J.L., Gonzalez, W.R. & Parsons, S.O. (1976). Human factors review of nuclear power plant control room design (Report No. EPRI NP-309). Palo Alto, CA: Electric Power Research Institute.

ABSTRACT

Human factors engineering is an interdisciplinary specialty concerned with influencing the design of equipment systems, facilities, and operational environments to promote safe, efficient, and reliable operator performance. The human factors aspects of five representative nuclear power plant control rooms were evaluated using such methods as a checklist-guided observation system, structured interviews with operators and trainers, direct observations of operator behavior, task analyses and procedure evaluation, and historical error analyses. The human factors aspects of design practices are illustrated, and many improvements in current practices are suggested. The study recommends that a detailed set of applicable human factors standards be developed to stimulate a uniform and systematic concern for human factors in design considerations.

APPLICATION

Designers interested in applying human factors considerations to control rooms would find this report of use.

Seminara, J.L. & Pack, R.W. (1982). Communication needs of the nuclear power plant operator. IEEE Transactions on Power Apparatus and Systems, PAS-101, 792-796.

ABSTRACT

Nuclear power plant operators and trainers were interviewed to examine human factors considerations associated with control room operation. One part of this review dealt with communications. Over 80 percent of the interview sample reported problems and frustrations with existing communication systems. The nature of the problems uncovered and future research needs are the subjects of this paper.

APPLICATION

This paper analyzes the communication problems within a nuclear power plant as taken from interviews.

Seminara, J.L. & Parsons, S.O. (1979). Human factors methods for nuclear control room design. Volume 2: Human factors survey of control room design practices (Report No. EPRI NP-1118). Palo Alto, CA: Electric Power Research Institute.

ABSTRACT

The final report of this study is published in four volumes with this volume devoted to a description of the human factors survey of control board design practices. Special attention is given to warning system designs. Twenty board designers from a mix of architect-engineering and Nuclear Steam Supply Systems firms were surveyed. The study concludes that there is an urgent need for a human factors engineering design guide tailored to the special demands of the utility industry. Also, there is a need for a human factors standard which utilities could use in specifying, developing, or evaluating new control room designs.

APPLICATION

The use of human factors in the design of power plant control rooms shown in the report can be applied to operating power plants, as well as to those in the design stage.

Seminara, J.L., Parsons, S.O., Schmidtt, W.J., Gonzalez, W.R. & Dove, L.E. (1980). Human factors review of power plant maintainability (Report No. NP-1567-SY). Palo Alto, CA: Electric Power Research Institute.

ABSTRACT

The human factors aspects of five nuclear power plants and four fossil fuel plants were evaluated using such methods as a checklist-guided observation system, structured interviews with maintenance personnel, direct observations of maintenance tasks, reviews of procedures, and analyses of maintenance errors or accidents by means of the "critical incident" technique. The study recommends that a more systematic and formal approach be adopted to ensure that future power plants are "human engineered" to the needs of maintenance personnel. Design guidelines and standards are urgently required to guide the development of new power plants and to upgrade existing plants. Such guidelines and standards should be predicated on existing human factors data supplemented by future research directed at solving problems unique to the power industry.

APPLICATION

This report highlights many of the "special" human engineering problems encountered by maintenance personnel. It provides a realistic perspective on the influence of human engineering on equipment maintainability. It is a good source document for personnel or departments anticipating upgrading in-plant systems/equipment or installing new devices.

Seminara, J.L., Seidenstein, S., Eckert, S.K. & Smith, D.L. (1979). Human factors methods for nuclear control room design. Volume 1: Human factors enhancement of existing nuclear control rooms (Report No. EPRI NP-1118). Palo Alto, CA: Electric Power Research Institute.

ABSTRACT

The final report of this study is published in segments. This volume of the final report deals with those measures that should be considered in upgrading existing operational or near-operational control rooms from the human factors standpoint. The recommendations offered in this report assume that power generation will not be interrupted to accomplish the remedial measures advanced.

APPLICATION

This report demonstrates the use of human factors in the design of power plant control rooms. The approaches shown in the report can be applied to operating power plants, as well as to those in the design stage.

Shackel, B. (Ed.).(1978). Applied ergonomics handbook (5th ed.). Surrey, England: IPC.

ABSTRACT

Industry requires man-plus-machine to be an efficient production unit. Ergonomics can help in the design or process of a product, and with general working conditions. This book emphasizes factors that affect people in industry, and provides a summary of important European ergonomics research.

APPLICATION

People who are involved in industrial workplace or equipment design should find this a helpful guide. This book covers various areas such as displays, noise, and lighting.

Shea, D.J., Jr. (1981, October). Analytical techniques for creating a job design basis for a nuclear power plant operating crew. Paper presented at CSNI Specialist Meeting on Operator Training and Qualifications, Charlotte, NC.

ABSTRACT

This paper attempts to give some direction to answering two questions:

1. How are the operational needs of a plant defined?
2. Once defined, how are the operational needs of a plant allocated to the human, to an automatic function, or to both?

The methodology involves comparing three current system analysis procedures —Meister's determination of system requirements and functions, the suggestions of the NRC in NUREG-0659 Appendix B, and a System Operability Assessment Review Project currently being conduted on a PWR — and combining the best features of each approach.

APPLICATION

The primary thrust of this paper is to make a case for Job Design and to suggest analytical techniques for doing it. The paper is addressed to an audience concerned with either operational plants or plants whose design is nearly complete.

Sheehy, E.J. (1983). A nuclear safety basis for assigning priorities to human engineering concerns at nuclear power plants. Proceedings of the Human Factors Society - 27th Annual Meeting, 1, 180-183.

ABSTRACT

While it is generally agreed that safety-related discrepancies should receive first priority, it is not at all clear just what "safety-related" means when considered in an operational sense. This paper describes the current state of evolving standard definitions for hardware-oriented safety features. It discusses how these definitions could be expanded to include operationally related considerations and explores some benefits which would ensue. These include (1) establishing a nuclear safety basis which can be used in establishing priorities for resolution of human engineering concerns, and (2) obtaining legal recognition of operational concerns in general in the design and licensing arenas.

APPLICATION

This document could be useful to persons involved in evaluation of human engineering problems. Discussion exists on the meaning of "safety-related" in terms of equipment or systems.

Sheridan, T.B. (1980, February). Human error in nuclear power plants. Technology Review, 23-33.

ABSTRACT

This report discusses the dilemma of coping with human error. Nuclear power, commercial aviation and office operations of all kinds are becoming more automated to circumvent the human operator. No complex systems where human lives or large amounts of capital are at risk can be allowed to run completely by itself; somewhere there is a human operator to control and monitor and take over in case of emergency. It also discusses human reliability versus machine reliability. Finally it suggests that the computer offers a way to help the operator.

APPLICATION

Those interested in human error and ways of reducing it will find this paper of use.

Sheridan, T.B. & Johannsen, G. (Eds.). (1976). Monitoring behavior and supervisory control. New York: Plenum Press.

ABSTRACT

This book includes all papers presented at the International Symposium on Monitoring Behavior and Supervisory Control of March 1976. The papers are organized into three sections: man-vehicle control, general models, and process control. Following these three sections of papers are brief reports of four workshops which were held in conjunction with the symposium.

APPLICATION

This book is a useful reference for those interested in defining the problems in man-machine situations, and toward meeting engineering needs.

Shives, T.R. & Willard, W.A. (Eds.).(1981, April). Innovation for maintenance technology improvements: Proceedings of the 33rd meeting of the mechanical failures prevention group. Gaithersburg, MD: National Bureau of Standards.

ABSTRACT

These proceedings consist of a group of 34 submitted entries (32 papers and 2 abstracts) from the 33rd meeting of the Mechanical Failres Prevention Group which was held at the National Bureau of Standards, Gaithersburg, Maryland, April 21-23, 1981. The subject of the symposium was maintenance technology improvement through innovation. Areas of special emphasis included maintenance concepts, maintenance analysis systems, improved maintenance processes, innovative maintenance diagnostics and maintenance indicators, and technology improvements for power plant applications.

