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"EXPERIENCE
FROM OPERATING AND FUELLING
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REACTOR OPERATOR TRAINING PROGRAMS UTILIZING NUCLEAR POWER PLANT SIMULATORS

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Abstract

REACTOR OPERATOR TRAINING PROGRAMS UTILIZING NUCLEAR POWER PLANT SIMULATORS.

Individuals must obtain licences from the USAEC to operate controls of nuclear facilities in the United States of America. To obtain licences, individuals must pass USAEC examinations. Some individuals must be examined prior to initial criticality at a facility. Individuals must have extensive actual operating experience at a comparable reactor to sit for these examinations. They may obtain operating experience by completing USAEC-approved training programs that utilize nuclear power plant simulators. The USAEC has accepted four such training programs since 1969, which are administered by the nuclear power plant system vendors. The programs consist of: (1) nuclear fundamentals courses; (2) research reactor operations; (3) nuclear power plant design lectures; (4) observation at operating nuclear power plants; and (5) simulator operations.

Individuals seeking licences after plants become operational must demonstrate their proficiency at reactor controls during examinations. In 1971, the USAEC approved the use of simulators in training programs for these individuals and has utilized simulators during the examinations. These programs are limited to personnel whose control rooms closely parallel that of the simulator. The USAEC requires that licensed individuals participate in requalification programs. The program requires that licensees manipulate reactor controls through a specified number of evolutions during their licence tenures. To minimize the number of plant evolutions solely for requalification, manipulation of simulator controls is permitted, providing the simulator's operating characteristics and control room are similar to that of the facility involved. Final evaluation of the merits of using simulators in place of control manipulation at operating plants is the knowledge and understanding exhibited by trainees during the administration of examinations. USAEC examiners have found that individuals trained using simulators have a better understanding of plant responses to transient conditions and abnormal situations. Also, they have found trainees more confident when responding to questions that require prediction of plant responses to postulated situations. Also, simulators are an extremely effective means for examining and evaluating individuals. The USAEC believes that simulators, used in conjuction with comprehensive training programs, are effective training devices, and intend to encourage use in future training programs.

A. Introduction and Background

The requirement that reactor operators must demonstrate their qualifications and receive licenses from the AEC to perform their functions was established as a statutory requirement by the U. S. Atomic Energy Act of 1954.

Further, pursuant to the Act, the Regulation, Part 50, Chapter 10, Code of Federal Regulations, "Licensing of Production & Utilization Facilities," provides that the controls of any reactor licensed under Part 50 shall not be manipulated by anyone who is not a licensed operator or senior operator as provided in 10 CFR Part 55, "Operator's Licenses". Part 55 establishes the procedures and criteria for the issuance of licenses to operators and senior operators, and therefore, governs the regulatory program of operator licensing.

TABLE I. OPERATOR WRITTEN EXAMINATION CATEGORIES

A.	Principles of Reactor Operation
B.	Features of Facility Design
C.	General Operating Characteristics
D.	Instruments and Controls
E.	Safety and Emergency Systems
F.	Standard and Emergency Operating Procedures
G.	Radiation Control and Safety

TABLE II. SENIOR OPERATOR WRITTEN EXAMINATION CATEGORIES

H.	Reactor Theory
I.	Radioactive Materials Handling, Disposal and Hazards
J.	Specific Operating Characteristics
K.	Fuel Handling and Core Parameters
L.	Administrative Procedures, Conditions and Limitations

B. Types of Licenses & Examinations

The Commission presently issues two types of licenses. In general, anyone who manipulates reactor controls must be licensed as a reactor operator, while those who direct the licensed activities of licensed operators must be licensed as senior reactor operators. Practically speaking, the reactor operator in a power station would be the control room operator, and his shift supervisor would normally be the senior reactor operator. Herein, the two types will be referred to as "operator" and "senior operator."

To test the knowledge of applicants for each of these types of licenses, Commission examiners administer both written examinations and operating tests.

The written examination for the reactor operator consists of seven separate categories (Table 1), while the written examination for the senior reactor operator consists of the same seven operator categories and an additional five categories (Table II).

At a nuclear power station, the operating test normally consists of both an oral examination during a plant walk-through and an actual demonstration at the reactor console during a reactor startup. For both operators and

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TABLE III. SCOPE OF THE ORAL AND OPERATING TEST

To: Determine the Applicant's:
A. Ability to Read and Interpret Control Instrumentation.
B. Ability to Manipulate the Control Equipment.
C. Knowledge of How to Operate Other Facility Equipment.
D. Knowledge of Radiological Safety Practices and Radiation Monitoring Equipment.

senior operators, the scope of both portions of the operating test is the same (Table III), except that the senior operator is expected to give answers to questions as if he were the operator's supervisor. For example, it is expected that an operator would recognize unexpected reactor behavior and that he would notify his shift supervisor. However, the senior operator would be expected to know what to do next.

