REACTOR OPERATOR TRAINING PROGRAMS UTILIZING NUCLEAR POWER PLANT SIMULATORS

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Abstract

The Nuclear Regulatory Commission (NRC) requires that all operators of the controls of nuclear facilities be licensed. Applicants for licenses must pass written examinations and operating tests administered by NRC. Some individuals must be examined prior to initial criticality at a facility, while others must have had extensive actual operating experience at a comparable reactor to sit for these examinations. Operating experience may be obtained through approved training programs that utilize nuclear power plant simulators. Since 1969, NRC's predecessor, the USAEC, has accepted four such training programs that are administered by the nuclear power plant system vendors. The programs consist of (1) nuclear fundamentals courses, (2) research reactor operation, (3) nuclear power plant design lectures, (4) observation at operating nuclear power plants, and (5) simulator operations.

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Individuals seeking licenses 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 and during the examinations. These programs are limited to personnel from facilities having control rooms that are closely parallel to that of the simulator. NRC also requires that licensed individuals participate in requalification programs that require licensees to manipulate reactor controls through a specified number of evolutions during their license 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 rather than operating plants is the knowledge and understanding exhibited by trainees during the administration of examinations. NRC examiners have found that individuals trained using simulators have a better understanding of plant responses to transient conditions and abnormal situations and also are more confident in answering questions that require prediction of plant responses to postulated situations. Also, simulators are extremely effective for examining and evaluating individuals. NRC believes that simulators, used in conjunction with comprehensive training programs, are effective training devices and intend to encourage their use in future training programs.

The requirement that reactor operators must demonstrate their qualifications and receive licenses from the NRC to perform their functions was established as a statutory requirement by the U.S. Atomic Energy Act of 1954.[1] Further, R 1

pursuant to the Act, the Code of Federal Regulations, Part 50, Chapter 10, Licensing of Production and Utilization Facilities,[2] provides that the controls of any reactor licensed under Part 50 shall not be manipulated by anyone who is not a licensed operator or a senior operator as provided in 10 CFR Part 55, Operator's Licenses.[3] 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. R 2 R 3

This article reviews U.S. experience in the use of nuclear power plant simulators in reactor operator training programs. The article was updated from a paper[4] that was presented at the 1973 IAEA Symposium on Experience from Operation and Fueling of Nuclear Power Plants. R 4

TYPES OF LICENSES AND EXAMINATIONS

The Commission presently issues two types of licenses.[5] In general, anyone who manipulates reactor controls must be licensed as a reactor operator, and those who direct the 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." R 5

The Commission examiners administer both written and operating examinations to test the knowledge of applicants for licenses. The written examination for the operator consists of the following seven

categories:

1. principles of reactor operation,
2. features of facility design,
3. general operating characteristics,
4. instrumentation and controls,
5. safety and emergency systems,
6. standard and emergency operating procedures,
7. radiation control and safety.

The written examination for the senior operator consists of the above seven categories plus the following:

1. reactor theory,
2. radioactive materials handling, disposal, and hazards,
3. specific operating characteristics,
4. fuel handling and core parameters,
5. administrative procedures, conditions, and limitations.

The operating test at a nuclear power station normally consists of both an oral examination during a plant walk-through and an actual demonstration at the reactor console during a reactor startup. The scope of both portions of the operating test is the same for both operators and senior operators, except that the senior operator is expected to answer questions as if he were the operator's supervisor. The scope of the oral and operating test consists of (1) reading and interpretation of control instrumentation, (2) manipulation of the control equipment, (3) ability to operate

other facility equipment, and (4) knowledge of radiological safety practices and radiation monitoring equipment. An operator would be expected to recognize abnormal reactor behavior and notify his shift supervisor, whereas the senior operator would be expected to know what to do.

Some personnel must receive their examinations and licenses prior to initial fuel loading and startup of a facility, since licensed operators must be present at this time. 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 "hot" examinations, which refer to the test that includes actual operation of the reactor.

LICENSE APPLICATION AND ELIGIBILITY

Applicants for operator or senior operator licenses must submit a signed application to the Commission. In addition, an authorized representative of the facility at which the applicant will be working must certify that the applicant has a need for the license, has completed a training program (supplying the details of such), and has learned to operate the reactor controls competently and safely. A report of medical examination of the applicant on an NRC form must also be submitted.

