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Report to the Honorable
Alfonse M. D'Amato
U.S. Senate

August 1987

NUCLEAR REGULATION

Efforts to Ensure Nuclear Power Plant Safety Can Be Strengthened

GAO/RCED-87-141

GAO United States
General Accounting Office
Washington, D.C. 20548

Resources, Community, and
Economic Development Division

B-226879

August 13, 1987

The Honorable Alfonse M. D'Amato
United States Senate

Dear Senator D'Amato:

This report responds to your May 2, 1986, request. You asked us to review the Nuclear Regulatory Commission's efforts to provide the public with reasonable assurance that nuclear power plants in this country operate safely and asked us to determine how the Commission enforces its safety regulations. You also wanted to know what actions the Commission takes when it finds that utilities are not complying with regulatory requirements.

Unless you publicly announce its contents earlier, we plan no further distribution of this report until 30 days from its date of issuance. At that time, we will send copies to appropriate congressional committees; the Chairman of the Commission; and the Director, Office of Management and Budget. We will also make copies available to others upon request.

This work was performed under the direction of Keith O. Fultz, Associate Director. Other major contributors are listed in appendix I.

Sincerely yours,

J. Dexter Peach
Assistant Comptroller General

Executive Summary

Purpose

In April 1986 a nuclear accident occurred near Chernobyl in the Soviet Union. As a result, many in government, industry, and the public expressed renewed interest in the safety of nuclear power plants in the United States. To determine whether the Nuclear Regulatory Commission (NRC) ensures that nuclear power plants are constructed and operated safely, Senator Alfonse D'Amato asked GAO to assess NRC's safety standards, enforcement activities, and inspection efforts. (See ch. 1.)

Background

Under the Atomic Energy Act of 1954, NRC and the electric utilities share the responsibility of ensuring that nuclear plants are constructed properly and operated safely. NRC issues rules and regulations (standards) and licenses for the construction and operation of the plants, inspects the plants to ensure compliance with the standards and the licenses, and requires corrective action for deficiencies found. Also, NRC can shut a plant down if it presents an undue risk to public health and safety. The utilities establish plant-specific quality assurance programs that include training, safety, and self-assessment procedures.

To carry out its regulatory responsibilities, NRC headquarters develops policies, standards, and guides as prescribed by the agency's five commissioners. NRC's five regional offices implement the policies and procedures established. NRC has also assigned at least one inspector to each of the 107 operating plants to oversee day-to-day activities.

Results in Brief

The Atomic Energy Act allows NRC to shut plants down when safety problems pose an undue public health and safety risk, but NRC lacks guidelines to determine when to shut a plant down. As a result, although NRC ordered a few plants shutdown, it did not take this action for other plants with similar problems.

In fiscal years 1985 and 1986, NRC identified more generic safety issues—potential design, construction, or operating problems affecting groups of plants—than it resolved. NRC takes from several months to 10 or more years to resolve these issues. The longer these issues remain open, the longer plants may not operate as safely as they could.

Each year NRC regional and plant inspectors find thousands of safety violations. However, NRC headquarters does not consolidate the information to evaluate safety trends and/or determine the status of corrective actions taken by the utilities.

Principal Findings

NRC Lacks Guidelines

NRC does not have guidelines that provide the utilities notice that a plant has safety or management problems severe enough to warrant NRC's shutting the plant down. The Atomic Energy Act allows NRC to take this action when reasonable assurance does not exist that the plants operate safely. However, NRC's commissioners cannot agree on the specific types and/or degree of safety problems that could endanger public health and safety such that NRC would require the utility to cease operations at a plant.

GAO reviewed the operating history of five plants and found that despite records of chronic safety violations, NRC did not close them. With only one exception, a safety incident occurred that made continued operation impossible or the utilities shut them down when the problems grew severe. NRC's Director of Nuclear Regulatory Research pointed out that the decision to shut a plant down must be made on a case-by-case basis. Although GAO agrees that the ultimate shutdown decision has to be made on an individual plant basis, NRC still needs to provide utilities clear signals on the types of safety and management problems that could result in a shutdown.

