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COMPTROLLER GENERAL OF THE UNITED STATES
WASHINGTON, D.C. 20548

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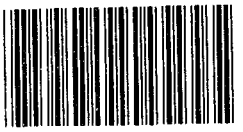
American Nuclear Society DLG01599



The Honorable Richard S. Schweiker
United States Senate

Dear Senator Schweiker:

This report responds to your April 19, 1979, request for a prompt analysis of the Nuclear Regulatory Commission's program for licensing nuclear powerplant operators. As you indicated, information from the Three Mile Island nuclear accident and from other nuclear plants has raised questions concerning the Commission's program.

In responding to your request, we have answered the specific questions that you had asked. Moreover, our review has resulted in questions beyond those you asked which we believe must be answered to assure that this important element of nuclear powerplant operation is being carried out safely. These questions are discussed in the text of this report although we were unable to answer them because of the short time frame for carrying out your request. But we believe the questions should be raised in a public forum now so that other parties--the President's recently appointed Commission investigating the Three Mile Island accident, the Nuclear Regulatory Commission, and congressional committees--can consider them in carrying out their studies of the Three Mile Island accident and related matters.

HUMAN/OPERATOR ERROR AT THREE MILE ISLAND AND OTHER NUCLEAR POWERPLANTS

A/C ABC01340

The specific events that caused the nuclear accident at the Three Mile Island powerplant are being carefully evaluated by the Commission, in particular the Office of Inspection and Enforcement. However, the Chairman of the NRC Commission and the Director of the Office of Nuclear Reactor Regulation have publicly stated that human error was a major contributor to the accident at Three Mile Island. ABC00984 Because officials of the Commission's Office of Inspection and Enforcement are currently performing their official investigation, they refused to make available to us any specific information being generated. In their opinion, their investigation would be impeded if specific

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facts were released prematurely. Commission officials did offer to brief us continuously on the status of their inquiry.

While the principal causes of the Three Mile Island nuclear accident are tentative, documentation shows that human/operator error has occurred at other commercial nuclear powerplants. According to the Commission's statistics, human error accounted for 18 percent of all reportable incidents in 1978, with specific operator error accounting for one-third of that percentage. Human error could involve errors that were caused by a nuclear facilities' management, maintenance, and other technical personnel who are not required to be licensed by the Commission. Operator error relates only to those personnel who are licensed to operate a nuclear reactor. Although we cannot provide specific information on the human/operator errors at the Three Mile Island powerplant, we have described two other examples of human/operator errors at powerplants to illustrate the nature of such errors.

Rancho Seco Nuclear Plant, California, March 1978

On March 20, 1978, Rancho Seco experienced a severe cool-down caused by the loss of electrical power to a substantial portion of the nonnuclear instrumentation. The loss of electrical power was caused when a control room operator began replacing a burned-out light bulb on one of the control consoles. To change the light bulb, the light assembly was pulled out from the panel and flipped down, exposing the bulbs. During the change, a bulb was dropped into the open light assembly cavity, creating an electrical short.

Later investigations by the utility showed that approximately two-thirds of the nonnuclear instrumentation signals were affected by the power loss. Erroneous signals provided faulty information to both the control room and the integrated (computerized) control system. The integrated control system cut off all main feedwater flow in response to faulty signals. The cutoff in feedwater flow caused the reactor cooling system pressure to increase and the reactor to trip or shut down.

In the period following the reactor shutdown, the operators still were hampered by the lack of instrumentation and by equipment responding to inaccurate signals. These false signals had several effects. It was difficult for the operators to ascertain which indications were valid, given the

changing plant conditions and the wide variety of possible errors that were introduced. Only a select few parameters were known to be valid readings, and the operators had to control the plant based on that information. The second effect was that false signals were fed into the integrated control system, so equipment was operated without regard to actual conditions.

Power was finally restored to the nonnuclear instrumentation 1 hour and 10 minutes after the reactor trip, which permitted proper operator response to plant conditions. By this time, the reactor cooling system had dropped to around 285 degrees Fahrenheit. This meant that the reactor had cooled approximately 300 degrees Fahrenheit per hour, which was well in excess of the technical specifications. Immediate action was taken to return the temperature to the permissible heat range.

