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FACIL:STN-50-528 Palo Verde Nuclear Station, Unit 1, Arizona Publi 05000528
STN-50-529 Palo Verde Nuclear Station, Unit 2, Arizona Publi 05000529
STN-50-530 Palo Verde Nuclear Station, Unit 3, Arizona Publi 05000530
AUTH.NAME AUTHOR AFFILIATION
VAN BRUNT,E.E. Arizona Public Service Co.
RECIP.NAME RECIPIENT AFFILIATION
KNIGHTON,G. Licensing Branch 3

SUBJECT: Forwards responses to NRC comments re qualification & structure of detailed control room design room review team, per Suppl 1 to NUREG-0737.

DISTRIBUTION CODE: A003S COPIES RECEIVED:LTR 1 ENCL 40 ON SIDE SIZE: 34
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NOTES:Standardized plant. 05000528
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Arizona Public Service Company
P.O. BOX 21666 • PHOENIX, ARIZONA 85036

April 9, 1984
ANPP-29252 - WFQ/KEJ

Director of Nuclear Reactor Regulation
Attention: Mr. George Knighton, Chief
Licensing Branch No. 3
Division of Licensing
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Subject: Palo Verde Nuclear Generating Station (PVNGS)
Units 1, 2 and 3
Docket Nos. STN-50-528/529/530
File: 84-056-026; G.1.01.10

Reference: 1. NRC letter from G. W. Knighton, NRC, to E. E. Van Brunt, APS, dated January 10, 1984. Subject: Review Comments on Palo Verde Control Room Design Review.
2. Letter from E. E. Van Brunt, APS, to G. W. Knighton, NRC, dated June 17, 1983. (ANPP-24121).
3. Letter from E. E. Van Brunt, APS, to G. W. Knighton, NRC, dated June 30, 1983 (ANPP-24212).

Dear Mr. Knighton:

Reference (1) provided the staff's comments on the Reference (2) submittal concerning the PVNGS Detailed Control Room Design Review (DCRDR) Program Plan. The staff provided specific comments on Control Room Design Review process and stated that it should be strengthened to assure that the process produces results that satisfy the requirement of Supplement No. 1 to NUREG-0737.

Attachment A of this letter provides APS' response to the specific comments made by the staff in Reference (1) regarding the qualifications and structure of the DCRDR Review Team which performed the PVNGS DCRDR System Factors Study. This attachment describes the structure of the System Factors Review Team and identifies the individuals which participated in the System Factors Review.

Attachment B of this letter describes how the System Factors Review was conducted by PVNGS to identify control room operator tasks and information and control requirements. The results of the system function/task analysis were used by the PVNGS Operations Department to generate, verify and validate the Emergency Operating Procedures (EOP's) as described in the Procedure Generation Package. This attachment also sites several examples which provide indication of how the control boards were checked by the System Factors Review Team during the control room survey portion of the PVNGS DCRDR.

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A detailed description of the coordination effort between the PVNGS DCRDR and the PVNGS Emergency Operating Procedure (EOP's) development is given in Attachment C of this letter. This attachment describes how the results of the DCRDR System Factors task analysis was used to support development of the PVNGS EOP's.

Attachments A, B and C of this letter demonstrate in detail how the PVNGS DCRDR System Factors Review (systems function/task analysis) was conducted to identify information and control requirements as required by Supplement No. 1 to NUREG-0737. Also, in response to the Reference (1) letter, APS does not plan to revise the Summary Report submitted in Reference (3), as a result of the staff comments.

If you have any further questions concerning this matter, please contact me.

Very truly yours,

E. E. Van Brunt

E. E. Van Brunt, Jr.
APS Vice President, Nuclear
ANPP Project Director

EEVB/KEJ/sp
Attachment

cc: E. A. Licitra (w/a)
D. Tondi "
A. Ramey-Smith "
A. C. Gehr "

April 9, 1984
ANPP-29252 - WFQ/KEJ

STATE OF ARIZONA)
) ss.
COUNTY OF MARICOPA)

I, Edwin E. Van Brunt, Jr., represent that I am Vice President, Nuclear, of Arizona Public Service Company, that the foregoing document has been signed by me on behalf of Arizona Public Service Company with full authority to do so, that I have read such document and know its contents, and that to the best of my knowledge and belief, the statements made therein are true.

Edwin E. Van Brunt

Edwin E. Van Brunt, Jr.

Sworn to before me this 9th day of April, 1984.

Nora E. Meador

Notary Public

My Commission Expires:

My Commission Expires April 6, 1987

[illegible]

ATTACHMENT A

QUALIFICATIONS AND STRUCTURE
OF THE
PVNGS DCRDR
SYSTEM FACTORS TASK
REVIEW TEAM

The primary objective of the PVNGS System Factors Task was to identify, prioritize, and correct discrepancies associated with the control room operator tasks and plant system functions as these tasks/functions affect plant operations during normal, abnormal, and emergency conditions.

To obtain the task primary objective, the System Factors Task took the "review team" approach. The review team consisted of permanent, rotating and part-time members. The permanent members of the team were cognizant design engineers which represented the Utility (Arizona Public Service Company), Architect/Engineer (Bechtel Power Corporation), Nuclear Steam Supply System (NSSS) Supplier (Combustion Engineering) and Human Factors Specialists from the Human Factors Consultant (Torrey Pines Technology). Rotating members of the team were plant operators which were rotated in pairs of two for each meeting session. All of the team plant operators had previous nuclear power plant operating experience. The part-time members were two Human Factors experts from the Human Factors Consultants. These Human Factors experts were available to the review team for consultation whenever the team required Human Factors assistance.