APPLICATION

These papers would be of use to anyone interested in maintenance technology and prevention of mechanical failures in particular.

Siegel, A.I., Bartter, W.D. & Kopstein, F.F. (1982). Job analysis of maintenance mechanic position for the nuclear power plant maintenance personnel reliability model (NUREG/CR-2670). Washington, DC: Nuclear Regulatory Commission.

ABSTRACT

An analysis was performed of the job of maintenance mechanics in nuclear power plants in order to provide a part of the information required for modeling nuclear plant maintenance activities. It is believed that such a model would provide substantial insights into the various human, equipment, and environmental factors that are likely to affect reliability of maintenance personnel, and thereby suggest and allow evaluation of standards, design changes or other modifications to improve reliability and minimize public risk.

The work yielded a diversity of information relative to the job of the maintenance mechanic in nuclear power plants. The information obtained will be used to develop the logic and content of a model for quantitatively assessing the activities of maintenance personnel, especially from the point of view of public safety.

APPLICATION

This paper provides the necessary information for those interested in a maintenance personnel reliability model. Many implications are given in the executive summary.

Siegel, A.I., Bartter, W.D., Wolf, J.J., Knee, H.E. & Haas, P.M. (1983). Front-end analysis for the nuclear power plant maintenance personnel reliability model (NUREG/CR-2669). Washington, DC: Nuclear Regulatory Commission.

ABSTRACT

The front-end analysis performed for the nuclear power plant maintenance personnel reliability modeling program consisted of three primary tasks which are addressed within this report. The first of these was a front-end user survey which investigated the need for and potential content of a structured methodology for nuclear power plant maintenance. The second task was a literature review of existing human behavioral methodologies and an assessment of their applicability for this program. The third task was the development of a comprehensive program plan for the maintenance reliability model.

Results of these tasks indicated that a computerized model would be very useful and that the type of methodology to be developed should be of the simulation type. This report also provides a 35-month program plan for its development.

APPLICATION

A description of a front-end analysis for a maintenance personnel reliability modeling program is contained in this report. This information plus the 35-month program plan for the analysis development would be useful to persons interested or involved in maintenance front-end analysis.

Siegel, A.I., Federman, P.J. & Burkett, J.R. (1974). Increasing and evaluating the readability of Air Force written materials (Report No. AFHRL-TR-74-28). Lowry AFB, CO: Air Force Human Resource Laboratory. (NTIS No. AD 786-820)

ABSTRACT

This report describes how to apply techniques that have been used in measuring the readability/comprehensibility and reading level of textual materials. Instructions are provided in a step-by-step fashion for determining the reading level of written material and for presenting subject matter material through methods rather than prose. The report also explains the procedures in the appendices for various readability technique analyses.

APPLICATION

This manual is intended to serve as a source document for use by Air Force training and development personnel, as well as others who prepare reading material for the Air Force. The principles outlined could be useful to individuals involved with preparation of written materials.

Siegel, A.I., Lambert, J.V. & Burkett, J.R. (1974). Techniques for making written material more readable/comprehensible (Report No. AFHRL-TR-74-47). Lowry AFB, CO: Air Force Human Resource Laboratory. (NTIS No. AD 786 849)

ABSTRACT

This technical memorandum presents an outline of how to apply psycholinguistic and intellective concepts to enhance the readability and comprehensibility of written materials. Guidelines for making the reader's task easier are provided, and some readability measurement procedures are also discussed.

APPLICATION

This material may be useful to persons involved in procedures upgrades, procedure development or manual preparation.

Smidt, D. (1980, November). Human error: An essential problem of nuclear power plants. Paper presented at the 7th Annual PNS Colloquium, Karlsruhe, F.R. Germany.

ABSTRACT

The author defines the part played by man in the nuclear power plant. The discussion of tactical errors and their avoidance is followed by a report on the actual state of plant technology and possible improvements. Subsequently a study of the strategic errors stemming from the interaction between plant and man, personnel selection, and education is made.

APPLICATION

If the interaction between man and machine is designed with the physiological strengths and weaknesses of man taken into account, human errors will not be essential problems in nuclear power plants.

Speaker, D.M., Thompson, S.R., & Luckas, W.J., Jr. (1982). Identification and analysis of human errors underlying pump and valve related events reported by nuclear power plant licensees (NUREG/CR-2417). Washington, DC: Nuclear Regulatory Commission.

ABSTRACT

This report provides a useful and adaptable data base of human error associated with the operation, testing, and maintenance of reactor safety system pumps and valves in licensed nuclear power plants. To produce this data base, a practical and workable methodology was developed and implemented on more than 3,000 Licensee Event Reports (LERs) which resulted in a human error data base six times larger than indicated by the LERs themselves. This data base is intended to provide a realistic assessment of the appropriate human error populations required in NUREG/CR-1880.

APPLICATION

This report provides a data base which is associated with the operation, testing, maintenance reliability, and valves in nuclear reactor safety system pumps.

Staff. (1969, May). Annunciator Review. Instruments & Control Systems, 69.

ABSTRACT

This article provides a synopsis of various annunciators on the market today. A brief overview of annunciator functions and applications is provided. The review examines 39 manufacturers and the applications in which various combinations of interface may be used.

APPLICATION

The review is intended for use in situations where monitoring of a condition is necessary.

Stewart, C. (1981). The probability of human error in selected nuclear maintenance tasks (Report No. EEC-SSDC-5580). Washington, DC: Nuclear Regulatory Commission.

ABSTRACT

This is an informal, preliminary report of a study that used a refined survey technique to collect human error data on nuclear reactor maintenance. The objectives of the study were to test a technique for collecting sensitive human error data in such a way that it can be used for statistical calculations of probability. This type of data is useful in engineering design, human engineering, and fault tree analysis during research and development and during assessment of operational systems. Although results of this survey are preliminary, the response rate and quality of returns are sufficiently high to encourage further development and use of the technique.

APPLICATION

The survey technique reported here is especially applicable to the collection of human error data in process control and maintenance operations. Such data can be difficult to acquire in an objective, systematic, and complete fashion, so that they are useful for statistical data processing. This technique apparently overcomes those obstacles.

Stewart, C. (1981). Reactor operator adaptation to design change (Report No. EGG-SSDS-5644). Washington, DC: Nuclear Regulatory Commission.

ABSTRACT

This report reviews the learning theory concepts of stimulus-response and negative transfer and describes how they may be used to explain potential reactor operator performance problems following control room design modification. Reactor operator adaptation as a potential problem was identified as the tempo increased for control room review and modification during 1979-1980, as a response to the Three Mile Island incident.

APPLICATION

This report will be of use to anyone concerned with operator performance/training after control room design review and modification.

Stewart, C. (1982). Human reliability and fault tree analysis. Proceedings of the Human Factors Society - 26th Annual Meeting, 664-667.

ABSTRACT

A method was developed to collect data on human reliability as an adjunct to fault tree analysis. The need for these data, the method used for data collection, and the utility of quantified data for design support are described. Recommendations are made for research to raise the sample size and validate the estimates.

APPLICATION

This survey technique is feasible for use in research and development, and in system evaluation. It can be used to identify problems and place them into perspective. It can also be used to compare systems (different systems or the same systems, before and after modification).

Stilwell, W.G., Seaver, D.A. & Schwartz, J.P. (1982). Expert estimation of human error probabilities in nuclear power plant operations: A review of probability assessment and scaling (NUREG/CR-2255). Washington, DC: Nuclear Regulatory Commission.

ABSTRACT

This report reviews probability assessment and psychological scaling techniques that could be used to estimate human error probabilities (HEPs) in nuclear power plant operations. The techniques rely on expert opinion and can be used to estimate HEPs where data do not exist or are inadequate. These techniques have been used in various other contexts and have been shown to produce reasonably accurate probabilities. Some problems do exist, and limitations are discussed. Additional topics covered include methods for combining estimates from multiple experts, the effects of training on probability estimates, and some ideas on structuring the relationship between performance shaping factors and HEPs. Preliminary recommendations are provided along with cautions regarding the costs of implementing the recommendations. Additional research is required before definitive recommendations can be made.