Since licensed operators must be present during the fuel loading and initial startup operation of a nuclear power station, it is necessary that some personnel receive their examinations and licenses prior to initial fuel loading at a facility. Obviously, an actual startup demonstration as part of the operating test cannot be given at this time, and reactor and plant responses can only be discussed between the applicant and the examiner.

These operating tests are commonly known as "cold" examinations, as opposed to what are called "hot" examinations which refer to the test which includes actual operation of the reactor.

C. License Applications

Each applicant for an operator or senior operator license must submit a signed application to the Commission. In addition, an authorized representative of the facility licensee at the facility where the applicant seeks a license must certify that he has need for the license, he has completed a training program (supplying the details of such) and that he has learned to operate the reactor controls in a competent and safe manner. A report of medical examination of the applicant on an AEC Form must also be submitted.

D. Eligibility for Examinations

Eligibility of an applicant for examination is determined after receipt of the application. This application must describe the training the applicant has received at this facility, and for "hot" examination applicants, indicate the startup and shutdown experience he has accumulated.

The same information is required of applicants for "cold" examinations, except the certification of actual operating experience on that reactor, which has not yet been operated at the time of the application. In lieu of this experience on his own reactor, eligibility for "cold" examination maybe determined on the basis of a certification that the applicant has had extensive operating experience at a comparable facility.

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E. Requirements for Examination Prior to Criticality (Cold)

Prior to the advent of nuclear power plant simulators our procedures for determining cold examination eligibility recognizes that an applicant has had extensive operating experience at a comparable facility by one of three methods:

a. The applicant holds or has held an operator's license at a comparable facility.

b. If the comparable facility is not subject to licensing, a certification of the necessary experiences was acceptable. Examples of such non-licensed facilities would be those reactors operated by the Department of Defense.

c. The applicant passed an AEC administered written examination and operating test at a comparable facility, but was not issued a license.

I would like to stress that most trainees receive experience in excess of the programs outlined herein acquiring the desired competence. However, we administer examinations to individuals who meet these requirements. Although methods "a" and "b" are essentially self-explanatory, the latter method need some further explanation.

When it became apparent in the United States that the number of nuclear power plants were going to increase to a rapid rate, it also became apparent that operators and senior operators could not be supplied in sufficient quantities from operating plants unless they became training facilities instead of production facilities. Consequently, the nuclear steam supply vendors proposed that training programs be developed that would assure that well qualified individuals would be available to staff the large number of plants expected to be operational commencing with the seventies.

The first program, proposed by the Westinghouse Electrical Corporation, consisted of the following:

1. A nuclear fundamentals course including the operation of a research reactor.

2. A design lecture series directed toward the facility for which he would seek a license.

3. Residence at an operating nuclear power plant for six months during which the trainees participated in day-to-day activities as well as classroom studies regarding facility. Hence, one operating plant was used as a training facility.

At the completion of the program the trainees were administered an AEC examination. Those who passed the examination were issued a certification letter stating that they had met the requirements of an operator for that facility. Licenses were not issued to these trainees. This outlines method "c".

E. Programs Utilizing Nuclear Power Plant Simulators

Although one power plant was being utilized, part time, as a training facility, it was apparent that the number of facilities that were available for training would be very limited. Consequently, the General Electric

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Company proposed that a nuclear power plant simulator be incorporated in a training program to provide trainees with the necessary control manipulation to meet our cold eligibility requirements.

Individuals who successfully complete a training program which utilizes a nuclear plant simulator will be considered eligible for "cold" examinations provided that:

a. They have completed an appropriate course in Nuclear Technology fundamentals.

b. They have manipulated the controls of any nuclear reactor throughout ten (10) complete startups.

c. They have observed several months of day-to-day operation of operating power reactors, as members of shift operating crews.

Our decision to implement these procedures is based upon several pertinent considerations, including:

a. The completeness and accuracy with which the simulators are constructed.

b. The extent to which the simulators provide various types of control room experience to the trainee, including the ability to simulate normal startup and shutdown operations, as well as a multitude of casualty drill situations.

c. The extent of operating experience of the simulator instructors.

Presently, we have approved training programs utilizing a nuclear power plant simulator for the nuclear steam supply vendors, General Electric, Westinghouse, Babcock and Wilcox and Combustion Engineering.

To determine that the simulators met the requirements of (a) and (b) above we compared the proposed simulators to the information contained in the Final Safety Analysis Report of the facility after which it was modeled and detailed drawings of the facility's control room.

Our comparison included the number of systems simulated, the degree of simulation, and the fidelity of simulation. In addition, we determined that the number and type of malfunctions were adequate for the intended training purposes.

Our final acceptance of a nuclear power plant simulator depends upon the comparison of the simulator's response to various transients to that of the plant's response as determined during the startup testing program.

Appendices 1 and 2 indicate the extent of our review, the completeness of approved simulators and the number of malfunctions programmed, and other specific simulator characteristics.

We determine the competency of the training staff by administration of senior operator examinations.