Eligibility of an applicant for examination is determined after receipt of the application. The 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.

Similar information is required of applicants for "cold" examinations, except the certification of actual operating experience on the reactor. In lieu of this experience on the reactor, eligibility for "cold" examination may be determined on the basis of certification that the applicant has had extensive operating experience at a comparable facility.

REQUIREMENTS FOR EXAMINATION PRIOR TO CRITICALITY
(COLD EXAMINATION)

Prior to the advent of nuclear power plant simulators, an applicant was eligible for cold examination provided (1) he had or had held an operator's license at a comparable facility; (2) he had a certification of the necessary experiences if the comparable facility was not subject to licensing (e.g., reactors operated by the Department of Defense); or (3) he had passed an NRC-administered written examination and operating test at a comparable facility but was not issued a license.

It should be stressed that most trainees receive experience in excess of the programs outlined herein to acquire the desired competence. However, examinations are administered to individuals who meet these requirements. Methods 1 and 2 are essentially self-explanatory, but the method 3 needs further explanation.

When it became apparent in the United States that the number of nuclear power plants were going to increase at a rapid rate, it also became apparent that sufficient operators and senior operators could not be supplied from operating plants unless the plants became training facilities instead of

production facilities. Consequently, the nuclear steam supply system (NSSS) vendors proposed that training programs be developed that would assure the availibility of well-qualified individuals to staff the large number of plants expected to become operational in the seventies.

The first program, proposed by the Westinghouse Electric Corporation consisted of (1) a nuclear fundamentals course, including the operation of a research reactor; (2) a design lecture series directed toward the facility for which the license was needed, and (3) residence at an operating nuclear power plant for 6 months where the trainees would participate in day-to-day activities as well as classroom studies. Hence, one operating plant was used as a training facility.

At the completion of the program, the trainees were administered an AEC examination, and those who passed 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 3.

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

Individuals who successfully complete a training program that utilizes a nuclear plant simulator will be considered eligible for cold examinations provided that they have completed an appropriate course in nuclear technology fundamentals, they have manipulated the controls of any nuclear reactor throughout ten complete startups, and they have observed several months of daily operation of power reactors as members of shift operating crews.

The decision to implement these procedures is based on several pertinent considerations, including (1) the completeness and accuracy with which the simulators are constructed; (2) 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 and a multitude of casualty drill situations; and (3) the extent of operating experience of the simulator instructors.

Presently, training programs utilizing nuclear power plant simulators are in effect for the NSSS vendors General Electric, Westinghouse, Babcock and Wilcox, and Combustion Engineering. To determine that the simulators met the requirements of (1) and (2) above, they were compared with the information in the Final Safety Analysis Report of the facility after which it was modeled and with detailed drawings of the facility's control room. The comparison included the number of systems simulated, the degree of simulation, and the fidelity of simulation. In addition, the number and type of malfunctions were evaluated as to their adequacy for the intended training purposes.

Final acceptance of a nuclear power plant simulator depends on the comparison of the simulator's response to various transients with that of the plant's response as determined during the startup testing program. The competency of the training staff is determined by senior operator examinations.

Thus, 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. To date, over 900 individuals have been trained at the centers that utilize the simulators. A unique feature of these programs is that the certification responsibility is transferred from NRC to the training staff. Of course, the programs and the evaluation process are audited very closely. Part of the audit consists of administration of examinations to the initial groups of trainees.

REQUIREMENTS FOR HOT EXAMINATION

First Method

In order to be eligible for an examination after a facility achieves criticality, an individual must receive on-the-job training that includes plant maneuvering 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 examinations, applicants must 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 downtime at a facility to properly prepare individuals for examinations and to administer examinations. In addition, scheduling of the examinations can be complicated by unexpected requirement for power, which is outside the control of the plant staff.

Second Method

Thus, NRC has approved of training programs that utilize simulators for the training startups and for the control manipulation portion of our examinations. To date, these programs have been limited to personnel of plants having control rooms that closely resemble that of the simulator. In addition to the training center maneuvering, the applicant must have manipulated the controls of a reactor during power changes or other significant reactivity changes that may or may not include reactor startups. These training programs require several months residence at the training center, one of which is devoted to operation of the simulator controls.