APPLICATION

This information would be useful to persons interested in predicting human error probability or human reliability. The report discusses techniques for probability assessments and psychological scaling.

Straker, E.A. (1981). Verification and validation for safety-parameter display systems (Report No. EPRI-NSAC-39). Palo Alto, CA: Electric Power Research Institute.

ABSTRACT

This report defines a level of verification and validation which is appropriate for a Safety Parameter Display System (SPDS). Specific verification and validation activities are defined. The expected results of each activity are identified by indicating typical contents of documents that would be produced.

APPLICATION

This report provides information which can be used by utilities or vendors to develop verification and validation procedures, plans, and activities for SPDS application.

Swain, A.D. (1980). Human factors in nuclear power plant operations (Contract No. AC04-76DP00789). Albuquerque, NM: Sandia National Laboratory.

ABSTRACT

This report describes some of the human factors problems in nuclear power plants and the technology that can be employed to reduce those problems. Many of the changes to improve the human factors in existing plants are inexpensive, and the expected gain in human reliability is substantial. The human factors technology is well-established and there are practitioners in most countries that have nuclear power plants.

APPLICATION

This report demonstrates the use of human factors technology to reduce reliability problems in the design of nuclear power plants.

Swain, A.D. & Guttman, H.E. (1980). Handbook of human reliability analysis with emphasis on nuclear power plant applications (NUREG/CR-1278). Washington, DC: Nuclear Regulatory Commission.

ABSTRACT

The purpose of this handbook is to aid qualified persons in evaluating the effects of human error on the availability of engineered safety features and systems in nuclear power plants. The handbook expands the human error analysis presented in WASH-1400 and includes principles of human behavior and ergonomics, analytical procedures, mathematical models, and human error probabilities derived from related performance measures and experience.

APPLICATION

The derived probabilities should be adequate to determine the relative merits of different configurations of equipment, procedures, and operating practices within a plant and for gross comparisons among plants.

Taylor, D.F., & Voss, T.J. (1981). A pilot evaluation of three alternative formats for emergency control room procedures. Transactions of the American Nuclear Society, 43, 235-236.

ABSTRACT

The format of control room procedures is one aspect of procedure utility that can affect the capability of operators to diagnose and manage abnormal transients. Procedure utility refers to the usability and acceptability of the procedures to the operator. This paper describes an effort to define operationally the utility of procedure formats and to establish the relative utility of several proposed formats.

APPLICATION

Information is presented about performance differences using different formats. This data could be of interest to individuals developing documentation such as procedures.

Tiesenhausen, G.V. (1982). An approach toward function allocation between humans and machines in space station activities (NASA Report No. TM-82510). Washington, DC: National Aeronautics and Space Administration.

ABSTRACT

Present NASA and contractor studies are evolving toward the definition of a future manned permanent space station. This report attempts to provide certain basic guidelines and data to assist in the allocation of functions between humans and automated systems and for human/machine participation. The report describes the significant human capabilities and limitations and provides criteria and guidelines for various levels of automation and human participation. An appendix contains a collection of human factors data.

APPLICATION

This report may be helpful to engineers and other personnel making decisions concerning the allocation of tasks to humans or machines.

Tillitt, D.N., Petersen, R.J., & Smith, R.L. (1982). Performance and design requirements for a graphics display research facility (NUREG/CR-2711). Washington, DC: Nuclear Regulatory Commission.

ABSTRACT

Performance and design requirements for a Graphics Display Research Facility (GDRF) are presented. The GDRF is an evolutionary, computer-based, human-engineering experimentation center that is specifically designed to address long-term research issues associated with automation, human performance, and risk in the operation of nuclear facilities. It is expected that the GDRF will meet future human-engineering research needs in a more timely and cost-effective manner than is possible under current conditions.

This report discusses the requirements, specifications, and implementation considerations for the facility; the necessary hardware, software, and personnel capabilities; and the potential costs of construction and operation for various levels of research activity.

APPLICATION

Research capabilities provided by the GDRF will directly support the licensing and regulation of nuclear facilities within the U.S. The ultimate goal of this research is to support regulatory directives for minimizing the risk of human error in the operation of nuclear facilities.

Topmiller, D.A., Burgy, D.C., Roth, D.R., Doyle, P.A. & Espey, J.J., Jr. (1981). Survey and analysis of communciations problems in nuclear power plants (Report No. EPRI NP-2035). Palo Alto, CA: Electric Power Research Institute.

ABSTRACT

This report presents the results of a Technical Planning Study performed to investigate communications problems in nuclear power plants. Four operating power plants were surveyed by a research team comprised of human factors, operations, and engineering personnel. Specific problems identified were that (1) existing systems cannot handle high communications demand due to outmoded or incompatible equipment, (2) communications systems lack centralization, (3) high signal density and multiple messages result in confusion and failure to process signals, (4) noise levels in both the control room and other plant areas reduce speech intelligibility, and (5) communications procedures are not well developed and are not utilized to their best advantage.

APPLICATION

Even though the primary purpose of this study is to furnish a point of departure for the conduct of future research, the specificity and nature of the findings should be of interest to design organizations and plant managers.

Topmiller, D.A., Eckel, J.S., & Kozinsky, E.J. (1982). Human reliability data bank for nuclear power plant operation. Volume 1: A review of existing human reliability data banks (NUREG/CR-2744). Washington, DC: Nuclear Regulatory Commission.

ABSTRACT

This report describes a survey and comparative analysis of previous and current attempts to quantify and predict human operator and maintainer performance as a function of design, training, procedural, or situational factors. An assessment was made of these methods and techniques as to their potential applicability to PRA and as a supplement to the data and procedures in NUREG/CR-1278.

APPLICATION

This report provides information needed to implement a data bank for human reliability procedures. The review of previously established data banks ensures the reader has various options to choose from.

Toto, G., & Lindgren, A.J. (1981). An independent safety assessment of Department of Energy nuclear reactor facilities procedures, operations and maintenance (Report No. DOE/US-008). Washington, DC: Department of Energy.

ABSTRACT

The 1979 accident at the Three Mile Island commercial nuclear power plant led to a number of studies of nuclear reactors, in both the public and private sectors. One of these is that of the Department of Energy's (DOE) Nuclear Facilities Personnel Qualification and Training (NFPQT) Committee, which has outlined tasks for assessment of 13 reactors owned by DOE and operated by contractors. This report covers one of the tasks, the assessment of procedures, operations, and maintenance at the DOE reactor facilities, based on a review of actual documents used at the reactor sites.

APPLICATION

A reasonable profile of procedure characteristics is derived from a comprehensive list of documents in use at the DOE reactor sites. Characteristics of a well-operated plant are produced from a review of industry standards and guidance.

Turner, J.A. & Karasek, R.A., Jr. (1983). Software ergonomics: Effects of computer application design parameters on operator task performance and health. Ergonomics, 27, 663-690.

ABSTRACT

Evidence is reviewed that the operating characteristics of computer application systems, in addition to physical characteristics of display units (CRTs), are the cause of many observed effects on operator health and task effectiveness. These effects are hypothesized to occur through changes in task structure, and the man-machine redivision of labor that results when computer application systems are introduced into the work setting. First, the association between task dimensions and models of operator performance effectiveness and well-being are reviewed. Second, application system design parameters that affect task structure are identified. Then, empirical evidence supporting this three-part causal linkage — application system parameters to task characteristics to operator effectiveness and health — is presented. The findings suggest that by improving dialogue quality, taking advantage of two-way communication to reduce uncertainty, using smaller and less integrated systems and matching system performance to operator needs, a job can be created that is likely to improve both operator well-being and effectiveness.