Consequently, the first use of simulators was brought about to enable the large number of trainees that were entering the nuclear industry to obtain the necessary operating experience without using an operating nuclear power plant as a training facility.

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To date, over 600 individuals have been trained at the training centers that utilize the simulators.

A unique feature of these programs transfers the certification responsibility from AEC to the training staff. We, of course, audit the programs and the evaluation process very closely. Part of our audit has consisted of administration of examinations to the initial groups of trainees.

F. Hot Eligibility

In order to be eligible to sit for an examination after a facility achieves criticality an individual must receive on-the-job training which includes plant manuevering and two reactor startups under the direct supervision of a licensed operator or senior operator in addition to formal classroom training.

During the administration of our examinations we require applicants to demonstrate their proficiency at the reactor controls by performing reactor startups from a substantially subcritical condition until generation of nuclear heat.

These startups can involve a substantial amount of down time at a facility to properly prepare individuals for examinations and for the administration of examinations. In addition, scheduling of the examinations can be complicated by unexpected requirements for power which is outside the control of the plant staff.

Consequently, we were asked to approve training programs which utilize simulators for the training startups and to conduct the control manipulation portion of our examinations using the simulator. To date, these approved training programs have been limited to personnel whose control rooms closely parallel that of the simulator. In addition to the training center maneuvering we require the applicant to have manipulated the controls of his reactor during power changes or other significant reactivity changes which may or may not include reactor startups.

These training programs require several months residence at the training center of which one month is devoted to operation of the simulator controls.

F. Renewal Eligibility

Recently, the USAEC required that licensed individuals participate in requalification programs as a condition for license renewal without reexamination. One requirement of the program is that licensees manipulate the reactor controls through at least ten reactivity changes during the two year tenure of their license. Simulators that reproduce the general operating characteristics of the facility involved and whose instrumentation and control arrangement is similar to that of the facility involved may be used to meet the manipulation requirement of the regulation. To date, we have not had the opportunity to evaluate the use of the simulators in these requalification programs.

G. Growth of Simulators in the U.S.

Because simulators are now approved for use in a variety of training programs utilities are developing their own training centers that utilize nuclear power plant simulators. To date, we have been informed that five utility training centers utilizing eight simulators will be operational by 1976. These include Tennessee Valley Authority (2), Consolidated

Edison Company of New York (1), Carolina Power and Light Company (1), Duke Power Company (1), and a joint venture by Public Service Electric and Gas Company of New Jersey, General Public Utilities and Philadelphia Electric and Gas Company (3).

H. Administration of Examinations Utilizing Simulators

During the conduct of our examinations we require the applicant to demonstrate his proficiency at the controls during normal, abnormal and emergency conditions.

First, we examine two applicants simultaneously at the control panels of the simulator. While one applicant is performing a reactor startup from a substantially subcritical condition, through criticality to some low power level, the other applicant is being interrogated regarding the remainder of the control room panels. At the completion of the first startup the applicants' roles are reversed.

Next, we request the simulator staff to initialize the simulator to a steady state power level. All pertinent controls are placed in manual. One applicant is assigned to the reactor controls and the other to the plant controls. The applicants are then required to demonstrate their proficiency during power increases and decreases. Once again, the applicants switch roles and perform additional exercises.

Not all the applicants perform the same exercises. Variations include establishing and verifying heat-up rates, loading the turbine, and conducting an orderly shutdown. Each applicant is expected to be able to perform all of these operations.

After the examiner observes an applicant's performance of normal operations, the applicant is required to demonstrate his proficiency during simulated abnormal situations. For example, during a reactor startup, the examiner observes the applicant's performance as he manipulates the controls, predicts instrument responses and establishes reactor periods. Then, malfunctions are initiated, such as a rod drift or nuclear instrumentation failure, and the applicant's response is evaluated. After loading the turbine, the bypass valves are failed full open or closed as power is increased. On several occasions the examiner "reports" via telephone that an incident is happening in the plant which required control room action pursuant to facility procedures or technical specifications.

Usually, the examinar concluded by initiating a scram, except where the applicants had scrammed because of a previous malfunction, and once again the applicant's performance is evaluated.

The examinations also include assigning applicants to perform the function of senior operators. During such time they are expected to direct the activities of the operators during abnormal situations. The examination for two applicants requires between three and four hours to complete.

We have examined a total of 99 applicants; 30 operators and 69 senior operators. About half of these individuals have had previous operating experience. Five of the thirty operator applicants failed the operating portion of the examination. Fourteen of the senior operator applicants failed the operating portion of the examination at the senior operator level, but seven passed at the operator level. Hence, 87 applicants out of 99, or 87.5%, of those examined at the simulator demonstrated, to our satisfaction their ability to read and interpret the control instrumentation, manipulate the reactor controls in a safe and competent manner, and their knowledge of how to operate the facility, including operation under emergency conditions.