Following this accident, engineers from Babcock and Wilcox--designers of the plant--investigated the matter and recommended that a closer look be made of operator training as it relates to loss of nonnuclear instrumentation power. Subsequently, the Commission agreed on March 24 that the plant could restart power for commercial operation if the Babcock and Wilcox recommendations were followed.

Calvert Cliffs Unit 1,
Lusby, Maryland, December 1975

A plant operator discovered that a manually operated water supply valve to two auxiliary feedwater pumps was shut; thus, both pumps did not have a supply of water. Because this was a manually operated valve, there were no control panel indications that the valve had been closed. At least one auxiliary feedwater pump must operate to remove heat from the reactor if the main feedwater system should fail. The utility analyzed this "occurrence" and concluded that a plant operator erred about 2 weeks earlier when valve positions were changed. The utility also concluded that had operation of the auxiliary feedwater pumps been required, "it is highly probable" that the operator would have noticed the lack of water supply to the pumps prior to any serious damage occurring.

ORIGINS OF THE COMMISSION'S OPERATOR LICENSING PROGRAM

Personnel with various levels of qualifications form the organization that operates a commercial nuclear power plant. The operating utility consists of onsite personnel

concerned with the day-to-day operation of the plant, maintenance, and certain related technical services. The levels of the operating organization normally include managers, supervisors, professional-technical staff, control room operators, technicians, and repairmen. However, the Commission licenses only those persons who physically manipulate reactor controls (operators) and those persons who direct the activities of licensed operators (senior operators).

The Atomic Energy Act of 1954 established the requirement that individuals who operate nuclear reactors not owned by the Government must be licensed. Section 107 of that act required that the Atomic Energy Commission prescribe uniform conditions for licensing individuals as operators, determine the qualification of such individuals, and issue licenses to such individuals in such form as the Commission may prescribe.

The implementing regulations that were developed required that the controls of a nuclear powerplant would be manipulated only by individuals who were licensed under title 10 of the Code of Federal Regulations, Part 55, relating to operators' licenses. This regulation established the procedures and criteria for issuance of licenses to operators. Part 55 was amended in 1963 to require certain individuals to hold senior operator licenses and was amended again in 1973 to require operators and senior operators to participate in requalification programs as a condition for license renewal without reexamination. The Energy Reorganization Act of 1974, in amending the Atomic Energy Act, retained the requirements for licensed operators and senior operators and authorized the Nuclear Regulatory Commission to issue operator and senior operator licenses.

ELIGIBILITY REQUIREMENTS FOR OPERATORS

The NRC Commission has no minimum eligibility requirements for either type of operator. Instead, the Commission, as part of a regulatory guide to the nuclear industry, endorses a standard established by the American Nuclear Society 1/ pertaining to selection and training of nuclear powerplant personnel. The standard is intended as a guide and does not preclude anyone from not conforming to it. The

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1/A nonprofit professional society interested in furthering nuclear standards throughout the world.

following recommendations are made in the standard for individuals requiring licenses.

Operator:

a. High-school graduate or equivalent.

b. Two years of powerplant experience or its equivalent, provided that a minimum of 1 year is at a nuclear powerplant.

Senior operator:

a. High-school graduate or equivalent.

b. Four years of responsible powerplant experience, of which a minimum of 1 year must be nuclear powerplant experience. A maximum of 2 years of the remaining 3 years of powerplant experience can be fulfilled by academic or related technical training on a one-for-one basis.

In addition to recommendations concerning education and experience, the standard says minimum health requirements shall be established for operating personnel. The Commission requires each applicant for an operator or a senior operator license to complete a certificate of medical history. Besides asking the applicant to answer for himself such questions on the certification as "Have you ever seriously considered committing suicide?", the applicant's eyes, ears, heart, blood pressure, and pulse must be examined by a physician.

GAO questions

1. The Commission has no minimum eligibility requirements but endorses recommendations made by the American Nuclear Society. Should the Commission have minimum eligibility requirements? If so, what should those requirements be?

2. Is a person with a high school education suited to operate the controls of a nuclear powerplant? Should that person be better educated?