APPLICATION

Since display units (CRTs) are becoming a part of many jobs today, this paper is a useful guide to some of their observed effects on operator health and task effectiveness.

U.S.A. Standards Institute. (1960). Method for measurement of monosyllabic word intelligibility (USAS S3.2-1960). New York: Author.

ABSTRACT

This report is intended to describe the procedures to be followed in conducting intelligibility tests which employ monosyllabic word lists. The test is intended to provide a yardstick or baseline for the measurement of identification of spoken words over communication systems.

APPLICATION

This report provides information on standards associated with intelligiblity of communications over various amplification systems. This test can be used to check speech intelligibility over various communication devices.

Van Cott, H.P., & Kinkade, R.G. (Eds). (1972). Human engineering guide to equipment design (rev. ed.). Washington, DC: U.S. Government Printing Office.

ABSTRACT

The primary purpose of this book is to provide a guide in human engineering which the designer can use in the same manner as handbooks in other areas to assist in solving design problems as they arise. It provides in a single volume authoritative data, principles, design practices, and a comprehensive bibliography.

APPLICATION

This guide will be a useful reference that will assist individuals in identifying and resolving HFE problems, and in determining what is important at various design stages.

Vesely, W.E., Davis, T.C., & Saltos, N. (1983). Measures of the risk impacts of testing and maintenance activities (NUREG/CR-3541). Washington, DC: Nuclear Regulatory Commission.

ABSTRACT

This report is a companion to the previous report, Measures of Risk Importance and Their Applications: NUREG/CR-3385. This report focuses on quantifying the importance of online tests, maintenances, and repairs in controlling the risk. The importance measures which are defined are applied to evaluate the corrective and preventative benefits of online testing, maintenance, and repair. The corrective and preventative benefits are measured in terms of the impacts in risk which result. The corrective value of a repair or unscheduled maintenance action is termed the restoration worth of the action and is defined to be the reduction in risk which results from restoring a failed component or system. The preventative value of a test or maintenance action is termed the expected worth of the action and is defined to be the expected risk reduction from performing the action. There is a great deal of information obtainable from these kinds of measures which can be simply calculated in any PRA and enhance the usefulness of the PRA. If there is a general message from this work regarding risk assurance programs and inspection programs it is on the usefulness of risk analysis techniques in these programs. To be most effective with regard to risk control, inspection programs and risk assurance programs directed at testing and maintenance should be guided by the risk impacts of the test or maintenance.

APPLICATION

This report discusses preventative and corrective maintenance. Testing (including online) and repair are also covered. These factors are reviewed in relation to risk analysis. This material would be of interest to individuals involved with risk assurance programs and risk control inspection programs.

von Herrmann, J.L. (1983). Methods for review and evaluation of emergency procedure guidelines. Volume I: Methodologies (NUREG/CR-3177). Washington, DC: Nuclear Regulatory Commission.

von Herrmann, J.L., Brinsfield, W.A., & Brown, R.G. (1983). Methods for review and evaluation of emergency procedure guidelines. Volume II: Application to Westinghouse plants (NUREG/CR-3177, EGG-2243). Washington, DC: Nuclear Regulatory Commission.

Brinsfield, W.A., Burns, E.T., McClymont, A.S., Mays, S.E., & von Herrmann, J.L. (1983). Methods for review and evaluation of emergency procedure guidelines. Volume III: Application to General Electric plants (NUREG/CR-3177, EGG-2243). Washington, DC: Nuclear Regulatory Commission.

ABSTRACT

Systematic methods for reviewing and evaluating emergency procedure guidelines are presented. The deficiencies of existing "event-oriented" emergency procedures are discussed and the industry efforts to produce improved guidelines in the aftermath of Three Mile Island (TMI) are summarized. It is concluded that the function- or system-oriented approaches which have evolved since TMI have, in theory, the potential to produce effective guidelines. Methods for systematically examining potential accident sequences using "operator action event trees" are developed in this first volume which can help ensure that functional or symptomatic guidance can, in reality, lead to unambiguous and effective diagnosis and response regardless of the specific failure events.

In Volumes II and III, the methodology from Volume I was applied to Westinghouse and General Electric plants respectively. Information for these two cases are detailed within the respective volumes.

APPLICATION

This information is useful to organizations upgrading procedures or developing symptom-based procedures. Discussion is provided on the "symptoms" approach. Two volumes specifically address Westinghouse and General Electric plants.

Voss, T.J. (1983). Lessons learned from a control room improvement project. Transactions of the American Nuclear Society, 44, 171.

ABSTRACT

The purpose of this project was to resolve problems identified by the U.S. Nuclear Regulatory Commission in a prelicensing audit. The major control room improvements involved: relocating 200 controls or displays; rearranging, color coding, and engraving 1100 annunciators; rewriting and engraving almost 5000 labels; applying demarcation and summary labeling; and improving lighting. Numerous other changes were made.

APPLICATION

Persons interested in a control room improvement project may find this brief paper of use.

Voss, T.J., Talley, W.T., & Baker, C.C. (1983). Interpreting guidelines for nuclear power plant control rooms. Proceedings of the Human Factors Society - 27th Annual Meeting, 1, 20-22.

ABSTRACT

If human factors guidelines are not carefully interpreted and applied, control room projects can be degraded. Evaluation guidelines can be misleading when used for designing control room improvements. Guidelines identify what may be adequate, but not the best solutions. The quality of an improvement project depends upon finding the best feasible solution for each problem. Therefore, reliance should be placed not merely on NUREG guidance, but rather upon the larger body of human factors literature.

APPLICATION

The guidelines for control room design review are helpful up to a point at which looking at other human factors literature will prove invaluable.

Wait, H.J., & Manning, M.W. (1980). Design concepts for independent central alarm station and secondary alarm station intrusion detection systems (NUREG/CR-1468). Washington, DC: Nuclear Regulatory Commission.

ABSTRACT

Fixed-site nuclear facilities are required to have a continuously manned Central Alarm Station (CAS) and Secondary Alarm Station (SAS). All security alarms are required to annunciate at each alarm station such that a single act cannot remove the capability of calling for assistance. This report reviews various types of intrusion detectors, signal transmission methods and receiver units relative to establishing the required intrusion alarm system's independence and redundancy.

APPLICATION

This planning document is a reference guide for establishing independent intrusion alarm annunciator systems for the Central Alarm Station (CAS) and Secondary Alarm Station (SAS) at fixed-site nuclear facilities.

Ward, J.S. (1984). Women at work - ergonomic considerations. Ergonomics, 27, 475-480.

ABSTRACT

This paper explores the ergonomic implications for women at work of the provisions contained within the Health and Safety at Work Act of 1974, with particular reference to the design and maintenance of equipment, lifting and carrying tasks, training and supervision, access to the workplace and the working environment.

APPLICATION

Given the increasing number of women in the work force, and their differences in body size, muscle strength and visual and auditory acuity from men, this article gives a general background for ergonomic considerations for women at work.

Webb Associates (Eds.). (1978). Anthropometric source book. Volume I: Anthropometry for designers. Volume II: A handbook of anthropometric data. Volume III: Annonated bibliography of anthropometry (NASA Reference Publication 1024). Washington, DC: National Aeronautics and Space Administration.

ABSTRACT

The anthropometric source book is designed to provide NASA, NASA contractors, the aerospace industry, Government agencies, and a wide variety of industriel users in the civilian sector with a comprehensive, up-to-date tabulation of anthropometric data. Specifically, it is tailored to meet the needs of engineers engaged in the design of equipment, habitability areas, workspace layouts, life-support hardware, and clothing for the NASA Space Shuttle/Spacelab program. The intent is to provide the designer not only with dimensional data but with underlying anthropometric concepts and their application to design.

Volume I is a nine-chapter treatment covering all basic areas of anthropometry and its application to the design of clothing, equipment and workspaces.

Volume II summarizes the results from anthropometric suverys of 61 military and civilian populations of both sexes from the United States, Europe, and Asia.