For those individuals that failed this portion of the examination, the principal deficiencies noted were unfamiliarity with the normal and emergency procedures, inability to explain what information was being displayed on meters and recorders and what use to make of this information; inability to manipulate the controls properly during normal operation, improper operator action during an abnormal occurrence, and, to use simulator terminology, a complete "freeze" during emergency situations.

Those that failed the operating portion of the test at the senior operator level were not able to demonstrate to our satisfaction their awareness of the overall situation or their ability to direct the activities of the operators during abnormal situations. Nor did they exhibit the depth of knowledge required of senior operators regarding the administrative controls, procedures and technical specifications for their facility.

I. Advantages and Disadvantages of the NFPS

By using the simulator for conducting examinations we are able to observe the applicants actually perform several normal and abnormal operations. This is beneficial to the examiner and the applicant because the evaluation of the individual is based on many procedures rather than a few, as is necessary during a talk-through of normal and abnormal operations. A second advantage is that the examiner can observe the operator monitoring rapidly changing parameters and exercising complete control over a given abnormal situation; whereas in a talk-through of an abnormal or emergency situation, each changing parameter must be discussed separately from the others and the priority the operator would place on his actions is difficult to determine.

We observed an excellent correlation of the results of the written examinations and plant walk-throughs with the observed performances at the NFPS. Those who performed unsatisfactorily at the simulator also indicated marginal or inadequate knowledge during the remainder of the oral test. Those who performed adequately at the simulator also passed the written examination and balance of the oral test.

Some disadvantages have been noted in conducting examinations using the simulator, but many, if not all of these, can be eliminated as the development of these training tools continues.

First, we found that procedures had not been prepared for all the casualties that were programmed. Hence, in some cases, the examiner had to evaluate an applicant's performance based on his own knowledge of proper operating techniques rather than on an approved facility procedure. In cases where examiner was in doubt as to the appropriateness of the operator's actions, consultations were held with facility management prior to making a final evaluation of these actions.

The length of the initial examinations were somewhat longer than the normal "cold" examination. The simulator portion required between three and four hours and the remaining oral portion about four hours. In part, this was because continuity of examination was not possible since the plant construction was not sufficiently complete at the time of initial simulator examinations. Different examiners conducted the simulator portion and oral portion of the examination for the same individual. I believe this resulted, at times, in an applicant explaining some systems and procedures more than once. However, more recent examinations during which we utilized the simulator indicate that the time required for the examination is comparable to the time required for cold examinations that do not use a simulator.

J. Cold Examination Results

In addition to administering cold examinations utilizing the simulator, we have administered cold examinations to individuals who had received training at the NPPS training center. These examinations were administered at the individual's plant and we followed our normal cold operating test procedures. During the administration of these examinations the examiners found the applicants to be more confident in predicting reactor and plant response to given normal and abnormal operations than were other applicants who had not attended the NPPS training center. Also, they exhibited a greater understanding of normal and emergency procedures. Based on our experience to date we have determined that the simulator is a useful training tool and examining device.

Conclusion

The training of nuclear power plant operators, like the design, construction and operation of these reactors, has evolved considerably during the past decade. Improved techniques for training, such as the nuclear plant simulator, have been and should continue to be developed.

We have kept abreast of all training developments and have tried to cooperate to the fullest extent with facility licensees in the consideration of such techniques as they apply to the training and licensing of operators. We shall continue to encourage, and to facilitate use of, all improvements which maintain or enhance the competence of operating personnel.

APPENDIX A

COMPARISON OF THE GENERAL ELECTRIC
NUCLEAR POWER PLANT SIMULATOR TO
THE DRESDEN UNIT NO. 2
FINAL SAFETY ANALYSIS REPORT

BWR SIMULATORS

DEGREE OF SIMULATION VS MODELED PLANT

	SYSTEM OR MALFUNCTION	GE
FSAR-CH. 3 Reactor	Reactor and Core	a
	Control Rod Drive System	a
FSAR-CH. 4 Reactor Coolant System	Recirculation System	a
	Isolation Condenser	a
FSAR-CH. 5 Containment Systems	Primary Containment System	a
	Secondary Containment System	e
FSAR-CH. 6 Engineered Safeguards	Core Spray Subsystem	a
	LPCI/Containment Coolant Subsystem	a
	HPCI	a
	Automatic Pressure Relief Subsystem	a
	Standby Liquid Control System	d^3
	Containment Atmospheric (inerting) Control System	e
FSAR-CH. 7 Control and Instrumen-	Control Rod Control System	a
	Recirculation Flow Control System	a

KEY: a - Full Simulation
b - Partial Simulation
c - On-off Simulation
d - Mocked-up panels
e - Non-existent or not simulated

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Appendix A (cont.)