3. The term "equivalent" high school education is not defined. Should it have a specific meaning?

4. "Powerplant experience" can pertain to that experience acquired during any stage of a powerplant's

life including the design and the construction. Should "powerplant experience" be more specifically defined?

5. The term "responsible powerplant experience," when referring to a senior operator, is not defined. Should it have a specific meaning?

6. Should medical examinations for nuclear powerplant operators be more stringent? Should psychological profiles be developed for these operators, analyzing their response capabilities in stress situations?

TRAINING PROGRAM FOR OPERATORS

A training program, together with a training schedule prior to reactor startup, is developed by the utility and submitted to the Commission for a paper review and approval. Usually the training program for applicants with no previous nuclear experience starts 2 years before fuel loading and covers a period of 14 to 17 months. Applicants who have previous nuclear experience are phased in at the proper times in accordance with their experience.

Typically, there are four phases to the training program. In phase I, a basic course which normally lasts 12 weeks is usually presented to the applicants by a local university. The course includes approximately 10 weeks of basic study, which includes nuclear physics, health physics, chemistry, and plant technology. The study program is followed by 2 weeks of practical operational training on a nuclear training or research reactor, where the applicants participate in various experiments and manipulate the controls during 10 reactor startups.

In phase II, the applicants receive both observation and simulator training. Observation training involves observing the day-to-day operation of a nuclear powerplant. This training is conducted by the plant operating organization. During the observation training, the applicant observes various operations, surveillance testing, and the practical aspects of the radiation protection program. The training period varies from 1 to 3 months. In conjunction with plant observation, the applicant receives training on a powerplant simulator.

Simulator training varies from 2 to 3 months and is usually given by the manufacturer of the reactor or by the utility, if it has its own simulator. While at the

simulator, the applicant observes and participates in the various phases of powerplant operations (such as reactor startups and power-level changes) and learns to use normal procedures and, to a lesser extent, other procedures to cope with abnormal and emergency conditions.

In phase III, training consists of a lecture series, given by the plant operating organization, to familiarize the applicant with the design features of his plant. This phase normally takes 6 weeks. During phase IV, the applicant must successfully complete a Commission approved onsite training program that covers information on the plant for which he seeks a license. In addition to classroom training, the applicant will engage in the day-to-day activities, such as procedure writing, construction check-out, and pre-operational testing, for a period of approximately 1 year prior to fuel loading. The time spent in this phase varies according to the experience of the applicant; however, the minimum required time is 6 months.

After the plant has become operational, it may be necessary for the utility to train replacement applicants because of turnover in personnel. These applicants would go through the same four-phase training program already mentioned, except they do not necessarily go through the observation and simulator program. The Commission believes that the replacement applicants have probably been at the plant for a couple of years and participated in all the pre-critical check-out of the equipment and startup testing of the plant. Thus all their training would be received at the plant site. Normally the training program for replacement applicants covers a period of 6 to 8 months.

GAO questions

1. The Commission basically performs a paper-review of a utility's training program. Should the Commission establish its own minimum training requirements? Should the Commission have its staff personally inspect the training program?

2. The plant operating organization is very much involved in training operator applicants. Should the Commission review and approve the individuals who give this training?

3. Only about six utilities have their own simulators. Should the Commission require that each utility have a simulator onsite so that operators can continually improve their skills?

4. It appears that there are no specific criteria on what the simulator training should include. Should such criteria exist and what should the criteria be?

5. Abnormal conditions are given lesser attention in the simulator training program. Should this be expanded?

6. Replacement applicants do not necessarily participate in the simulator training program. Should it be a requirement that they do so?

OPERATOR EXAMINATIONS

Regulation Title 10 of the Code of Federal Regulations, Part 55, states that an application for an operator's license will be approved if the Commission finds that among other things, the applicant has passed a written examination and operating test as may be prescribed by the Commission. These examinations will determine whether the applicant has learned to operate, and in the case of a senior operator, to operate and direct the licensed activities of licensed operators in a competent and safe manner.