In this regard, GAO notes that while NRC has shut down five operating plants over the past 25 years, its decisions to close these plants or allow continued operations look inconsistent because it did not take the same action for other plants with similar problems.

Safety Standards

NRC's safety standards do not, nor are they required by law to, eliminate all risks associated with nuclear power plant operations. Since NRC recognizes that the plants pose some risk to public health and safety, it requires them to have back-up safety systems, conducts research to identify causes and consequences of accidents, systematically analyzes some older plants to determine if they meet current safety standards, and identifies generic safety problems, which may indicate a need for new standards.

However, NRC may take from several months to 10 or more years to resolve (identify and approve a solution for) generic issues, including those NRC believes pose the highest safety risk. As of December 1986, NRC had a backlog of 163 unresolved generic issues, including 32 considered to pose a significant risk to public health and safety. In addition, during fiscal years 1985 and 1986, NRC identified 41 issues but resolved only 32 issues. The longer these issues remain open, the less assurance NRC has that safety standards are up to date and the plants are operating safely. Previously, GAO recommended that NRC assess ways to eliminate the backlog of unresolved generic issues. NRC has recently started to do so. (See ch. 2.)

Violations Found

NRC finds safety violations through its plant inspections. Between fiscal years 1981 and 1986, NRC found 12,170 safety violations; NRC categorized 477 as posing the more significant safety risk. Although NRC's regional offices may know the status of corrective actions taken by the utilities in response to the violations found, NRC headquarters does not routinely consolidate the regional information for program management purposes. GAO believes that this information would be useful to NRC management and its commissioners for evaluating safety trends and assessing the effectiveness of its inspection and enforcement programs. (See ch. 4.)

Recommendations

GAO recommends that the Chairman, NRC,

- develop guidelines to use as a framework in deciding the types and/or degree of safety problems that constitute undue risk such that NRC would consider shutting a plant down and
- annually develop consolidated information for all operating plants showing the status of corrective actions planned or taken by the utilities.

Agency Comments

GAO discussed the facts presented in this report with NRC staff. Generally, the staff agreed with the facts but did offer some clarifications that were incorporated where appropriate. As requested, GAO did not ask NRC to review and comment officially on this report.

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Abbreviations

GAO	General Accounting Office
IAEA	International Atomic Energy Agency
NEA	Nuclear Energy Agency
NRC	Nuclear Regulatory Commission
RCED	Resources, Community, and Economic Development Division (GAO)
SALP	Systematic Assessment of Licensee Performance
TVA	Tennessee Valley Authority

Introduction

The April 1986 nuclear accident near Chernobyl in the Soviet Union caused many in this country and abroad to question the adequacy of nuclear safety standards. As of December 31, 1986, 26 countries had an estimated 380 operating nuclear power plants. Currently, this country has 107 operating plants.

The Atomic Energy Act of 1954, as amended (42 U.S.C. 2011), allows—and encourages—electric utilities to build and operate nuclear power plants and requires the Nuclear Regulatory Commission (NRC) to ensure that industry uses, safeguards, transports, and disposes of nuclear materials in a safe and environmentally acceptable manner. NRC accomplishes its purposes by (1) issuing licenses for nuclear power plant construction and operation and other nuclear material uses, (2) issuing rules and regulations governing licensed activities, (3) inspecting its licensees, and (4) taking enforcement actions including issuing notices of violations and imposing civil penalties (fines).

NRC's Organization for Regulating Nuclear Safety

NRC's mission is to ensure that nuclear power plant activities are conducted in a manner that protects public health and safety. To carry out this mission, NRC regulates both the construction and operation of nuclear plants. Five commissioners appointed by the President and confirmed by the Senate head NRC; one of the commissioners is appointed as chairman. The commissioners establish NRC's policies, rules, and regulations, and approve or disapprove license applications and other regulatory proceedings that come before it. The commissioners have five staff offices and three advisory committees to assist them.