The System Factors Review Team was headed by the System Factors Task Chairman whose function was to ensure the team met its primary objective goal during the meeting sessions. The Chairman, a representative of the Human Factors Consultant, was appointed in this case to provide an independent point of view during the review. The review team members were made up of the following permanent, rotating members and part-time members:

Chairman:	Anthony Spurgin	Torrey Pines Technology
Full Time:	Richard Guidetti	Bechtel Power Corporation
	William Harris	Combustion Engineering
	James Rowland	Arizona Public Service Company
Rotating:	John Malik	Day Shift Supervisor*
	Richard Gouge	Shift Supervisor*
	Michael Halpin	Shift Supervisor*
	Howard Humbert	Shift Supervisor*
	Daniel Ensign	Assistant Shift Supervisor*
	David Callaghan	Assistant Shift Supervisor*
	Robert Vallely	Assistant Shift Supervisor*
	Frank Buckingham	Assistant Shift Supervisor*
	Darol Jurn	Assistant Shift Supervisor*
	John Scott	Assistant Shift Supervisor*
Part-time:	Dr. A.J. Eschenbrenner	Torrey Pines Technology
	J. Lonigro	Torrey Pines Technology

*Arizona Public Service Company

Recording Secretary: Earl Gagnon Torrey Pines Technology

Resumes for the Chairman, full time members, part-time members and recording secretary are part of this attachment.

ANTOHNY J. SPURGIN
Senior Staff Engineer
General Engineering Division

PROFESSIONAL SPECIALTY Control Systems Design and Analyses, Safety Analyses and Probabilistic Risk Assesment.

EDUCATION B.S., Engineering, London, 1952.

EXPERIENCE Currently working on an indicator readout system for BWR control, the Disturbance Analysis and Surveillance System, for EPRI. This requires an intimate knowledge of the system's response to operator actions and reactions.

Responsible for conducting System Factors Task for the Human Engineering Review Program at the Palo Verde Nuclear Generating Station.

Senior Staff Engineer responsible for work proceedings on application of Probabilistic Risk Assesment techniques to petro-chemical, chemical, and coal plants. Directed the controls system design and transient analysis groups working on the Fort St. Vrain plant and several large High Temperature Gas-Cooled plants. While attached to the Fort St. Vrain project at the site, directed the redesign of several systems and subsystems.

Project engineer of the Diablo Canyon Project for two years. Prior to this was responsible for the Electrical and Control System design of a hydraulic rod drive system. Designed the Protection and Control System for Westinghouse 3-loop PWR plants. Undertook studies of transient behavior of PWR plants of various types including writing the simulation for these studies.

PROFESSIONAL ASSOCIATIONS

Professional Nuclear Engineer, California, 1978
Professional Controls Engineer, California, 1977
Senior Member of IEEE
Chairman, IEEE Working Group working on Standards.
Member of Power Generating and Nuclear Power Engineering Committees.

RICHARD GUIDETTI
Cognizant Engineer
Bechtel Power Corporation

EDUCATION	Engineering Studies, West Coast University, Los Angeles U.S. Navy Nuclear Power School	
SUMMARY	8 years	Instrument and Controls Engineer engaged in design and construction of nuclear power plants; assigned as a Supervising Engineer and Deputy Engineering Group Supervisor
	5 years	Supervising Nuclear Plant Operator engaged in startup and operation of commerical nuclear power plants
	7 years	U.S. Navy engaged in commission of nuclear submarine, prototype refueling and training of nuclear plant operators

EXPERIENCE

Mr. Guidetti is currently an Instrumentation Deputy Engineering Group Supervisor on the Arizona Nuclear Power Project consisting of three 1350 MW C-E System 80 PWR units. He has developed logic and elementary diagrams, layout design and has coordinated efforts for the main control panels including extensive involvement in control room human factors. He also has written specifications, Final Safety Analysis Report input, setpoint list, instrument installation and location drawings and developed a nuclear safety related instrument isometric program. His duties have also included coordinating the activities of the field/home construction/engineering groups.

Earlier, Mr. Guidetti was a Controls Engineer on the Rancho Seco Nuclear Project, a 900 MW B&W 2-loop nuclear reactor, resolving engineering problems during the late phase of construction and during the startup and turnover phases. He assisted the utility's operating staff in writing operating and emergency procedures before the plant received its operating license.

Before joining Bechtel, Mr. Guidetti was a licensed Supervising Control Operator at the Millstone Nuclear Generating Station, Unit 1 (a GE BWR) and Unit 2 (a C-E PWR), with a total generating capacity of 1480 MW. He participated in all phases of design review, acceptance testing, startup, operating and refueling. During this period Mr. Guidetti received extensive operator training including Westinghouse PWR and GE BWR simulator training.

In the U.S. Navy, Mr. Guidetti was part of the commissioning crew for a nuclear-powered submarine and was an instructor on the S3G prototype reactor. He also was a member of the S3G Oral Qualification Board.

While at Bechtel, Mr. Guidetti was assigned to Sacramento Municipal Utility District (SMUD) to aid in the updating and writing of plant operating procedures. During this assignment, he completed the review and update of several secondary plant operating procedures and all the plant electrical casualty procedures which numbered appoximately 50.