The written examination for reactor operators consists of seven categories 1/ and generally requires 6 to 8 hours to complete. Written and oral examinations are revised each time they are given at a particular nuclear facility. However, the questions are always selected from the same standard body of questions. Most of the questions require essay type answers. The written examination for senior operators consists of the same seven categories as for the reactor operator plus an additional five. Approximately 4 to 6 hours are required to complete the five senior categories, which include reactor theory and specific operating characteristics. The principal difference between the reactor operator and senior operator examinations is that the five senior categories are more difficult and more indepth about powerplant operation.

The typical operating test takes from 4 to 6 hours and proceeds as follows. First, the examiner explores the applicant's knowledge of reactivity effects, theory of operation, and radiation protection practices and procedures.

1/Examples include principles of reactor operation and features of facility design.

The major portion of the operating test, however, is conducted in the control room. At a minimum the examiner will have the applicant talk through the startup, indicating controls and instrumentation used in taking the reactor to criticality. The examiner also determines the applicant's knowledge of how to operate the facility under emergency conditions. This is accomplished by postulating symptoms of an incident to the applicant. From the symptoms the applicant must determine the type of incident that has occurred and indicate the immediate actions required by procedure.

The final phase of the operating test is touring the plant with the applicant. During the plant tour the applicant must review local procedures and demonstrate his knowledge and understanding of local plant operations. Typical systems explored include electrical control centers, diesel generators, engineered safety features, plant instrument air systems, and selected operating equipment.

GAO questions

1. The difference between the examination given to the senior operator and the operator appears ill-defined. Questions asked of an applicant for a senior operator's license supposedly are more difficult and more indepth. Should specific criteria be developed addressing the difference in degree of the difficulty and complexity?

2. The examiners who prepare, give, and evaluate the examinations are not all Commission employees--they are often part-time consultants who work full-time for the national laboratories. Often these part-time examiners themselves have not taken commercial powerplant licensing examinations, and do not hold licenses. Many have not had experience in commercial nuclear powerplants. Many have not been through simulator training for nuclear powerplants. Is this appropriate? Can this lead to examination problems?

3. An average score of 70 percent overall is passing on the written examination. However, a person could fail one or more categories and still pass overall. Is this appropriate?

4. A person who fails one or more parts of the written examination but passes overall does not have to receive additional training on those parts that he failed. Is this appropriate?

5. Approximately 90 percent of those persons who take the written examination pass on the first try. Is the examination too easy and should it be revised?

OPERATOR RETRAINING AND RELICENSING

If an individual is denied his senior operator application, an evaluation is made to determine if he should be licensed as an operator. If he passed the operator's written examination and demonstrated sufficient knowledge and understanding at an operator level, he is issued an operator's license. If an individual fails to pass his written examination, the operator test, or both, he may file a new application to be retested 2 months after the date he was denied a license. An applicant may file a third application 6 months after the date of denial of his second application, and may file further successive applications 2 years after the date of denial of each prior application.

At license renewal time (a period of 2 years), the licensee submits an application supported by his utility management and the Commission issues a renewal license provided there is evidence in the application that the person has (1) actively and extensively engaged as an operator or as a senior operator under his existing license, (2) has discharged his responsibilities competently and safely, and (3) is capable of continuing to do so. The phrase "actively engaged," in this context, is interpreted by the Commission as having reported to the plant on a daily basis.

Also, there must be evidence that the licensee has successfully participated in a requalification program. This program is administered by the utility and audited by the Commission for its quality. It must include an oral and written examination of each licensee. On the written examination the Commission requires that anybody who gets less than 80 percent in a given category should go to a preplanned lecture on that subject. The criteria for additional training in the program is that if an individual gets less than 70 percent in the annual written exam or has an unsatisfactory performance on the oral examination, he must go into accelerated training. If lacking in both areas, he is prohibited from performing licensed duties.

Other parts of the requalification program require that each operator manipulate the controls at least 10 times in a 2-year period and participate in walk-through-type drills, including emergency drills. Manipulating the controls means startups, orderly shutdowns, and power changes.

Lastly, the Commission requires documentation that each licensee review procedure changes, license requirements, and design changes.

GAO questions

1. The Commission requires that a nuclear powerplant operator undergo examination once a year. Is 1 year or a much shorter period appropriate? For example, the Federal Aviation Administration requires that airline pilots be reexamined every 6 months.