	SYSTEM OR MALFUNCTION	GE
	Reactor Pressure Control System	a
	Nuclear Instrumentation	a
	Process Computer	a
	Reactor Vessel Instrumentation	a
	Radiation Monitoring	b[2]
	Reactor Protection System	a
	Containment Isolation System	a
	Turbine Generator Control System	a
	Feedwater Control System	a
	Rod Worth Minimizer	a
FSAR-CH. 8 Electrical	345 Kv	a
	138 KV	a
	4160 V	a
	480 V	a
	120/208 V	a
	125 V DC Station Batteries	c[1]
	Diesel Generators	a
	250 V DC Station Batteries	c[1]
	48/24 V DC	c[1]
FSAR-CH. 9 Radwaste System	Gaseous Radioactive Waste System	b
	Liquid Radioactive Waste System	e
	Radiation Monitoring Systems	b[2]

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Appendix A (cont.)

	SYSTEM OR MALFUNCTION	GE
FSAR-CH. 10 Auxiliaries	Fuel Pool Cooling and Cleanup System	e
	Reactor Water Cleanup System	a
	Reactor Shutdown Cooling System	a
	Reactor Vessel Head Cooling System	a
	Instrument and Service Air System	e
	Service Water System	e
	RBCCW	e
	Makeup Water System	e
FSAR-CH. 11 Turbine and Condensate Systems	Turbine	a
	Feedwater	a
	Condensate	a
FSAR-CH. 14 Incidents	Control Rod Drop	e
	Main Steamline Break Outside Drywell	a
	Loss of Coolant	a
	Startup of Cold Recirculation Loop	e
	Recirculation Pump Trip	a
	Flow Controller Malfunction	a
	Main Steam Isolation Valve Closure	e
	Feedwater Controller Malfunction	a
	Turbine Trip with Failure of Bypass	e
	Turbine Stop Valve Trip with Partial Bypass	a
	Turbine Pressure Regulator Malfunction	a

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Appendix A (cont.)

	SYSTEM OR MALFUNCTION	GE
	Loss of Main Condenser Vacuum	b[4]
	Loss of Electrical Load	a
	Loss of Auxiliary Power	a
	Failure of One Diesel Generator	a
	Power Bus Loss of Voltage	a
Number of Malfunctions Associated with Given Systems	Generator	5
	Electrical	6
	Turbine	12
	Pressure Regulator	4
	Off Gas	1
	Feedwater and Condensate System	7
	Condenser	2
	Nuclear Instrumentation	12
	Reactor Protection System	2
	Control Rod Drive System	15
	Radiation Monitoring	5
	Reactor and Main Steam	7
	Recirculation System	10
	Auxiliaries	3
	Engineered Safeguards	1
Simulator Capabilities	Backtrack	a
	Freeze	a
	Snapshot	e[5]
	Fast Time	e
	Slow Time	e[6]
	Time Delay Malfunctions	e
	Initialization Points	19

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BWR FOOTNOTES (APPENDIX A)

1. Simulator has annunciator panels only with no modeling to computer.
2. Process Radiation Monitoring System - air ejector off gas, main steam line, and stack gas radiation levels are recorded. These radiation levels are modelled by computer. Back panel drawers for calibration and source check are not at simulator. Process liquid monitor not included on simulator.

   Area Radiation Monitoring System - Multipoint recorder with common high radiation alarm. Isolation condenser vent monitor modelled for tube leak. Other points not modelled.
3. Switches, meters, indicating light provided on control board. Response of system is not modelled.
4. Capability of failing sealing steam which results in slow loss of vacuum.
5. Not now but will install. They are putting in line printer for recall.
6. Doesn't have slow time as such but can walk through a transient by repeatedly pushing and releasing freeze button.

APPENDIX B

COMPARISON OF PRESSURIZED WATER
NUCLEAR POWER PLANT SIMULATORS
TO FINAL SAFETY ANALYSIS REPORTS

SIMULATOR	POWER PLANT
Westinghouse (W)	Zion Unit No. 1
Babcock & Wilcox (B&W)	SMUD Unit No. 1
Combustion Engineering (CE)	Calvert Cliffs Unit No. 1

PWR SIMULATORS

DEGREE OF SIMULATION VS MODELED PLANT

	SYSTEM OR MALFUNCTION	W	B&W	CE
FSAR-CH. 3 Reactor	Reactor	a	a[8]	a
	Control Rod Drives	a	a	a
FSAR-CH. 4 Reactor Coolant System	Reactor Fluid System	a	a	a
	Reactor Coolant Pumps	a	a	a
	Pressurizer	a	a	a
	Quench Tank	a	a	a
	Steam Generators	a	a	a
FSAR-CH. 5 Structures	Containment Isolation System	a	a	a[16]
FSAR-CH. 6 Engineered Safety Features	HPSI	b[2]	a	a[17]
	LPSI	b[2]	a	a
	Safety Injection Tanks	b[2]	a	a
	Containment Spray	a	a	a
	Containment Air Recirc. and Cooling System	a	a	a
	Containment Iodine Removal System	e	NA	a
	Hydrogen Control System	NA[26]	NA	e[18]

KEY:
- a - Full Simulation
- b - Partial Simulation
- c - On-Off Simulation
- d - Mocked-up panels
- e - Non-Existent or Not Simulated
- NA - Not Applicable

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Appendix B (cont.)