PROFESSIONAL AFFILIATIONS

Registered Professional Engineer, State of California

WILLIAM J. HARRIS
Cognizant Engineer
Combustion Engineering, Inc.

ATTACHMENT A

EDUCATION

Two years college

Naval Schools
- Electrical (16 weeks)
- Electronics (42 weeks)
- Nuclear Power (52 weeks)

EXPERIENCE

Mr. Harris currently is assigned as Supervisor of Application Engineering for several pre-System 80 NSSS. This assignment entailed the following duties: Provides instrumentation and control engineering schedular budget, and technical data and services for each pre-System 80 NSSS project; assigns priorities of design work between various projects; identifies and implements standardization of design; implements special project contract requirements which modify the standard design; supervises eight pre-System 80 project application engineers.

Earlier, Mr. Harris was an applications engineer in Instrumentation and Control Engineering. The assignment as applications engineer entails the following duties: Participation in the development of schedules and budgets for the design effort with department managers; system engineering work; maintain familiarity with design procedures, criteria and new or pending developments; project requirements; review and approve design criteria, specifications, drawings, and drawing changes; handles interfaces between other functional groups as required by department QA procedures; coordinate contract price changes; represent the Project Office in project authorized meetings with the department; represent the Project Office in interfaces with customers, vendors, AEC, A/E and CE manufacturing facilities as requested by the Project Manager.

Prior to the Arizona Human Factors review, Mr. Harris was assigned to a similar effort on the SONGS nuclear units full time for a period of six months.

Prior to joining Combustion Engineering, Mr. Harris worked with Bechtel as a senior control systems engineer participating in the design of a nuclear power plant utilizing a pressurized water reactor. Responsible for selecting components and designing control systems for safety related balance of plant systems interfacing with the nuclear steam supply systems.

In support of this effort, Mr. Harris prepared specifications, inquiries, bid evaluations, requisitions, and reviewed all vendor documents for such items as control valves, instrument valves, field mounted instruments, control systems and panels, sampling systems, seismic instrumentation, radiation monitors, prepared component and system logic diagrams and reviewed associated elementary wiring diagrams to insure conformance with the logic diagrams. Mr. Harris also prepared qualitative failure modes and effects analysis for all BOP logic diagrams associated with safety related components and systems. Finally, Mr. Harris was responsible for preparing all project inputs for the FSAR relating to control and instrumentation systems.

Mr. Harris has an additional 23 years engineering related experience from the United States Navy. During this 23 years of service, Mr. Harris served in the following capacities:

Technical Advisor and Writer - Mr. Harris directed preparation of engineering texts covering such topics as electrical and electronic theory, design, theory of operations, casualty procedures, maintenance and repair of electrical and electronic systems and components.

Engineering Officer - Mr. Harris supervised diverse engineering ratings at a Naval Advisory Detachment in Southeast Asia.

Electrical Officer - Mr. Harris was responsible for inspections and maintenance of approximately 125 inactive ships.

Repair Officer - Mr. Harris directed the repair and alteration of Nuclear Systems of Naval Nuclear Power Plants. Duties during this assignment included: preparation of procedure, qualification of personnel, and overall supervision of the work.

Operating Staff Nuclear Power Training Unit - Mr. Harris participated in the training of naval personnel for engineering duty in nuclear power submarines and land based nuclear power plants.

Reporting to the facility in as a Chief Petty Officer, Mr. Harris was subsequently commissioned as Ensign, interviewed by Admiral Rickover and retained in the nuclear power program as an officer. Duties during this assignment included: leading enlisted petty officer in charge of primary instrumentation systems, reactor operator, chief operator, shift supervisor, training officer, and assistant engineer.

Instructor - Mr. Harris used established curricula in formulating and conducting classroom instruction for such topics as basic electricity and electronics as well as electrical systems and components--motors, generators, switchgear, cables, and instrumentation systems.

Submarine Electrician - As an enlisted submarine electrician, Mr. Harris supervised and performed operational and overhaul maintenance of electrical power systems.

JAMES W. ROWLAND
I&C Engineer
Arizona Public Service Company

EDUCATION

BSME, Arizona State University
Major: Mechanical Engineering
Special emphasis on nuclear engineering
Attended various seminars related to the controls field

SUMMARY

8 years	Instrument and Controls Engineer responsible for design and construction of 3 nuclear power plants and associated facilities
1/2 year	Engineering Aid/Technician in design and testing of gas turbine engines and components

EXPERIENCE

Mr. Rowland is currently an Instrumentation and Controls Engineering Supervisor on the Arizona Nuclear Power Project consisting of three 1270 MW Combustion Engineering System-80 pressurized water reactors. He has been responsible for utility interface with the Architect/Engineer and suppliers. This work includes drawing review, specification review, and purchase order handling of plant protection, engineered safety features, and nuclear process control systems. Additionally, he was responsible for the computerized control and monitoring system on the waste water treatment facility that supplies cooling water for the plant. He also has coordinated start-up activities for the power plant and water treatment facility.

Prior to joining APS, Mr. Rowland worked as an engineering aide during the design phase of a gas turbine surge control valve. He performed design calculations, supervised the construction of a test model, and performed other engineering tasks.