In addition, NRC has an Executive Director for Operations, whose staff of about 3,000 people review license applications, conduct inspections, manage research programs, monitor the nuclear utility industry activities, and perform other support functions. The Executive Director for Operations, who reports directly to NRC's Chairman, directs and coordinates the operational and administrative activities of the program and support staff offices. The Executive Director also coordinates the development of policy options for the commissioners' consideration. Until its recent reorganization, NRC had four program offices, including the Office of Nuclear Material Safety and Safeguards, that regulate the processing, transporting, and handling of nuclear materials used by nuclear power plants. The other three, which are the subject of this report, are discussed below.[1]

Office of Nuclear Reactor Regulation

This office licenses nuclear power plants; it grants the utility a construction permit to begin plant construction and an operating license before the plant begins operations. The office reviews license applications to ensure that each plant can be built and operated without undue risk to public health and safety and monitors the plants over their operating lives. This office also issues orders of various types to power plant licensees to require compliance with safety regulations in one or several areas. From January 1981 to April 1987, NRC staff said that NRC issued approximately 500 to 600 orders that were almost entirely related to improving plant design, not operations. This office also provides guidance to the regional offices, which issue confirmatory action letters to document a licensee's agreement to take certain actions to remove significant health and safety, environmental, or safeguards concerns.

Office of Nuclear Regulatory Research

The Office of Nuclear Regulatory Research plans and conducts a research and standards development program to support NRC's licensing and regulatory functions and to respond to current and future NRC needs. The program covers such areas as facility operation, engineering technology, accident evaluation, probabilistic risk analysis, plant siting, worker and public health and safety, and waste management. This office sets standards (new and revised) for plant construction and operation, conducts safety research to confirm the adequacy of regulatory requirements (standards), and resolves safety issues that arise from NRC's or the utilities' inspection programs.

Office of Inspection and Enforcement

NRC's inspection and enforcement programs verify whether utilities comply with applicable regulatory requirements. NRC's headquarters develops and promulgates inspection policies and procedures, conducts some inspections, and assesses the effectiveness of inspection programs carried out by NRC's five regional offices. NRC's five regional offices conduct announced and unannounced inspections to ensure compliance with the plant's license and technical specifications, the Atomic Energy Act, and NRC's rules and regulations. In addition, NRC has resident inspectors,

[1] NRC reorganized its regulatory programs on April 12, 1987, after we had completed our review. Because our report refers to the activities of NRC units before the reorganization, we have described the old organizational structure in this section. The reorganization is discussed at the end of this section.

located at each of the 107 operating plants, who monitor day-to-day activities. According to NRC's 1984 and 1985 annual reports, it conducted about 3,660 and 4,350 inspections of nuclear power plants under construction or operating, respectively.

NRC requires utilities to take corrective actions for safety violations found during the inspections. To do this, NRC primarily uses three types of enforcement actions: (1) Notices of Violations generally for all detected instances of noncompliance with NRC requirements, (2) civil penalties (fines) in instances of significant or repetitive noncompliance or when a Notice of Violation has not been effective, and (3) orders to suspend, modify, or revoke licenses for serious cases, such as when NRC finds that a plant's construction did not comply with its approved design. In addition, NRC sends letters, conducts meetings, and/or requires improvement programs for inspection deficiencies.

On April 12, 1987, NRC reorganized its regulatory programs because of the changing nature of its work. Under the reorganization, NRC abolished the Office of Inspection and Enforcement and divided its duties between three other offices. The inspection duties were transferred to NRC's Office of Nuclear Reactor Regulation and Office of Nuclear Material Safety and Safeguards; enforcement functions were transferred to a new Office of Enforcement. NRC's Office of Nuclear Reactor Regulation and Office of Nuclear Regulatory Research were not abolished, but some activities such as resolving generic safety issues were transferred from NRC's Office of Nuclear Reactor Regulation to its Office of Nuclear Regulatory Research.

NRC's Safety Standards

The Atomic Energy Act authorizes NRC to prescribe regulations or orders related to the design, location, and operation of nuclear power plants to protect public health and minimize danger to life or property. In this regard, NRC has established mandatory rules, regulations, license conditions, general design criteria, and operating technical specifications, as well as detailed staff technical interpretations of the regulations.