	SYSTEM OR MALFUNCTION	W	B&W	CE
FSAR-CH.7 Instrumentation and Control	Reactor Protective System	a	a	a
	Reactor Regulating System	a[5]	a	a
	Reactor Pressure Regulating System	a	a	a
	Pressurizer Level Regulating System	a	a	a
	Feedwater Regulating System	a	a	a
	Steam Dump and Turbine Bypass System	a	a	a
	Turbine Runback	a	a	a
	Turbine Generator Control System	a	a	a
	Nuclear Instrumentation	a[6]	a	a
	In-core Instrumentation System	b[7]	b[14]	e
FSAR-CH. 8 Electrical Systems	13,900 Volt System	NA	a	a
	6900 Volt System	NA	a	NA
	4160 Volt System	a	a[10]	a
	480 Volt System	a	a	a
	125 Volt D.C. System	c	a[9]	e[21]
	120 Volt Vital A.C. System	d[30]	a[9]	e[21]
	Main Generator	a	a	a
	345 KV Ring Bus	b[4]	NA	NA
	25.3 KV System	a	NA	NA
	Emergency Diesel Generators	a	a	a
	Station Control Batteries	e	e	e
	Turbine Generator Coastdown	a	a	NA[32]
FSAR-CH. 9 Auxiliary Systems	Chemical and Volume Control System	a	a	a
	Shutdown Cooling System	a[1]	a	a

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Appendix B (cont.)

	SYSTEM OR MALFUNCTION	W	B&W	CE
	Circulating Water System	a	a	a
	Spent Fuel Pool Cooling System	e	e	a
	Component Cooling Water System	a	b[27]	a
	Service Water System	a	a	a
	Salt Water System (Nuclear Service Raw Water System)	NA	c[11]	a
	Station Ventilation Systems	e	d	b[22]
	Instrument Air System	e	b[28]	a
	On-line Computer	e	b[29]	e[19]
	Generator Hydrogen Cooling	a	a	a
	Generator Station Cooling	b[3]	a	a
	Generator Hydrogen Seal Oil	a	a	d
FSAR-CH. 10 Steam and Power Conversion	Main Steam System	a	a	a
	Condensate System (Includes Heater Drain System)	a	a	a
	Feedwater System	a	a	a
	Aux. Feedwater System	a	a	a
	Condenser Vacuum System	a	a	a
	Air Ejectors and Gland Exhaust	a	a	a
FSAR-CH. 11 Waste Processing and Radiation Protection	Liquid Radwaste System	e	a[12]	e
	Gaseous Radwaste System	e	e	e
	Radiation Monitoring System	a	b[13]	e[20]
FSAR-CH. 14 Incidents	Uncompensated Operating Reactivity Changes	NA	a	a
	Startup Accident	a	a	a
	Rod Withdrawal at Rated Power	a	a	a
	Moderator Dilution	Na	a	a

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Appendix B (cont.)

	SYSTEM OR MALFUNCTION	W	B&W	CE
	Cold Water Accident	a	a	a
	Loss of Coolant flow	a	a	a
	Stuck Rod	a	a	a
	Rod Drop	a	a	a
	Loss of Electric Power	a	a	a
	Steam Line Failure	a	a	a
	Steam Generator Tube Rupture	a	a	a
	Control Rod Ejection	e	e	a
	Loss-of-Coolant Accident	a	a	a
	Letdown Line Rupture	NA	a	a
	MHA	a	e[15]	a
	Loss-of-Load	a	a	a
	Loss of Feedwater	a	a	a
	Excess Loads	a	e	a
	Waste Gas Incident	e	e	e
	CVCS Malfunction	a	a	a
	Turbine Generator Accidents	a	a	a
	Waste Liquid Release	e	e	e
Number of Malfunctions Associated With Given Systems (23)	Control Rod Drive System	9	2	9
	Reactor Protective System	0	1	3
	Reactor Regulating System	2	5	2
	Nuclear Instrumentation	7	3	4
	Pressurizer	5	5	6
	Primary System (Leakage)	2	1	2
	Reactor Coolant Pumps	3	6	7
	Chemical and Volume Control System	9	8	10
	Auxiliary Systems (Water and Comp. Air)	4	7	7

Appendix B (cont.)

	SYSTEM OR MALFUNCTION	W	B&W	CE
	Steam Generators and Main Steam	9	4	8
	Turbine	2	5	8
	Feedwater and Condensate Systems	7	5	9
	Condenser	2	1	3
	Engineered Safeguards	3	3	8
	Electrical	4	4	9
	Radiation Monitoring	6	0	2
	Isolation System	0	0	1
	Fuel	0	1	1
	Flux	0	1	0
Simulator Capabilities	Backtrack	a	e[31]	a
	Freeze	a	a	a
	Snapshot	a	e[31]	a
	Fast Time	e	a	a
	Slow Time	e	a	a
	Time Delay Malfunctions	a	a	a
	Initialization Points	20[24]	16	20[25]

PWR FOOTNOTES (APPENDIX B)

1. 100% based on original layout of RHR. New version of RHR with changes to ECCS system is not simulated at this time but will be operable within this year.