Also prior to this time, Mr. Rowland worked as a laboratory technician and performed production testing of gas turbine engines. This work consisted of turbine start testing following manufacturing of overhaul and included operation and monitoring of the turbine during this testing.

ATTACHMENT A

A. JOHN ESCHENBRENNER

PROFESSIONAL SPECIALTY

Psychological Research

EDUCATION

B.S., Psychology, Saint Louis University, 1964
M. S., Psychology, Saint Louis University, 1967
Ph.D., Experimental Psychology, Saint Louis University, 1968

EXPERIENCE

In his present capacity at McDonnell Douglas, Dr. Eschenbrenner is assigned to the Human Performance Laboratory and has responsibility for the design and conduct of human performance and applied human factors design studies, particularly in the areas of training/selection technology and computer-based instructional systems. Recently, he was principal investigator on Air Force contract F33615-77-C-0076, Methods for Collecting and Analyzing Task Analysis Data. He is currently program manager on Army contract MDA903-79-C-0390, development of a Mission Track Selection Process for the Army Initial Entry

Rotary Wing (RERW) flight training program.

He was Deputy Program manager for the Air Force (AF) AIS Utilization Project. This project included a system analysis of AF training and education requirements.

He directed the AIS Instruction Materials, Instructional Strategies, and Personnel and Training Subsystem efforts. He also served as MDC Engineering Representative on a major AIS subcontract with Applied Science Associates.

He was responsible for in-house and contract research and development (CRAD) training technology studies.

When he first joined McDonnell Douglas Corporation in 1968, Dr. Eschenbrenner participated in human factors research and development work on earth resources reconnaisance systems, perceptual motor skills, and human information processing.

PROFESSIONAL AFFILIATIONS

Member American Psychological Association, American Education Research Association, Human Factors Society, Sigma XI, Missouri Psychological Association.

PROFESSIONAL ACTIVITIES

Consulting Editor - Human Factors, The Journal of the Human Factors Society (1969-1974).
Member - Scientific Affairs Committee, Missouri Psychological Association (1971-1973).
Review board, Division C. (Learning and Instruction), American Educational Research Association Annual Meeting (1977).

LICENSE

State Board of Registration for the Healing Arts of Missouri
State Committee of Psychologists
License No. 00366, 13 August 1978

JOSEPH K. LONIGRO, JR.

PROFESSIONAL SPECIALTY

Industrial/Aerospace training

EDUCATION

A.A.S., Electrical Engr., DeVry Inst. of Technology, 1963
B.S., Management Science, Southern Illinois University, 1973
M.A., Curriculum and Instruction, University of Northern Colorado, 1976.

EXPERIENCE

Senior Human Factors Engineer - McDonnell Douglas (1963)

Responsible for the design and application of advanced audiovisual techniques to control and display simulations, part-task trainers and maintenance simulators. Responsible for the human engineering evaluation of the control rooms at Arizona Public Service's Palo Verde Nuclear Generating Station. Control room and panel design and layout are being evaluated using detailed human factors checklists that assess plant operability in terms of the man/machine interface.

Subsystem Manager - Responsible for the management of the Air Force AIS including design, implementation and testing of the Media Subsystem; including design of carrels based on course parameters and on human factors data; the selection of media hardware based on instructional objectives, engineering reliability and maintainability, and human factors data; the design and production of all mediated courseware (software); and the facility design for the AIS learning centers; and surveying training requirements.

PROFESSIONAL ASSOCIATIONS

Member American Educational Research Association
Association for Educational Communications and Technology
Human Factors Society
Member Audio Visual Technology Faculty Advisory Committee, Community College of Denver, Colorado (1976-1979).

ERROL P. GAGNON
Licensing Engineer

PROFESSIONAL SPECIALTY

Licensing, safety criteria and technical specification preparation and review.

EDUCATION B.S., Engineering, San Diego State University, 1965

PROFESSIONAL EXPERIENCE AT GENERAL ATOMIC COMPANY (Since 1969)

Chairman of the Results Review Committee of the Human Factors Evaluation program for the Palo Verde Nuclear Power Generating Station control room and responsible for coordination of the program tasks.

Developed safety/licensing positions and criteria for various applications of nuclear power plants.

Evaluated nuclear power plant systems and components to identify and prioritize technical, safety and licensing issues.

Developed nuclear power plant transient performance specifications.

Senior Technical Representative at Fort St. Vrain responsible for technical coordination and guidance on the conduct and evaluation of the start-up test program.

Manager of the French Licensee Program responsible for the administrative and technical-transfer aspects of the nuclear power plant licensing agreements and contracts.

Performed simulation studies and evaluations of nuclear power plant transient performance/safety analyses, control systems, control room configurations and plant start-up procedures.

OTHER PROFESSIONAL EXPERIENCE

General Dynamics Corporation (1965-1969). Performed dynamic analyses of missile control systems.

PROFESSIONAL ASSOCIATIONS/HONORS

Member, American Nuclear Society

ATTACHMENT B

PVNGS

DCRDR

SYSTEM FACTORS TASK

(FUNCTION AND TASK ANALYSIS)

DESCRIPTION

5976A/1704A

Systems Factors was one of the three parallel tasks that were performed as part of the PVNGS Detailed Control Room Design Review (DCRDR). The System Factors Task covered those aspects of the control boards that relate to the total information and controls that are displayed and made available to the control room operator (man/machine interface).