NRC's rules, regulations, and general design criteria (collectively referred to as regulations) are contained in Title 10, Chapter 1, Code of Federal Regulations. NRC regulations are formal legal requirements that utilities must meet to construct and operate their plants. However, the regulations are frequently general statements, subject to a wide range of interpretation, that do not specify the details or methods necessary to achieve compliance.

As a result, NRC's staff have developed in many areas more detailed technical positions of the regulations to serve as the primary tools to evaluate utility compliance with the formal regulations. The interpretations are contained in documents, such as

- regulatory guides and branch technical positions, which describe acceptable methods the utilities can use to implement specific parts of NRC's regulations;
- the Standard Review Plan, which provides the NRC staff with guidance on how to review utilities' construction and operating license applications and provides information to the nuclear industry on NRC's regulatory policies and procedures;
- periodic bulletins and generic letters, which notify the utilities constructing and/or operating nuclear power plants about significant new safety issues and actions the utilities should take to resolve the issues, and
- NRC staff reports, which provide technical analyses of nuclear power plant safety issues of current interest.

The NRC staff interpretations and guidance listed above have been referred to within NRC as "requirements" or "regulatory requirements." These interpretations are not legal requirements unless incorporated into the regulations or license conditions.

NRC's Executive Director for Operations has stated that NRC uses many different ways (such as bulletins, orders, and license amendments) to transmit new requirements or guidance to utilities. However, the guidance may not be applicable to every plant. Thus, any assessment of whether a nuclear power plant adheres to NRC regulatory standards should take into consideration compliance with applicable NRC staff documents that provide interpretations and guidance for implementing the basic regulations, as well as the basic regulations published in the Code of Federal Regulations

International Safety Programs and Services

Two international organizations are involved with nuclear power plant safety—the International Atomic Energy Agency (IAEA), headquartered in Vienna, Austria, and the Nuclear Energy Agency (NEA), headquartered in Paris, France. The United States belongs to both organizations

IAEA has established safety standards for its 112 members to use when developing nuclear power programs. As part of its program, IAEA developed 60 guidelines to help its members ensure adequate nuclear power plant safety. IAEA also maintains an incident-reporting system. Since IAEA's role is advisory, its members regulate their own nuclear activities. In 1982 IAEA created teams of experienced individuals, often managers of nuclear power plants, to review its member plants' safety practices against practices used elsewhere and to exchange ideas for safety improvements. However, IAEA does not assess a plant's compliance with the regulatory requirements of the country in which it is located nor does it require corrective actions when problems are identified.

NEA operates a worldwide incident-reporting system, funds safety research projects, and conducts exercises to assess the performance of nuclear plant safety systems among its 24 member countries. NEA also sponsors meetings and conferences to exchange safety data. However, NEA neither develops safety standards like IAEA or NRC nor conducts inspections of plant operations.

Objectives, Scope, and Methodology

On May 2, 1986, Senator Alfonse D'Amato asked us to assess NRC's commercial power plant safety procedures. Specifically, we were asked to determine how NRC (1) minimizes the risks associated with operating nuclear power plants, (2) enforces its safety standards, and (3) finds violations of the standards.

Senator D'Amato had also asked us to determine whether (1) the nuclear reactors under the Department of Energy's jurisdiction are subject to the same safety standards as those under NRC's jurisdiction and (2) NRC's and the Federal Emergency Management Agency's evacuation plans are adequate at the Shoreham plant located on Long Island, New York. On the basis of subsequent discussions, Senator D'Amato's staff agreed that work we are doing for the Chairman, Senate Committee on Governmental Affairs, concerning the safety of Energy's nuclear facilities would satisfy Senator D'Amato's question on nuclear reactors under Energy's jurisdiction. On December 2, 1986, we issued a report on the evacuation plan issue entitled Unique Features of Shoreham Nuclear Plant Emergency Planning (GAO RCED-87-50).

To obtain a perspective on how NRC minimizes the risk of operating plants, we reviewed the Atomic Energy Act and interviewed past and current NRC staff and officials from IAEA, an official from the Institute of Nuclear Power Operations (a utility-funded group organized to improve the safe and reliable operation of nuclear power plants), and a representative from the Union of Concerned Scientists, a nonprofit organization involved with nuclear safety. We also reviewed scientific journals and congressional hearings regarding nuclear safety; court cases related to the Atomic Energy Act; prior GAO reports; and pertinent NRC documents such as rules, regulations, policy statements, speeches, memoranda, and manuals.