2. 98% simulated based on system prior to new ECCS criteria. New ECCS system will be programmed and operable this year.

3. 75% simulated. Pump controls, automatic starts, and associated communicators are available but no temperature effects are programmed from a total loss of stator cooling.

4. 40% simulated. Only 2 of 6 lines connected to the ring are operable.

5. 100% simulation with exception of two malfunction associated annunciators whicn are being added in near future.

6. 100% simulation from control board. The "operation selector" switches on the source, intermediate and power range instrument drawers are not operable. Work is under way at this time to make all front panel controls operable.

7. 90% simulated. Flux distributions for malfunction not calibrated at present time.

8. The core simulated in the NPPS is rated 2568 MWt and the core in the Rancho Seco plant is rated 2772 MWt. Other than this difference, the simulation is a complete modeling of the core's performance as a heat source and reactivity insertion effects.

9. The 120 V AC and DC busses are simulated, however, there is no operator indication.

10. The major notable difference is that the Rancho Seco plant has two circulating water systems whereas the NPPS has only one.

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11. Console controls start and stop service pumps and cause pressure in the headers to show either "normal" or "zero".

12. The simulated liquid waste system is a simplified system from that being installed at Rancho Seco and is similar to the system used in the Duke Power Company Oconee plants. The Rancho Seco radioactive waste system is unique and essentially all other B&W NSS have utilized a system similar to the one simulated on NPPS.

13. 5 RMS channels simulated. The systems monitored are letdown, component cooling water, air ejector outlet, reactor building and station ventilation exhaust.

14. The NPPS contains 8 incore tubes and has 4 detectors in each tube. This is not as complete a system as installed on central station plants.

15. They simulate a double ended break of a 36" main coolant pipe; however, they also state that the MHA is not simulated.

16. Remote operated valves.

17. 12 local, normal valves can be operated from the instructor's console with appropriate control room response.

18. System added after simulator design was frozen.

19. Interlocks, alarms or indications for CEA drive system are simulated.

20. Certain interlocks or protective actions are simulated based on radiation levels, but indication of radiation levels in the plant are not.

21. Malfunctions are provided for loss of one 125 V DC and loss of one 120 V AC vital bus.

22. 25% ventilation equipment operated by the engineered safety features actuation system is simulated.

23. The numbers can be misleading. In most cases where fewer malfunctions are shown, the capability exists to fail or affect any one of multiple units which, if listed separately, would raise the total.

24. From 7-9-70 report—17 prexamined and 3 snapshot available. Appears to be good mix of power, xenon and burnup.

25. Reactor power not preprogrammed for intermediate powers, goes from 15% to 100%. Xenon is either at peak or equilibrium. Burnup either 10%, 50% or 90%.

26. Presently accomplished at Zion by venting only. Portable skid mounted recombiner units are being purchased. FSAR doesn't indicate any control room readout or control.

27. Loss of CCW will not cause temperature alarms on the components (CRD's, RCP's, etc.) cooled. An interlock prevents starting of components unless the CCW is operating. One exception is the Letdown Heat Exchanger for which the heat balance is simulated. Loss of CCW to this component will cause increasing letdown temperature and eventual isolation of letdown.

28. Compressors and indicators shown for instrument air system but not modelled to show effect of loss of air.

29. Data acquisition only - no trending capability except typewriter printout.

30. It is assumed to be on. Has indicating lights but there is no control over it.

31. Future plans are to add backtrack and snapshot capabilities.

32. This feature was removed from Calvert Cliffs plant.

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REFERENCES

[1] United States Code of Federal Regulations, Title 10, Part 50 and Part 55.

[2] AEC Licensing Guide - Operators' Licenses WASH 1094.

[3] American National Standard, ANSI-N18.1-1971 Selection and Training of Nuclear Power Plant Personnel.

DISCUSSION

S.F. COAKLEY: Are there are any regulations in the United States of America regarding the basic educational attainments of candidates applying for an operator's or a senior operator's licence? What tests are imposed to ensure the psychological stability of applicants?

D.J. SKOVHOLT: There is no stipulated requirement in our actual regulations, but our practice, which follows the recommendations of Standard N 18.1, is that candidates should have an education of high-school level or its equivalent.

Each application for a licence or for renewal thereof must be accompanied by a report of medical examination on a form prescribed by us. Part of the report is a medical history filled out by the applicant and the rest is an examination report by a physician of his choice. There is no routine requirement to test psychological stability, but there are items on the report which could suggest potential problems of this type. When our physicians review the medical reports, they look out for this kind of thing, and if they consider it necessary we call for a further examination by an appropriate medical specialist. Such an occurrence is rare but not unknown.

M. BROSSON: What is the operating experience of the examiners? Also, what is the relative importance of the three parts of the qualifying examination — written, oral and the tests on a simulator?