The primary objective of the PVNGS System Factors Task was to identify, prioritize, and correct discrepancies associated with the control room operator tasks and plant system functions as these tasks/functions affect plant operations during normal, abnormal, and emergency conditions. The approach to the System Factors Tasks was an evolving one since during the period of the PVNGS DCRDR (June, 1980 through June 1981), NRC guidance in NUREG-0700 (September 1981) was not available.

The initial System Factors Task approach was to construct checklists in a manner similar to those used in the Human Factors Task. System Factors checklists were developed by the Human Factors Consultants (Torrey Pines Technology). These checklists were used to interview cognizant design engineers of the Architect/Engineer (Bechtel Power Corporation). The results of the interviews indicated that the checklist method was not an acceptable vehicle for obtaining the task primary objective, though much of the information that was obtained during these interviews was very useful in the later studies.

To satisfy the task primary objective, it was decided that the System Factors Task could best be accomplished by the "review team" approach. This approach consisted of forming a multi-discipline, multi-organizational team which would review the control boards from a system function point of view. The review teams' objective was to ensure that the appropriate information and controls for each system were available on the control boards to support the control room operator in performing his/her tasks during normal, abnormal and emergency plant conditions.

The review team consisted of permanent, rotating and part-time members. The permanent members of the team were cognizant design engineers which represented the utility, Architect/Engineer, Nuclear Steam Supply System (NSSS) Supplier (Combustion Engineering) and Systems Factors Specialists from the Human Factors Consultant. Rotating members of the review team were the plant operators which were rotated in pairs of two for each of the review team's meeting sessions. All of the rotating members (plant operators) and one permanent member had previous nuclear power operating experience. Two Human Factors experts from the Human Factors Consultants served as part-time members. These Human Factors experts were available to the review team for consultation whenever the review team required Human Factors assistance.

The System Factors review team was headed by the System Factors Task Chairman whose function was to ensure the review team met its primary objective goal during the meeting sessions. The Chairman, a representative of the Consultant, was appointed in this case to provide an independent point of view during the review. The six (6) review team members, including the Chairman, were made up respectively of the following members: one (1) Instrument & Controls Engineer from the utility, one (1) Architect/Engineer Controls Engineer, one (1) NSSS Supplier System Engineer and two (2) plant operators. The two human factors experts were available to the review team whenever their expertise was required by the review team. This was made possible since the Human Factors Task was being performed in parallel to the System Factors Task.

The review team convened for three weeks. During these weeks the team fine tuned the process for obtaining the tasks' primary objective. The teams first challenges were to determine how to dissect the plant design for review purposes.

The team considered that it was most appropriate to divide the plant design into functional blocks. The review teams first major task was started by breaking the plant down into the functional blocks called systems (i.e., Reactor System, Secondary Systems, Electrical Systems, and Common Systems). This division was not by control board, but by the functional blocks that an operator will recognize as separate plant systems. This follows as the plant will be operated by tasks rather than by control board arrangement (layout). The systems were then broken down further into subsystems; subsystems into sections; and sections into subsections. How extensive the breakdown became was based on the system complexity and logical system boundaries. An example of how the review team broke down the Reactor System is shown below.

I. Reactor System

A. Engineered Safety Feature Actuation System (ESFAS)

1. Active

a. High Pressure Safety Injection (HPSI)

b. Low Pressure Safety Injection (LPSI)

c. Containment Spray (CS)

2. Passive

a. Safety Injection Tanks (SITS)

3. Support

   a. Essential Spray Pond

   b. Essential Cooling Water

   c. Essential Chilled Water

   d. Fuel/Auxiliary Building HVAC

   e. Control Building HVAC

   f. Containment H2

4. Post Accident Monitoring Instruments

B. Reactor Control System

   1. Pressurizer

   2. Reactor Coolant Pumps

   3. Reactor Vessel

   4. CEDMCS

C. Chemical & Volume Control System

   1. Charging

   2. Letdown

   3. Boron Control

D. Plant Protection System

The second major task for the review team was to develop a set of questions. These questions were developed to be the framework around which the System Factors Task review was to be performed. The set of questions was developed from the experience of the review team members and their interaction. This set of questions was uniformly applied to assure consistency of system analysis for each system, subsystem, section, and subsection.

1. What is the primary function of the system?

2. What are the basic requirements of the system?

3. Is the system related equipment mounted on the control board readily discernable as part of the system?

4. How does an operator know that the system is available to perform its function?

5. How does an operator know the system is working?

6. What are the operational modes of the system?

7. Can the system be easily operated when it is put in the most stressful mode of operation?

8. Are there adequate indicators and other control board devices to permit system operation from the Main Control Board?

9. What is the relationship between alarm windows and the system?

10. What is the equipment line-up criteria?

11. What specific actions does the operator take for each system related alarm?

12. Does the system have Main Control Board equipment which is unnecessary or better located remotely?

13. Does the system lack any Main Control Board equipment?

14. Is the control board equipment located on the correct control board? Is it arranged on the control board in a manner to minimize human error?

The process which the review team used to conduct the analysis of the system functions and operator tasks was by discussion. The discussion was generated by addressing the above fourteen questions. The members of the team drew upon their considerable knowledge of plant operations, design, safety and control analysis to ensure that all of the appropriate questions were raised about the impact of the system on both the control board layout and operator tasks. All of the questions were resolved using the knowledge within the group and by access to the control room simulator, which is identical to the plant control room or consulting outside experts at the utility, Architecture/Engineer, NSSS supplier or Human Factors Consultants.