2. Nuclear powerplant management, maintenance, and other technical personnel are not required to be licensed. Only the operators are required to hold licenses to manipulate the controls of a powerplant. Since virtually many, if not all, of the unlicensed personnel may critically affect plant operation, should other plant personnel also be required to hold licenses?

3. Licensee event reports identify errors or other problems that develop in reactor operations. When an operator makes an error, it has to be reported to the Commission through a licensee event report. However, the reports do not provide the names of operators who commit the errors. Therefore, it appears that the Commission cannot maintain operational error records based on what specific operators committed the errors. How effective is this? How can the Commission effectively monitor operator errors?

4. In completing licensee event reports, the utilities have considerable discretion in how they classify each event. Should the Commission require more specific details so that it can clearly distinguish human/operator error from a technical design problem?

5. To a large extent, the Commission relies on utility management to certify that an operator should have his license renewed. Should the Commission independently check this certification?

ENFORCEMENT OF THE OPERATOR LICENSING PROGRAM

After a control room operator has been licensed, he can be removed from that position if it was found that he committed a deliberate and willful act in violation of the Commission's regulations. Usually, utility management makes the initial decision to remove an operator, followed by a Commission investigation. At that point, the operator's license may be suspended until such time as the operator has successfully completed a reexamination. Under certain circumstances, the operator's license may even be permanently revoked depending upon the severity of the violation. Of the 2,533 licensed operators, the Commission has suspended 1 operator's license, and required 6 other operators to be reexamined.

There are two ways by which the Commission audits the requalification program. In one, personnel from the Operator Licensing Branch visit the facility once every 2 years and look at samples of the requalification exams. These exams are checked by evaluating the quality of the questions and rescoring several categories of the exams. In cases where the Commission has been dissatisfied with the requalification exams, Commission reexaminations have been given.

In the second phase, personnel from the Office of Inspection and Enforcement visit each facility once a year and assure that commitments made in the requalification program are being carried out. They check that everybody participated in the requalification training program, manipulated the controls the minimum acceptable number of times, and completed the yearly examinations and lecture courses, as required.

GAO questions

1. The Commission has found it necessary to suspend one operator's license and require six other operators to be reexamined. What criteria has the Commission established to determine if enforcement action must be taken against an operator?

2. In light of the apparently low number of enforcement actions and high percentage of operator errors, should the Commission's criteria for enforcement action be strengthened?

3. How effective are the utilities in self-enforcing operator violations?

CONTROL ROOM OPERATION

The typical control room at a commercial nuclear powerplant may be a room approximately 25 feet wide by 40 feet long. Covering the length of the room on both sides are control panels with lights and indicators monitoring every aspect of powerplant operation. Personnel within the control room continually oversee the control panels, checking for normal as well as abnormal conditions.

Most commercial nuclear powerplants operate on a five- or six-shift basis per week. On every shift, minimum requirements at a single unit plant are one senior operator, two licensed operators, and two auxiliary nonlicensees. Regulations require only one licensed operator in the control room at all times. A majority of the time, according to a Commission official, there are two licensed operators in the control room.

According to information obtained from the Commission, a profile of a control room operator would be a person 34 years old with 7 years of operating experience, and a high school education.

GAO questions

1. Control rooms in nuclear powerplants are not standardized. There are often considerable variations in the controls of the facilities. If the controls were standardized by the Commission, would this make operations easier for the operators? Would there be less chance for error?

2. Commission regulations require that only one licensed operator be in the control room at all times. Should the Commission amend its regulations and require that a senior operator plus one or more additional operators be continually present?

3. Commission regulations do not require that a nuclear engineer be on duty at a nuclear powerplant at all times. If this were required, there would be one "key" individual available at all times to cope with an emergency situation that may require nuclear engineering knowledge. Should this be required?

4. When a new nuclear powerplant becomes operational, the Commission has statistics which indicate that approximately 30 personnel are assigned to operate

the facility. However, the statistics indicate that many times as few as six operators have had actual commercial powerplant operating experience. Is this a sufficient number?