Volume III lists 236 annotated references related to the field of anthropometry.

APPLICATION

One of the most comprehensive collections of anthropometric data is contained within this three-volume series. These materials are useful to the designer or human factors specialist interested in body dimensions. In addition, Volume II contains data on European and Asian populations.

Weiss, C. (1983). Use of panel enhancements as operator aids in nuclear power plant control rooms. Proceedings of the Human Factors Society - 27th Annual Meeting, 1, 89-92.

ABSTRACT

Topical panel enhancement techniques were designed and implemented for one nuclear power plant control room. Panel enhancements designed and implemented effectively can be good operator aids for the searching and identifying of plant instrumentation, and in the processing of information.

APPLICATION

This paper discusses the purpose of providing operator aids through topical panel enhancements, and the constraints and methodology used in designing and implementing three panel enhancemnt techniques.

Woodson, W.E. (1981). Human factors design handbook. New York: McGraw-Hill.

ABSTRACT

This handbook is designed to provide a general reference to key human factors questions and human-product interface design suggestions in a form that engineers and designers can utilize with a minimum of searching or studying.

APPLICATION

This can be used as a handbook reference for data and guidelines on human factors engineering. The information is applications-oriented rather than theoretical or tutorial.

Wright, P. (1977). Presenting technical information: A survey of research findings. Instructional Science, 6, 93-134.

ABSTRACT

This paper reviews research investigations into various aspects of the presentation of technical information. It considers the objectives of different readers who may be consulting the information as a reference work or who may need to assimilate the information in its entirety. Ways of using headings, summaries and questions to achieve these differing objectives are discussed. The review also considers the usefulness of alternatives to prose, such as flowcharts, tabulation schemes and graphic presentations. It is concluded that although there is no single "best" presentation format, and although the research literature is in many places incomplete, nevertheless there are a number of studies demonstrating the advantages of particular presentation formats in specific circumstances. The results of these studies need to be given due weighting where decisions are taken about the appropriate way of presenting any technical information.

APPLICATION

This article provides excellent information on different methods for presenting information to the reader. Major topics include: a) the needs of different readers, b) the value of headings, c) use of flowcharts, tables and graphs, d) use of illustration, e) writing prose so that it can be understood, and f) presenting information so that it can be remembered. This is an exellect article for anyone contemplating writing procedures, instructions or manuals.

Wright, P. (1981, September). "The instructions clearly state . . . " Can't people read? Applied Ergonomics, 131-141.

ABSTRACT

Understanding and complying with the instructions that accompany consumer products is not always easy, and indeed people may ignore the instructions entirely. Designing adequate instructions is a complex task. The basic requirements for good instructions can be specified, but the problem is one of developing adequate design procedures to meet them. Such procedures will involve coordinating the skills of experts in verbal and graphic communication, as well as those of experts familiar with the research literature and with techniques of empirical evaluation. The consequences of poor instructions can be serious. Moreover, changes in the legal notion of product liability may encourage manufacturers to re-examine how their instructions are prepared.

APPLICATION

This paper will be of use to those who must write clear concise instructions, whether for consumer products or industrial machinery.

SECTION 3.0
SUPPLEMENTAL BIBLIOGRAPHY

Allison, C.E. (1981, April). Job and task analysis: A view from the inside. Paper presented at the Symposium on Training of Nuclear Facility Personnel, Gatlinburg, TN.

Altman, J.W., Marchese, A.C., & Marchiando, B.W. (1961). Guide to design of mechanical equipment for maintenance ability (ASD Technical Report No. 61-381). Wright-Patterson AFB, OH: Air Force Human Resources Laboratory. (NTIS AD-2 9332)

American National Standards Institute. (1973). Nuclear safety criteria for the design of stationary pressurized water reactor plants (ANSI N18.2-1973). LaGrange Park, IL: Author.

American National Standards Institute. (1975). Revision and addendum to nuclear safety criteria for the design of stationary pressurized water reactor plants ANSI N18.2-1973 (ANSI N18.2A-1973). LaGrange Park, IL: Author.

American National Standards Institute. (1977). Draft American national standard IEEE trial-use standard criteria for safety systems of nuclear power generating stations (ANSI/IEEE Std 603). LaGrange Park, IL: Author.

American National Standards Institute. (1978). Design basis criteria for safety systems in nuclear power generating stations (ANSI/ANS 4.1). LaGrange Park, IL: Author.

Banks, W.W., Blackman, H.S., Gertman, D.I., & Petersen, R.J. (1982). A multimethods approach to safety parameter display evaluation (NUREG/CR-2300). Idaho Falls, ID: EG&G Idaho, Inc.

Ben-Yaacov, G., & Good, E.M. (Eds.). (1980). Human factors considerations in the design of man-machine interface for power plant process computers. Omaha, NE: Gibbs & Hill, Inc.

Blanchard, B.S., & Lowery, E.E. (1969). Maintainability: Principles and practices. New York: McGraw-Hill.

Bockhold, G., Jr., & Roth, D.R. (1978). Performance measurement system for training simulators (Interim report on EPRI Project 769, NP-783). Palo Alto, CA: Electric Power Research Institute.

Booth, M., Brodsky, R.S., & Frenkhouser, W.L. (1981, February). Safety overview and management function. Albuquerque, NM: Sandia National Laboratory.

Bosshardt, M.J., & Bounas, D.A. (1981, April). Developing control room operator procedures. Paper presented at the Symposium on Training of Nuclear Facility Personnel, Gatlinburg, TN.

Brynda, W.J., Lobner, P.R., Powell, R.W., & Straker, E.A. (1978). Design guide for category II reactors, light and heavy water-cooled reactors (NTIS BNL-50831-11, UC-80). Upton, NY: Brookhaven National Laboratory.

Center for Occupational Research and Development. (1980). Resource handbook for power plant training programs (Report No. EPRI CS-1432). Palo Alto, CA: Electric Power Research Institute.

Code of federal regulations, Title 10. Chapter 1: Energy, part 55. Operator's Licenses. Washington, DC: U.S. Government Printing Office.

Department of Defense. (1966). Maintainability program requirements (for systems and equipment) (MIL-STD-470). Washington, DC: Author.

Designing for man's advances in control room operations. (1982, July/August). EPRI Journal, 6-13.

The Emergency Operating Procedures Implementation Assistance (EOPIA) Review Group. (1983). Emergency operating procedures generation package guideline (INPO 83-007). Atlanta, GA: Institute of Nuclear Power Operations.

Folley, J.D., & Altman, J.W. (1956). Guide to design of electronic equipment for maintainability (WADC-TR-56-218). Wright-Patterson AFB, OH: Air Force Human Resources Laboratory. (NTIS AD-101-729)

General Physics Corporation. (1978). Performance measurement system for training simulators (Interim Report EPRI NP-783). Palo Alto, CA: Electric Power Research Institute.

Gordon, J.F. (1981, March). Some ergonomic considerations of visual display units. Melbourne, Australia: Aeronautical Research Laboratories.

Hol, J.O., Ohra, G., & Netland, K. (1978, July). Design of pictures and use of colors and symbols for a CRT-based supervision system. Paper presented at the Symposium on Water Reactor Fuel Performance, Leon, Norway.

Institute of Electrical and Electronics Engineers Working Group 5.5. (1981, July). Proposed draft: Recommended practice for the use of color coding in nuclear power plant panels, controls, and displays. New York: Institute of Electrical and Electronics Engineers.

Johnson, R.C., Thomas, D.L., & Martin, D.J. (1977, June). User acceptance and usability of the C-141 Job Guide Technical Order System (Technical Report AFHRL-TR-77-31). Wright-Patterson AFB, OH: Air Force Human Resources Laboratory.

Joos, D.W., Sabri, Z.A., & Husseiny, A.A. (1979). Analysis of gross error rates in operation of commercial nuclear power stations. Nuclear Engineering and Design, 52.