In preparation for the review of the plant system functions, the team assembled a library to aid in the review. The documentation in the library consisted of the plant piping and instrument diagrams (P&ID's), System Description Manuals, Computer Description Manuals, Safety Analysis Reports (SAR's), and Combustion Engineering (CE) Standard Safety Analysis Reports (CESSAR's). Also used in the meeting discussions was information obtained from Combustion Engineering (CE) lecture notes on various CE systems. A photo montage of the control boards and control board layout drawings were also used extensively during the discussions. The plant control room simulator, which is identical to the control room was available to the review team on demand. During the discussions the control room simulator was used frequently by the review team both for visually verifying control boards physical arrangement and for performing dynamic tests.

The review team first started the systems review by using the above fourteen questions to generate the basis of the review. During the system analysis the following criteria was applied to further elucidate the functional characteristic of the systems, their operability from the control boards and adequacy of inventory for diagnosis and maintenance requirements.

1. Systems within a functional group should be grouped together.

2. Layout of identical systems within a group should be identical, not mirror images.

3. Associated control and displays should be in close proximity (i.e., within two feet from each other).

4. Displays which have to be compared should be adjacent and values easily readable and comparable.

5. Displays and controls which are considered to be either the most important or are used extensively should be placed in the optimum viewing use areas.

6. Devices of lesser use or importance should be placed in lower, optional areas.

7. Devices which are used infrequently should be removed to local boards.

8. Alarms, displays and controls for similar systems should have identical spatial arrangements.

9. Relationships between functional characteristics of systems and components should be the same on all of the control boards.

10. Boundaries between systems should be demarked and the areas so contained should be singular (i.e., one system should be clearly separated from another system).

11. Systems and subsystems should be clearly identified as systems, not by the identification of each individual component.

12. An annunciator system should show a distinction between safety and economics, functions with plant safety having the highest layout priority.

13. Easiest line up function during accident checkout.

14. For process flow type systems, other than the CVCS system, the arrangement of components should follow the process flow (e.g., valve suction then pumps, recirculation alongside pumps, discharge valves, etc.).

15. The layout of control variables, controllers and systems should not be ambiguous. It should be clear which system is which.

16. Between a safety related system and a normally operating system, the safety related system layout should have the highest priority. Between two safety related systems, the one required for instantaneous use should show priority layout over one required for long term use.

17. The operator shall have an immediate and adequate indication of the primary safety response of a system to his control actions.

18. Status instruments and recorders shall be clearly readable by the operator from his normal working position.

19. All controls, switches, valves, and other devices shall be designed to be easily operated by the operator but not be subject to inadvertent operation.

20. The design of displays and controls should enhance functional grouping.

21. All labels shall be as brief as possible, but consistent with clarity of purpose and of systematic hierarchy based on system, subsystem, and component designation.

22. For a given function, the simpler control/device design is to be preferred over a more complex control/device.

23. Alarm systems with audio signals shall be pleasant sounding and readily detectable.

24. Where possible, primary reactor protection systems devices shall be color coded for easy identification.

25. Sufficient instrumentation shall be provided for each system subsystem to optimize that systems/subsystem's safe operational control.

Once the basis of the system review was establish by addressing the fourteen framework questions, the review team then applied the above twenty-five criteria to the system review. All possible actions of each major component of the system were reviewed based on the operator task requirements of that component. At the component level of a system (i.e., section/subsection) it should be noted that the basic operator tasks for operating that major component became the same for all modes of the plant operating conditions.

All of the above questions and criteria were used by the review team to review the interrelationship of the components at each level of the functional breakdown. Each subsystem, section and subsection was reviewed for its system function and the operator's ability to monitor and control his/her control board functions. The instrumentation and controls were also analyzed by the review team to assure the ability of the control room operator to control and monitor the system.

It should be noted that at the time of the System Factors Task Analysis, the plant procedures for both normal and emergency situations were not available. An approach to cover this part of the study was considered by the review team by using procedures developed for a similar plant. This was not adopted as there were significant differences between the two plants system's instrumentation and controls.

With the objective to perform an inventory of control board hardware and relate that to system requirements, the review team made a comparison of the subsystems, sections and subsections, against the boards for proper placement of controls and indication in the control boards to support the plant operator task. This was done to ensure that the control boards instruments and controls provided the proper information and controls to meet system requirements.

The review team also went through the motions of typical plant operations in the control room simulator. The operations consisted of startup of pumps and monitoring key variables, switch-over from one plant mode of operation to another (i.e., from Safety Injection to long term recirculation), plant load changes, turbine trips and manual control of the steam generators. During this operation an assessment was made by the review team of the time available for these tasks compared to needs for personnel.