D.J. SKOVHOLT: Virtually all examiners have several years' experience in the supervision of reactor operations. This experience is not necessarily at nuclear power generating stations. In many cases it was at AEC production reactors, at high-flux testing reactors or in nuclear ships of the United States Navy.

Under our rules, an applicant must pass both the written examination and the operating-oral examination separately in order to receive his licence. Certainly, the performance demonstration at a comprehensive simulator has greatly increased the value of that portion of the test, as compared with the operating test at an actual station.

K.E.A. EFFAT: To what extent is a research reactor facility essential in such training programs?

D.J. SKOVHOLT: Research reactor are often used in teaching what we call the "nuclear fundamentals". This method provides an excellent opportunity for the candidate to see the theory he is learning reflected in an actual facility.

A.A. TOUREN: An operator's licence being valid for two years, has he to take a full examination in order to renew it, or is a simple test enough?

D.J. SKOVHOLT: Until recently, our practice ways that if an operator had been engaged actively in reactor operations during the two years, if there was no reason to question his continued competence, and if the facility management certified him to be capable, we would generally renew his licence without any re-examination. If he did not meet these criteria, an examination, usually a partial one, was given. About a month ago we changed our rules and now require that the operator participate in a requalification program, approved by the AEC, in order to be eligible for renewal of his licence without re-examination.

P.H. DAURES: What are the percentages of success and failure in the operator licensing examination?

D.J. SKOVHOLT: The failure rate is 15% for candidates taking the examination for the first time. Those who fail the first time are allowed to repeat the examination after two months, at which time the success rate is very high. Candidates failing a second and a third time have to wait for six months and two years, respectively, before re-applying. We thus encourage them to be very well prepared.

P.H. DAURES: Is the failure rate high among operators applying for renewal of their licences (every two years)?

D.J. SKOVHOLT: When an operator is asked to take a fresh licensing examination, it is generally because he has not worked satisfactorily or has long been absent from operation. It is found that many such persons decline to take the examination.

A. PALMGREN: In your paper you state the requirement that the simulator response and control room lay-out should closely correspond to those of the actual plant. Doesn't this create quite a problem? Do you not have to construct a simulator for every plant?

D.J. SKOVHOLT: The simulator must be reasonably realistic and complete with respect to the plant it is modelled after. We want to have the simulator teachers give instruction in operation of the plant, not operation of the simulator! It is of course not economically feasible to have a simulator at every plant, and obviously there are matters which must be taught additionally at the trainees' own plant if they have been trained at a simulator modelled after some other facility. Nevertheless, training at a simulator relating to a fairly comparable plant is highly beneficial.

A.G. KELLY: What is the pass mark in the operator licensing examinations?

D.J. SKOVHOLT: The pass mark for the written examinations is 70%. There is no clear pass grade for the oral-operating examination, since numerical grades are not used. A large number of attributes and capabilities are evaluated and the examiners exercise their judgement in determing the adequacy of the total performance.

H. HUBER: Before obtaining the nuclear power plant operator's licence, the candidates have to attend theoretical and practical training courses. According to US experience, what duration should these courses have in order to impart adequate training before personnel take the examinations?

D.J. SKOVHOLT: The approximate duration of each part of the training, which I can give you here only from memory, is as follows. The nuclear fundamentals course takes eight to twelve weeks. The practical training, including routine operations and observation at an operating nuclear power station as a shift crew member, lasts three to four months. At the simulator training centre the candidate spends at least 50% of the time at simulator controls and the remainder of the total of eight to sixteen weeks in the classroom.

All the above stages of training should be completed at least one year before the station goes into operation, since the personnel should be at the

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station during that period. There are two reasons for this. First, their services are needed during the pre-operational testing of the facility. Second, participation in pre-operational testing and procedure preparation and trial is a valuable final phase of the training program.

C. HUYS: Is it correct that the American National Standard you have referred to recommends that the management staff and plant superintendents should have the senior reactor operator's licence? If so, does this mean that they have to undergo the same training and pass the same examinations?

D.J. SKOVHOLT: Yes, the document recommends that certain management personnel concerned with day-to-day plant operations should possess the senior operator's licence to demonstrate this aspect of their qualifications. This class of personnel receives the same training and takes the same examinations as any other senior operator applicant. But possession of the senior operator's licence does not in itself imply full qualification for these higher positions.

Y.G. GONEN: Could you please give an estimate of the costs of training an operator and a senior operator? What is the training given to operators in reactor maintenance (including routine operations such as refuelling)?

D.J. SKOVHOLT: I have no data on the total cost of training for the entire training period. It is usually considered to be several tens of thousands of dollars. For the part constituted by training at a simulator training centre, a rough estimate would be 10 - 20 000 dollars, depending on the length of the training period and other details.

Operators are not normally expected to carry out maintenance tasks as such, but an operator is expected to perform, and usually does perform refuelling activities; his training and our examinations therefore include this aspect.