Kozinsky, E.J. (1981, October). Human factors research using the EPRI performance measurement system. Paper presented at the CSNI Specialist Meeting on Operator Training and Qualifications. Charlotte, NC.

Luckas, W.J., Jr., Lehieri, V., & Hall, R.E. (1982, May). Initial quantifications of human error associated with specific instrumentation and control system components in licensed nuclear power plants. Upton, NY: Brookhaven National Laboratory.

Michelson, C., & Hemes, C.J. (1981). New trends in the evaluation and implementation of the safety-related operating experience associated with NRC-licensed reactors. Nuclear Safety, 22, 11.

Nuclear Facilities Personnel Qualifications and Training Committee. (1981). A safety assessment of Department of Energy nuclear reactors. Washington, DC: Department of Energy.

Nuclear Regulatory Commission. (1981). Behavioral reliability program for the nuclear industry (NUREG/CR-2076). Washington, DC: Author.

Nuclear Regulatory Commission. (1981). Standards for psychological assessment of nuclear facility personnel (NUREG/CR-2075). Washington, DC: Author.

Persensky, J.J. (1981, October). The U.S. NRC Division of Human Factors safety perspective on operator training and qualifications. Paper presented at the CSNI Specialist Meeting on Operator Training and Qualifications, Charlotte, NC.

Pugh, L.C. (1981, October). The man-machine interface and plant operations. Paper presented at the 1981 ANS Nuclear Technology Exhibit, Beijing, China.

Ramsey, J.R., & Atwood, M.E. (1979, September). Human factors in computer systems: A review of the literature (Technical Report SAI-79-11-DEN). McLean, VA: Science Applications, Inc.

Rigby, L.V., & Cooper, J.I. (1961, October). Problems and procedures in maintainability (ASD Technical Note 61-126). Wright-Patterson AFB, OH: Air Force Behavioral Sciences Laboratory. (NTIS AD-273-108)

Rigby, L.V., Cooper, J.I., & Spickard, W.A. (1961, October). Guide to integrated system design for maintainability (ASD Technical Report 61-424). Wright-Patterson AFB, OH: Air Force Behavioral Sciences Laboratory.

Siels, D.L., Wolf, C.P., & Shelansk, V.B. (Eds.). (1981). The accident at Three Mile Island: The human dimensions. Boulder, CO: Westview.

Smith, D.J., & Babb, A.H. (1973). Maintainability engineering. New York: John Wiley & Sons.

Tew, J.L., Knuth, D., & Boyd, R. (1981, February). Radiological controls and worker and public health and safety. Albuquerque, NM: Sandia National Laboratory.

Trauth, C.A., Jr., Ellingson, A.C., Farr, D.E., & Jercinovic, L.M. (1978, December). Application of quality assurance human factors and reliability principles to the prevention of major environment, safety, and health incidents. Albuquerque, NM: Sandia National Laboratory.

U.S. Atomic Energy Commission. (1973, July). The safety of nuclear power reactors (light-water-cooled) and related facilities (Technical Report WASH-1250). Washington, DC: Author.

U.S. Navy. (1975). Interservice procedures for instructional systems development (NAVDETRA 106A). Alexandria, VA: Author.

Zahn, H.S. (1979). Developing maintainability for fusion power systems (Final Report). Washington, DC: Department of Energy. (NTIS C00-4194-8)

APPENDIX 1
INDEX OF ANNOTATED BIBLIOGRAPHY
BY TOPIC AREA

ADVANCED CONTROL ROOM

Boone & Banks (1980) (EGG-SSDS-5288)

Clark, Banks, Blackman, & Gertman (1982)

ANNUNCIATORS/ALARMS

American Nuclear Society (1979) (ANSI/ANS N2.3-1979)

Bagchi & Gottilla (1981)

Banks & Boone (1981) (NUREG/CR-2147)

Danchak (1982) (NUREG/CR-2776)

Instrument Society of America (1979) (ISA S18.1)

Meijer & Safryn (1981) (C-E Document No. 1PDR-81-004)

Merritt (1980)

Rankin, Duvernoy, Morgenstern, Ames, & Eckenrode (1983) (NUREG/CR-3217)

Roscoe (1984) (NUREG/CR-3684)

Staff (1969)

Wait & Manning (1980) (NUREG/CR-1468)

ANTHROPOMETRY

Cochran & Riley (1982)

Cochran & Riley (1983)

Das & Grady (1983)

Deeb, Drury, & Begbie (1983)

Easterby, Kroemer, & Chaffin (Eds.) (1980)

Kohl (1983)

Letbetter (1982)

Parris & McConville (1981) (EPRI NP-1918-SR)

Replogle (1983)

Scheller (1983)

Webb Associates (Eds.) (1978)

Banks (1980) (SD-D-80-002)

Banks (1981) (SD-B-81-002)

Banks & Boone (1981)

Banks & Clark (1981) (SD-B-81-001)

Banks, Gertman, & Petersen (1982) (NUREG/CR-2496)

Banks, Meyer, & Clark (1980)

Blackman, Gertman, Gilmore, & Lord (1983) (NUREG/CR-3556)

Bray, Petersen, Clark, & Gertman (1981) (EGG-M-09581)

Brooke & Duncan (1983)

Cakir, Hart, & Stewart (1980)

Danchak (1977)

Danchak (1981) (NUREG/CR-1994)

Electric Power Research Institute (1982) (EPRI-NSAC-40)

Electric Power Research Institute (1982) (EPRI-NP-2239)

Frey & Kismer (1982) (NUREG/CR-2586)

Gertman, Blackman, Banks, & Petersen (1982) (NUREG/CR-2942)

Gertman, Blackman, & Banks (1982) (EGG-SSDS-5878)

Grandjean & Vigliani (Eds.) (1980)

Helander (1982)

Helander, Billingsley, & Schurick (1984)

Kershner, Gebhard, Silverman, & Pannel (1982)

Larsen & Robb

Lutman, Petrick, & Hallam (1982) (EPRI-NSAC-45)

Luxenberg & Kuehn (1968)

Matula (1981)

Nuclear Regulatory Commission (1981) (NUREG-0835)

Olsen (Ed.) (1981)

Ramsey, Atwood, & Kirshbaum (Eds.) (1978)

Salvendy (Ed.) (1984)

Straker (1981) (EPRI-NSAC-39)

Turner & Karasek, Jr. (1983)

American Nuclear Society (1979) (ANSI/ANS 10.5-1979)

Brown, Burkleo, Mangelsdorf, Olsen, & Williams, Jr. (1981)

Cakir, Hart, & Stewart (1980)

Card, Moran, & Newell (1983)

Dowling, Bybee, Shukla, Howland, Blomsnes, & Netland (1978) (EPRI NP-640)

Engel & Granda (1975) (TR 00.2720)

Frey & Kismer (1982) (NUREG/CR 2586)

Institutt for Energiteknikk (1981)

Martin (1973)

Price, Maisano, & Van Cott (1981) (NUREG/CR-2623)

Pulliam, Price, Bongarra, Sawyer, & Kisner (1983) (NUREG/CR-3331)

Ramsey & Atwood (1979)

Ramsey, Atwood, & Kirshbaum (Eds.) (1978)

Rossiter & Skolnick (1980)

Salvendy (1984)

Tillitt, Petersen, & Smith (1982) (NUREG/CR-2711)

CONTROL ROOM DESIGN CRITERIA & REVIEWS

American National Standards Institute (1980) (ANSI/IEEE Std 567)

American Nuclear Society (1983) (ANSI 58.6-1983)

BWR Owners Group (1980)

Enlarged Nordic Cooperative Program on Nuclear Safety (1981, June)

Finlayson (1977)

Friar, Fowler, & Brown (1981)

Frogner & Rao (1978)

Gonzalez & Smith (1984)

Hartley, Levy, & Fecht (1984) (NUREG/CR-3696)

Human engineering guide to control room evaluation, Volumes I & II

Illuminating Engineering Society (1973) (A11.1-1973)