Finally the system instruments and controls were reviewed by the team against the control boards for proper placement of the instruments and controls associated with its respective system. A summary of the systems and their resulting placement is given below:

B01 - Electric Distribution Panel

- Switch Yard
- Unit Distribution
- Diesel Generators

B02 - Engineered Safety Features

- Active Safety Injection Systems
  - High Pressure Safety Injection
  - Low Pressure Safety Injection
  - Containment Spray
- Passive Safety Injection System
  - Safety Injection Tanks
- Safety Systems Support Systems
  - Essential Spray Pond
  - Essential Cooling Water
  - Essential Chilled Water
  - Essential HVAC
  - Post Accident Monitoring System
- Safety Equipment Status System

B03 - Chemical and Volume Control Systems

- Reactor Coolant
- Charging and Letdown
- Boric Acid

B04 - Reactor Systems

- Reactor Coolant
- Reactor Control
- Pressurizer Control

B05 - Plant Protection and Condensate Systems

- Reactor Protection System
- Core Protection Calculator
- Engineered Safety Feature Actuation
- Condensate

B06 - Steam Generator/Turbine Generator Systems

- Mainsteam
- Feedwater
- Auxiliary Feedwater
- Condensate Transfer and Storage
- Turbine Generator

B07 - Miscellaneous and HVAC

- Auxiliary Steam
- Containment Purge
- Cooling Tower
- Circulating Water
- Gas Radwaste
- Plant Cooling Water
- Instrument and Service Air
- Nuclear Cooling Water

Operators Console

- Plant Monitoring Computer Interactive CRT
- Core Monitoring Computer (COLSS) Interactive CRT

Communications Console

- Radiation Monitor CRT and Typewriter
- Communication Equipment
- Fire Protection Alarm CRT
- Security Equipment.

As mentioned above, the method by which the System Factors Tasks was accomplished was by the review team conducting discussion meetings at which

time the control boards and their corresponding system functions were reviewed by discussion against the control room operator tasks. All the key points made during the discussion periods were recorded by the teams' secretary. From the discussion notes produced in the team discussion meetings the System Factors discrepancy forms were constructed.

In conclusion, it should be noted that the System Factors Tasks discovered more discrepancies than any of the other DCRDR tasks (Human Factors and Operator Preparedness). Some examples are given below:

1. The addition of a master panel for adequate indication of safety status (HED 29A).

2. The addition of a wide range level indicator for Auxilliary Feedwater and Main Feedwater (HED 89A).

3. Relocation of syncroscope to ease the use of controls used to syncronize the Diesel Generators (HED 70B).

4. Added position indication to the Demineralizer By-pass valve (31C).

5. Redesign the Safety Engineered (SESS) board to conform to control board layout (79C).

6. Replaced power factor meters with megavar meters on Panel B06 (92C).

7. Performance of a separate demarcation study.

8. Performance of the Annunciator Prioritization Study.

The following example illustrates how the System Factors review team applied the framework questions to identify system factors Human Engineering Discrepancies HED's 17 and 117. (Copies of these HED's are attached to this attachment.) The review team was in the process of reviewing the Chemical and Volume Control System, a subsystem of the Reactor System Functional Block.

The review team chairman first addressed the following two questions to the control room operators: "What is the primary function of the system?" and "What are the requirements of the system?" These questions were directed to the operators in order to obtain their perception of the system function. This was substantiated by reviewing the System Description Manual and System P&ID. The team members established and agreed on the objectives of the system being discussed.

Once agreement was obtained by the team members on the objectives of the system being discussed, the chairman addressed the following question: "Is the system related equipment mounted on the control boards readily discernable as part of the system?" This question was addressed by the review team by using the control boards photo montage and the layout drawings of the control boards. If the control room simulator was required to answer this question the review team had access to it. The above review actions in this case verified the need for providing "demarcation" boundaries.

Once an agreement was obtained by the review team, the next two questions were addressed: "How does an operator know that the system is available to perform its function?" and "How does an operator know the system is working?" At this time the review team would review all major controls (i.e., switches, lights, alarms, indicators, etc.) to determine if the operator could in fact determine system status from the actual inventory of devices located in their functional grouping sections.

Upon completion of this review and discussion, the following framework question was addressed: "What are the operational modes of the system?" When the team addressed this question in this particular case, it led to HED17 (lacking wide-range pressure and load indicators for better pressurizer control during start-up). During the discussion of the plant modes, it was determined by the review team that when drawing or collapsing a bubble in the pressurizer, insufficient information was available in the area of the charging and letdown controllers to readily allow the operator to determine that a bubble was drawn or indeed that the pressurizer bubble was collapsing. Specifically no wide range level and pressure indicators were noted by the review team during the inventory of the control boards which would provide adequate pressurizer control indication during start-up.

When the review team addressed the following question: "Can the system be easily operated when it is put in the most stressful mode of operation?" The team proceeded to define the most stressful mode and to determine the "ease of operation" from the physical arrangements of the boards (e.g., was the pump switch to the discharge pressure indication proper for ease of location and operation).

When the chairman addressed the following question, "Are there indicators and other control board devices to permit system operation from the Main Control Boards?" The review team proceeded to determine if sufficient information and controls existed on the boards to support operator tasks. In this particular case, it was discovered that insufficient indicators existed in the area of the charging and letdown controllers to readily determine that a bubble was drawn or indeed that the pressurizer was solid. The installation of wide range pressure and level indicators were recommended (HED 17).

During the addressing of the following question, "What is the relationship between alarm windows and the system?" The review team conducted a limited

review of the alarms in this particular case since the team had already determined that a separate in-depth annunciation prioritization study was required. This question was used by the review team to determine that the existing alarms were proper (nothing major lacking or excessive) and the alarm's physical locations were proper in respect to the relative control locations.

When the question, "What is the equipment lineup criteria?" was addressed by the review team, the review team verified that the physical arrangement of pump controls to valve controls, indicators, lights, etc., were proper for the various operating modes of the plant.