Third Method

NRC has determined that it is acceptable to use nuclear power plant simulators in determining the qualifications of individuals who apply for licenses after initial criticality.

The Operator Licensing Branch will consider training programs that utilize appropriate nuclear power plant simulators for startup experience

for meeting the eligibility requirements of examinations. In addition, a reactor startup will not be required as part of the operating test, providing that appropriate certification regarding an individual's ability to manipulate the controls is contained in his application.

In order for the applicant to be eligible for this alternate program, the following requirements must be met.

1. The applicant must have manipulated the controls of his reactor facility during five significant reactivity changes that may or may not include reactor startups.

2. The applicant must have participated in an NRC-approved training program that includes training at a nuclear power plant simulator.

3. The application must contain a certification from the simulator training center attesting to the applicant's ability to manipulate the controls and keep the reactor under control during a reactor startup, predict instrument response and use the instrumentation during a reactor startup, follow the facility startup procedure, and explain alarms and annunciators during this operation.

The simulators used in the programs must meet the present requirements for simulators in Paragraph 3.e, Appendix A, 10 CFR Part 55, namely, that the simulator reproduce the general operating characteristics of the facility involved and that the arrangement of instrumentation and controls of the simulator is similar to that of the facility involved.

REQUIREMENTS FOR LICENSE RENEWAL

Recently, the NRC required that licensed individuals participate in requalification programs as a condition for license renewal without reexamination. One requirement of the program is that licensees must have manipulated the reactor controls through at least ten reactivity changes during the 2-year tenure of their license. Simulators that reproduce the general operating characteristics of the facility involved and have an instrumentation and control arrangement similar to that of the facility involved may be used to meet the manipulation requirement of the regulation. To date, the use of the simulators in these requalification programs has not been evaluated.

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. Five utility training centers utilizing eight simulators are scheduled to be operational by 1976. These include the 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).

ADMINISTRATION OF EXAMINATIONS UTILIZING SIMULATORS

During the examinations, the applicant must demonstrate his proficiency at the controls during normal, abnormal, and emergency conditions. First, two applicants are examined 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 is being interrogated regarding the remainder of the control room panels. At the completion of the first startup, the roles are reversed.

Next, the simulator staff is requested to initialize the simulator to a steady-state power level. All pertinent controls are placed in manual, and 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 heatup rates, loading the turbine, and conducting an orderly shutdown. However, 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 must 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

such as a rod drift or nuclear instrumentation failure are initiated, 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 requires control room action pursuant to facility procedures or technical specifications. Usually, the examiner concludes by initiating a scram, except where the applicants have scrammed because of a previous malfunction, and once again evaluates the applicant's performance.

The examinations also include assigning applicants to the role 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 3 and 4 hr.

ADVANTAGES AND DISADVANTAGES OF THE SIMULATORS

One advantage of the simulator in examinations is that the examiner can 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; in a talk-through of an abnormal or emergency situation, each changing parameter must be discussed separately, and the priority the operator would place on his actions is difficult to determine.

There has been an excellent correlation of the results of the written examinations and plant walk-throughs with the performances at the simulators. 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, can be eliminated as the development of these training tools continues. First, 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 the 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.

The initial examinations were somewhat longer than the normal cold examination. The simulator portion required between 3 and 4 hr and the remaining oral portion about 4 hr. This was partly due to the fact the plant construction was not sufficiently complete at the time of inital simulator examinations. Different examiners conducted the simulator portion and oral portion of the examination for the same individual. This resulted, at times, in an applicant explaining some systems and procedures more than once. However, more recent examinations utilizing 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.

COLD EXAMINATION RESULTS

In addition to cold examinations utilizing the simulator, cold examinations have been administered to individuals who had received training at the simulator training center. These examinations were administered at the individual's plant following the normal cold operating test procedures. During the administration of these examinations, the examiners found that the applicants were more confident in predicting reactor and plant response to given normal and abnormal operations than applicants who had not attended the training center. Also, they exhibited a greater understanding of normal and emergency procedures. Based on experience to date, NRC has 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 power plant simulator, have been and should continue to be developed.

NRC has 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. NRC shall continue to encourage and to facilitate the use of any improvements that maintain or enhance the competence of operating personnel.

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