Institute of Electrical and Electronics Engineers (1980) (ANSI/IEEE Std 567)

Institute of Electrical and Electronics Engineers (1977) (ANSI/IEEE Std 566)

Institute of Electrical and Electronics Engineers (1980)

Institute of Nuclear Power Operations (1982)

Luma, Guidetti, & Rowland (1981)

Maddox (1983)

Maddox & Brickey (1983)

Mallory, Fleger, Johnson, Avery, Walker, Baker, & Malone (1980) (NUREG/CR-1580)

Nuclear Regulatory Commission (1981) (NUREG 0659)

Nuclear Regulatory Commission (1981) (NUREG 0700)

Nuclear Utility Task Action Committee (1983) (INPO 83-026)

Nuclear Utility Task Action Committee (1983) (INPO 83-036)

Nuclear Utility Task Action Committee (1983) (INPO 83-042)

Nuclear Utility Task Action Committee (1983) (INPO 83-046)

Pen, Miller, & Feeher (1981) (EPRI-NP-1982)

Pine, Schulz, Edman, Hanson, Evans, Gonzales, Smith, & Seminara (1982) (EPRI-NP-2411)

Pulliam, Price, Bongarra, Sawyer, & Kisner (1983) (NUREG/CR-3331)

Sawyer, Pain, Van Cott, & Banks (1982) (NUREG/CR-2828, EGG-2211)

Schroeder & Fowler

Seidenstein, Williams, Goddard, & Chesney (1981) (EPRI-EL-1960, Volumes 1-6)

Seminara (1982) (EPRI NP-2360)

Seminara, Eckert, Seidenstein, Gonzales, Stempson, & Parsons (1979) (EPRI NP-1118-SY)

Seminara, Gonzalez, & Parsons (1976) (EPRI NP-309)

Seminara & Parsons (1979) (EPRI NP-1118)

Seminara, Seidenstein, Eckert, & Smith (1979) (EPRI NP-1118)

Stewart (1981) (EGG-SSDS-5644)

Voss (1983)

Voss, Talley, & Baker (1983)

Weiss (1983)

DISPLAYS & CONTROLS

Banks & Boone (1981) (NUREG/CR-2147)

Cochran & Riley (1982)

Cochran & Riley (1983)

Deeb, Drury, & Begbie (1983)

Engel & Granda (1975) (TR 00.2720)

Frey & Kismer (1982) (NUREG/CR-2586)

Gertman, Blackman, Banks, & Petersen (1982) (NUREG/CR-2942)

Hsu (1981)

Institute of Electrical and Electronics Engineers (1980) (IEEE Std 603-1980)

Luxenberg & Kuehn (1968)

Nelson (1984) (NUREG/CR-3631)

Replogle (1983)

Scheller (1983)

Weiss (1983)

American Nuclear Society (1983) (ANSI 58.6-1983)

Barks, Kozinsky, & Eckel (NUREG/CR-2598)

Knuth & Boyd (1981) (DOE/US-0013)

Nuclear Regulatory Commission (1973) (NUREG 75/014)

Nuclear Regulatory Commission (1980) (NUREG-0654)

Nuclear Regulatory Commission (1981) (NUREG-0696)

Ramos, et al. (1981) (NUREG-0814)

Acoustical Society of America (1971)

American National Standards Institute (1971) (ANSI 91.2-1962)

Barter, Siegel, & Federman (1982) (NUREG/CR-2668)

Bennett (1977)

Burgy, Doyle, Bersam, & Liddle (1980)

BWR Owners Group (1980)

Card, Moran, & Newell (1983)

Department of the Air Force (1980) (AFSC DH 1-3)

Department of Defense (1975) (MIL-HDBK-759)

Department of Defense (1979) (MIL-H-46855B)

Department of Defense (1981) (MIL-STD-1472C)

DeSteese, Pelto, Rankin, Rideout, & Shikiar (1982) (GRI-81/0106.1)

DeSteese, Pelto, Rankin, Rideout, & Shikiar (1982) (GRI-81/0106.2)

Enander (1983)

Failure Analysis Associates (1979) (EPRI AF-1041)

Gertner, Israeli, & Cassuto (1984)

Grandjean (1980)

Haas (1982)

Helander (Ed.) (1981)

Hopkins & Snyder (1982)

Hopkins, Snyder, Price, Hornick, Mackie, Smillie, & Sugarman (1982) (NUREG/CR-2833)

Illuminating Engineering Society (1973) (A11.1-1973)

Kohl (1983)

Kubokawa, Woodson, & Selby (1969) (NASA Report No. CR114272)

Lutman, Petrick, & Hallam (1982) (EPRI-NSAC-45)

McCormick & Sanders (1982)

Meese, Kok, Lewis, & Wyon (1984)

Meijer & Gill (1980)

Meister (1984)

Meister & Rabideau (1965)

Moray (Ed.) (1979)

Morgan, Cook, III, Chapanis, & Lund (1963)

Morse & Swift (1982)

Olson, Schreiber, & Melber (1984) (NUREG/CR-3785)

Parker, Jr., & West (Eds.) (1973)

Pauls (1983)

Price, Maisano, & Van Cott (1981) (NUREG/CR-2623)

Riso National Laboratory (Eds.) (1982)

Rodgers & Eggleton (Eds.) (1983)

Sabri (1980)

Seeman, Colley, & Stratton (1983)

Shackel (Ed.) (1978)

Sheehy (1983)

Sheridan & Johannsen (Eds.) (1976)

Swain (1980)

Topmiller, Burgy, Roth, Doyle, & Espey, Jr. (1981) (EPRI NP-2035)

U.S.A. Standards Institute (1960) (USAS S3.2-1960)

Van Cott & Kinkade (Eds.) (1972)

Voss (1983)

Woodson (1981)

Wright (1977)

HFE REQUIREMENTS & STUDIES

Banks & Boone (1981)

Edsberg (1981)

El-Bassioni, Hedrick, Starostecki, & Penland

Hopkins, Snyder, Price, Hornick, Mackie, Smillie, & Sugarman.(1982) (NUREG/CR-2833)

Tiesenhausen (1982) (NASA TM-82510)

JOB PERFORMANCE AIDS

American National Standards Insitute (1971) (ANSI 91.2-1962)

Anderson (1981) (ORNL/FTR-1032)

Deere, Dorris, Bovell, Crowe, & Kozinsky (1983) (NUREG/CR-3309)

Foley, Jr. (1973) (AFHRL-TR-72-73)

Hottman, Bateman, & Biers (1982) (NUREG/CR-2712)

Joyce, Chenzoff, Mulligan, & Mallory (1973) (AFHRL-TR-73-43)

Lineberry & Bullock (1980)

Moraal & Kraiss (Eds.) (1981)

Price, Post, & Kolsrud (1971)

American National Standards Institute (1972) (ANSI 18.7-1976)

Baker (1980, February)

Barter, Siegel, & Federman (1982) (NUREG/CR-2668)

Beare, Dorris, Bovell, Crowe, & Kozinsky (1983) (NUREG/CR-3309)

Bell & Swain (1983) (NUREG/CR-2254)

Brune & Weinstein (1980) (NUREG/CR-1369)

Clarke, Garin, & Preston-Anderson (1981)

Comer, Kozinsky, Eckel, & Miller (1983) (NUREG/CR-2744)

Cunningham & Cox (1972)

Doyle, Lothar, & Brewer (1983)

Embrey (1983) (NUREG/CR-2986)

Embrey, Humphreys, Rose, Kirwan & Rea (1984) (NUREG/CR-3518)

Finnegan (1980) (EPRI AP-1470)

Griffon (1979)

Haas & Bott (1980, April)

Hall (1982) (NUREG/CR-3010)

Koukol, Lapin, Leverton, & Pickering (1980) (EPRI NSAC-4)

McKeithan & Kfoury (1983)

Morse & Swift (1982, April)

Onodera, Miki, Nukada, & Nakamura (1982)

Post, Price, & Diffley (1976)