ACTIONS TAKEN BY THE NUCLEAR REGULATORY COMMISSION ON THE NUCLEAR POWERPLANT OPERATOR LICENSING PROGRAM

The Commission (NRC) recently has acknowledged that its powerplant operator licensing program needs considerable improvement. The Director of the Office of Nuclear Reactor Regulation acknowledged before the Three Mile Island accident that there were problems with the program, and actions were being taken to correct the problems. The Commission previously had contracted to have two independent evaluations of their operator training and licensing program. Both studies are still underway.

The same Commission official stated that the accident at Three Mile Island has compounded the existing problems, and clearly shows that the entire operator licensing program needs reexamination. The Chairman of the Commission also has recently stated that he had thought before the accident that operator training was adequate to prevent such incidents, but after the accident stated "that is clearly not the case."

As a result of the Three Mile Island accident, the Commission has taken the following immediate action to improve the operator program. The Commission (NRC) instructed the operators of all light water power reactors to review and understand the apparent operational error that led to the Three Mile Island accident. Specifically, the Commission has instructed the operators not to: (1) override the automatic action of their engineered plant safety features unless the continued operation of the safety features will result in unsafe plant conditions and (2) make operational decisions based solely on a single plant parameter indication where one or more confirmatory indications are available.

The Commission has also initiated a comprehensive evaluation of the overall operator licensing program.[1] This will be a reexamination of all aspects of the program. The Commission has not established a deadline for completing the evaluation, although it indicated that it would take at least several months to complete.

IN LOOKING AT HUMAN/OPERATOR ERRORS MORE COMPLEX PROBLEMS SHOULD NOT BE OVERLOOKED

Although much attention is now being directed at human/operator errors in nuclear powerplants, it is very important to be aware of the possibility of much more complex problems arising in nuclear powerplants. Specifically, the possibility exists that there may be technical design inadequacies.

For example, on January 8, 1979, a Commission inspector wrote a memorandum stating that there appeared to be generic safety problems with Babcock and Wilcox designed nuclear plants. The regional inspector asked that his memorandum be forwarded to the Atomic Safety and Licensing Boards 1/ for their consideration during licensing hearings. In response to this memorandum, the Commission's Division of Reactor Operations Inspection stated that, based on a preliminary evaluation, the warnings of the regional inspector did not "appear to be new issues or to put a different light on the issues and, therefore . . . do not meet the intended criteria for Board notification." In essence, the safety concerns of the regional inspector were not considered to be relevant and material. However, because the regional inspector insisted that these safety concerns be presented to the Atomic Safety and Licensing Boards, the Division recommended that the Boards be so notified.

On March 6, 1979, the Commission's Assistant Director for Light Water Reactors also recommended that those Atomic Safety and Licensing Boards with jurisdiction over Babcock and Wilcox designed plants be informed of the regional inspector's safety concerns. He specifically recommended that the Board for the Three Mile Island powerplant be informed.

We were told by Commission officials that the Three Mile Island Board did not receive the regional inspector's safety concerns until March 29, 1979--the day after the accident occurred. We were unable to determine what action, if any, has been taken by the Atomic Safety and Licensing Board. Since the accident, the Commission and those utilities operating Babcock and Wilcox designed plants agreed to

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1/An independent board which has a key role in the Commission's licensing and decisionmaking process.

close the plants until they could determine the specific causes of the accident.

CONCLUSIONS

Although the Commission is still analyzing the causes and effects of the Three Mile Island nuclear accident, it is clear that human/operator errors have been a problem at other nuclear powerplants. Based upon our limited review of the Commission's operator licensing program, and upon the number of human/operator error-related accidents in the past, we believe that the operator licensing program should be completely reevaluated. Commission officials have agreed that a complete reevaluation of the operator licensing program is needed, and have acknowledged that such an evaluation will be made.

The Nuclear Regulatory Commission and the recently appointed Presidential Commission should give attention to the specific questions ~~that we have~~ raised in this letter. We would like to point out to these organizations, however, that their investigations should take special precautions to assure that the potential for design and other generic weaknesses is not eclipsed by the emphasis on human error.

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As arranged with your office, unless you publicly announce its contents earlier, we plan no further distribution of this report until 3 days from the date of the report. At that time we will send copies to the President's recently appointed Commission investigating the Three Mile Island accident, the Nuclear Regulatory Commission, to interested congressional committees, and others upon request.

Sincerely yours,

Comptroller General
of the United States