The following question, "What specific actions does the operator take for each system related alarm?" was another verification that the board inventory was proper on the control boards for operator alarm response.

Upon completion of discussion on the above question, the following question was addressed by the review team: "Does the system have Main Control Board equipment which is unnecessary or better located remotely?" When the review team addressed this question, it led to HED 117 (Generator Stator Ground Voltmeter and test button are in a poor location). An HED was written since the generator stator ground voltmeter and test button were in a prime control board location creating excessive clutter of the control board and contributing to reduction of operator efficiency. This question was asked by the review team in order to eliminate extraneous devices (visual noise from the control boards inventory).

The framework question, "Does the system lack any Main Control equipment?" was another question that created discussion among the review team. This question provided a cross check and verified the suitability of the devices (information and control) located on the main control boards. It should be noted that several of the above questions are redundant and diverse, this provided a means of cross checking that all considerations were given for the various modes of operation, operator tasks and control board inventory.

The final framework question, "Is the control board equipment located on the correct control board? Is it arranged on the control board in a manner to minimize human error?" This question made the review team review their overall conclusion regarding the specific system. After having been involved in the details of the system, it would have been easy for the review team to have deviated from the intended system review or lost sight of the overall objective. Therefore, this final question assured that important facts did not get lost in the details.

The review team also addressed the 25 criteria when necessary to decide a point. For example, criteria 3 established the requirement to add a wide range level and pressure indicator on Panel B03 (HED 17). Likewise, criteria

7 established, the requirement to relocate the generator stator voltmeter to a local panel (HED 117). These questions were set up to guide the review team in making certain decisions in their system's review.

COORDINATION
OF THE
PVNGS DCRDR
WITH THE
PVNGS
EMERGENCY OPERATING PROCEDURES
GENERATION PACKAGE

Coordination between the PVNGS DCRDR and the PVNGS Emergency Operating Procedures generation existed as described below.

The System Factors Task was one of the three parallel tasks that were performed as part of the PVNGS Detailed Control Room Design Review (DCRDR). The objective of the Systems Factors Task was to establish requirements of control room operator tasks (information and control) in order to determine the adequacy of the control board devices.

During the System Factors Task the following actions were completed in this order:

- System and subsystems of major systems were identified down to the level of major components.
- Functions associated with the system and subsystems were identified down to the level of major components.
- Functions were analyzed to identify the Control Room Operator tasks and their interfaces with the plant systems.
- Operators tasks were analyzed to verify information and control requirements for major components operating sequences.
- A control room inventory was performed to identify all control room devices for comparison with those identified from the operator task performance (information and control).

The above actions were completed by a multi-discipline, multi-organizational review team made up of experienced plant operators, cognizant design engineers and Human Factors Experts. The review team representatives were from the utility, Architect/Engineer, NSSS Supplier and Human Factors Consultant.

The final results of the DCRDR System Factors Task were recommendations for control board design changes. These recommendations were reviewed by the DCRDR committee which categorized them for implementation.

Upon completion of the DCRDR System Factors Task, the results of the task were made available to the PVNGS Operations Department. The PVNGS Operations Department at this time was initiating an effort to develop an outline for the PVNGS Emergency Procedures.

As a result of the above effort, the PVNGS Operations Department generated an outline called the "PVNGS Emergency Procedure Technical Guideline." This guideline was then applied to simulator walkdowns for feasibility during various anticipated operational occurences and design basis accidents. The simulator walkdowns performed by the PVNGS Operations Department took into

consideration the control board design change recommendations which resulted from the DCRDR System Factors Task.

The results of the simulator walkdowns feasibility walk-throughs were applied to the PVNGS Emergency Procedures Technical Guideline. This guideline was then reviewed via discussion by the PVNGS Operations Department which had had plant operators and department management level personnel involved in both the DCRDR System Factors Task and PVNGS DCRDR committee's. The final results of these discussions by the Operations Department evolved into the PVNGS Plant Specific Technical Guidelines.

Once the PVNGS Plant Specific Technical Guidelines were developed and established by the Operations Department, the department proceeded to develop a "Procedure Writers Guide." This Procedure Writers Guide was based on human factors experience, staffing requirements, current control room design requirements and operators' knowledge which was gained both during the Emergency Procedure development process and operations participation in both the DCRDR System Factors Task and DCRDR committees.

At this point the PVNGS Emergency Procedure and Recovery Operations Procedures were drafted by the Operations Department. The results of the DCRDR Systems Factors Task were again taken into consideration by the Operations Department during the evolution of the Emergency Procedure and Recovery Operations Procedure.

Once the Emergency Procedure and Recovery Operations Procedures were established and the approach accepted by the Operations Department; and the DCRDR System Factors Task recommendations accepted for implementation by the utilities upper management, the coordination to validate and verify the results of both programs became a separate, but parallel task. This separate but parallel task approach was taken by the Operations Department to obtain an independent validation and verification of their Emergency Operating Procedures in order to provide a check to verify the adequacy of the DCRDR System Factors Task analysis.

At approximately the same period, the DCRDR System Factors Task, performed the Control Room Validation using the Operations Department Emergency Operating Procedures (small LOCA and plant start-up procedures) to determine if the control room crew could accomplish allocated control room functions as defined on the normal operating and emergency procedures. In addition, the Control Room Validation provided the necessary check of potential human engineering discrepancies which might have been introduced as a result of the DCRDR System Factors Task Analysis.