Riso National Laboratory (Eds.) (1992)

Samanta, Swoboda, & Heli (1981) (NUREG/CR-1879)

Seminara (1982) (EPRI NP-2360)

Seminara, Parsons, Schmidtt, Gonzalez, & Dove (1980) (NP-1567-SY)

Sheridan (1980, February)

Shives & Willard (Eds.) (1981, April)

Siegel, Bartter, & Kopstein (1982) (NUREG/CR-2670)

Siegel, Bartter, Wolf, Knee, & Haas (1983) (NUREG/CR-2669)

Smidt (1980, November)

Speaker, Thompson, & Luckas, Jr. (1982) (NUREG/CR-2417)

Stewart (1981) (EEG-SSDC-5580)

Stewart (1982)

Stilwell, Seaver, & Schwartz (1982) (NUREG/CR-2255)

Swain & Guttman (1980) (NUREG/CR-1278)

Topmiller, Eckel, & Kozinsky (1982) (NUREG/CR-2744)

Toto & Lindgren (1981) (DOE/US-008)

Vesely, Davis, & Saltos (1983) (NUREG/CR-3541)

ORGANIZATIONAL COMMUNICATIONS

Bauman, Davidson, & Van Cott (1984)

Bauman, Pain, Van Cott, & Davidson (1983) (EPRI NP-3141)

Goldhaber, Rogers, Lesnick, & Porter (1979)

Olson, McLaughlin, Osborne, & Jackson (1984)

Roberts & O'Reilly, III (1974)

Selway, Jr. (1984, April)

Seminara & Pack (1982)

PERSONNEL SELECTION & STAFFING

American Nuclear Society (1978) (ANSI/ANS 3.1-1978)

Baumen, Pain, Van Cott, & Davidson (1983)

Corcoran, Church, Cross, & Porter (1981, April)

Fullerton, Peelle, & Reed (1982) (NUREG/CR-3458)

Kisner & Frey (1981) (NUREG/CR-2587)

Lindell (1983)

Melber & Schreiber (1983) (NUREG/CR-2952)

Shea, Jr. (1981, October)

American National Standards Institute (1972) (ANSI 18.7-1976)

Brune & Weinstein (1981) (NUREG/CR-2005)

Canadian Standards Association (1979) (CSA N286.5-1979)

Department of Defense (1977) (MIL-HDBK-63038-1(TM))

The Emergency Operating Procedures Implementation Assistance (EOPIA) Review Group (1983) (INPO 83-004)

The Emergency Operating Procedures Implementation Assistance (EOPIA) Review Group (1982) (INPO 82-017)

The Emergency Operating Procedures Implementation Assistance (EOPIA) Review Group (1982) (INPO 82-013)

The Emergency Operating Procedures Implementation Assistance (EOPIA) Review Group (1983) (INPO 83-006)

The Emergency Operating Procedures Implementation Assistance (EOPIA) Review Group (1983) (INPO 82-016)

Fuchs, Engelschall, & Imlay (1981) (NUREG/CR-1999)

Fuchs, Engelschall, & Imlay (1981) (NUREG/CR-1875)

Green (1984) (NUREG/CR-2940)

Kammann (1979)

Lindell (1983)

Morgenstern, Clausen, Foley, Levy, Myers, Rankin, & Shikiar (1981) (NUREG/CR-1977)

Myers & Bell (1984) (NUREG/CR-3632)

Naval Air Systems Command (1980) (NAVAIR 00-25-700)

Nelson, Clark, & Banks (1981) (NUREG/CR-1995)

Nuclear Regulatory Commission (1982) (NUREG-0899)

Olson, Schreiber, & Melber (1984) (NUREG/CR-3785)

Post, Price, & Diffley (1976)

Potash (1980) (EGG-SSDC-5223)

Pulliam, Price, Bongarra, Sawyer, & Kisner (1983) (NUREG/CR-3331)

Siegel, Federman, & Burkett (1974) (AFHRL-TR-74-28)

Siegel, Lambert, & Burkett (1974) (AFHRL-TR-74-47)

Speaker, Thompson, & Luckas, Jr. (1982) (NUREG/CR-2417)

Taylor & Voss (1981)

Toto & Lindgren (1981) (DOE/US-008)

von Herrmann (1983) (NUREG/CR-3177) (3 volumes)

Wright (1981, September)

SIMULATORS

Beare, Crowe, Kozinsky, Barks & Haas (1982) (NUREG/CR-2534)

Beare, Dorris, & Kozinsky (1982)

Bolton, Faigenblum, Hope, & Rankin (1984) (NUREG/CR-3726)

Bott, Kozinsky, Crowe, & Haas (1981) (NUREG/CR-1908)

Electric Power Research Institute (1982) (EPRI-NSAC-40)

Hollnagel, Pedersen, & Rasmussen (1981) (RISO-M-2285)

Moraal & Kraiss (Eds.) (1981)

Oak Ridge National Laboratory (1981) (NUREG/CR-2353)

Rankin, Bolton, Shikiar, & Saari (1984) (NUREG/CR-3785)

THREE MILE ISLAND STUDIES

Fischetti, Adam, Eisenhut, & Horgan (1984, April)

Nuclear Regulatory Commission (1979) (NUREG-0585)

Nuclear Regulatory Commission (1980) (NUREG-0737)

Nuclear Regulatory Commission (1980) (NUREG-0660)

Rogovin, Frampton, Jr., Cornell, DeYoung, Budnitz, & Norry (1980) (NUREG/CR-1250, Volume 1)

Rogovin & Frampton, Jr. (1980) (NUREG/CR-1250, Volume 2)

TRAINING

Analysis and Technology (1983) (DOE EP-0095)

Bartter, Siegel, & Federman (1982) (NUREG/CR-2668)

Blackman, Gertman, & Petersen (1983) (EEG-REP-6274)

Bockhold, Jr., & Roth (1978) (EPRI-NP-783)

Bolton, Faigenblum, Hope & Rankin (1984) (NUREG/CR-3726)

Burgy, Newell, & Van Cott (1982, October)

Department of Energy (1983) (DOE/EP-0095)

Department of Energy (1984) (DOE/EV/10782-T1)

Dutton & Brown (1981, April)

Enlarged Nordic Cooperative Program on Nuclear Safety (1981, June)

Gertman, Blackman, Gilmore, & French (1983) (EEG-REP-6273)

Green (1984) (NUREG/CR-2940)

Haas, Selby, Hanley, & Mercer (1983) (NUREG/CR-3414, ORNL-TM-8848)

Hollnagel, Pedersen, & Rasmussen (1981) (RISO-M-2285)

Hottman & Bateman (1982)

Hottman, Bateman, & Biers (1982) (NUREG/CR-2712)

Institute of Nuclear Power Operations (1982) (INPO 82-011)

Institute of Nuclear Power Operations (1984)

Oak Ridge National Laboratory (1981) (NUREG/CR-2353)

Olson, Schreiber, & Melber (1984) (NUREG/CR-3785)

Rankin, Bolton, Shikiar, & Saari (1984) (NUREG/CR-3725)

Sawyer, Pain, Van Cott, & Banks (1982) (NUREG/CR-2828, EGG-2211)

Department of Energy (1984) (DOE/EV/10782-T1)

Electric Power Research Institute (1982) (EPRI-NSAC-40)

Hollnagel (1981) (RISO-M-2313)

Hottman, Bateman, & Biers (1982) (NUREG/CR-2712)

Price, Post, & Kolsrud (1971)

Straker (1981) (EPRI-NSAC-39)

WOMEN

Letbetter (1982)

Mackay & Bishop (1984)

Ward (1984)

OTHER

Advisory Committee on Reactor Safeguards (1980) (NUREG-0739)

Banks & Sprague (1982)

Code of federal regulations (1984)

Felker (Ed.) (1980) (A/R-75002-4/80-TR)

Nuclear Regulatory Commission (1980)

 U.S. Government Printing Office: 587-002/24075-5/85