In addition, we spoke with Dr. John Stevenson, a recognized expert on international nuclear regulation, and Dr. Lawrence Lidsky, a nuclear engineering professor at the Massachusetts Institute of Technology and a consultant to NRC on a new generation of inherently safe reactors. We also used five publications—NRC's 1984 and 1985 Annual Reports; a 1984 report by the Office of Technology Assessment entitled Nuclear Power in an Age of Uncertainty; a 1980 report to the NRC Commissioners and the public entitled Three Mile Island; and a report by the President's Commission entitled The Accident at Three Mile Island.

In addition, we obtained some information concerning the comparability of NRC's safety standards with those of the United Kingdom, Canada, the Federal Republic of Germany, France, Japan, and Sweden. We selected these countries because, together, they have a substantial number of nuclear plants (161). We primarily obtained this information through discussions with individuals who had different perspectives about nuclear safety in the various countries, such as NRC's Chief, Operating Reactor Programs Branch; NRC's Director, Office of Nuclear Regulatory Research; and Dr. Stevenson. We had planned to obtain data from the IAEA comparing the six countries' and NRC's safety standards and inspection and enforcement programs. However, various IAEA and NRC officials told us that such comparisons would be extremely difficult and had not been done by either organization. Because data comparing standards among countries was limited, we selected three indicators (capacity, availability, and unplanned power outages) to compare the performance of nuclear power plants in the six foreign countries with plants operating in the United States. We selected these indicators on the basis of published scientific information and discussions with NRC officials and because some relationship exists between a country's safety standards and how plants perform.

We also reviewed NRC programs and activities designed to develop new and/or revised standards to improve safe operations for plants. Specifically, we reviewed the results of NRC's systematic evaluation program to determine the extent to which plants reviewed under the program adhered to newer standards. We identified the standards that the plants did not meet, determined how NRC identified and resolved new safety issues, and determined whether the utilities implemented the changes required. We paid particular attention to the types of corrective actions the utilities took to correct problems similar to those that contributed to the Three Mile Island accident. Although we were able to determine from NRC's enforcement action tracking system whether NRC and the utilities had reached agreement concerning the action that should be taken regarding a safety issue, we could not determine whether the utilities actually took the action required because NRC's tracking system does not show this information for all plants.

To determine how NRC enforces its safety standards, we interviewed industry and NRC officials and others, such as a representative from the Union of Concerned Scientists, Dr. Stevenson, and Dr. Lidsky. We also reviewed congressional hearings, scientific journals, prior GAO reports on enforcement, and NRC documents. We also talked to three NRC headquarters project managers to determine the extent to which safety improvements recommended by NRC's systematic evaluation program had been made. In addition, we selected and examined five case histories and NRC investigative reports showing how NRC implements its enforcement requirements. Three of the cases came from a prior GAO report, and the other two cases involved significant safety incidents that occurred during 1985. Although the examples may not be indicative of NRC's practices overall, they do show how NRC enforces its standards in certain situations and provides some general insight into NRC's enforcement program.

To determine whether NRC finds safety violations and the enforcement actions it takes, we used computer runs from NRC's enforcement action tracking system and 766 system, a system NRC uses to list all violations on a plant-by-plant basis. We gathered data on the number of violations found, the severity of the violations, and the corrective action that NRC required the utility to take. For civil penalties, we summarized the information by the fiscal year in which the penalty was imposed. For consistency of presentation, if the utilities paid the civil penalty in a subsequent fiscal year, we reflected the payment for the year in which the penalty was imposed. We had expected to compare violations noted and enforcement actions taken by foreign countries with NRC's activities. However, these data were not available. We did find that NRC had some general information concerning safety incidents found by foreign countries, but NRC would not provide us this information for publication because it considers it to be proprietary.

We discussed the facts presented in this report with NRC staff. Generally, the staff agreed with the facts but did offer some clarifications that were incorporated where appropriate. As requested, we did not ask NRC to review and comment officially on this report. Our work was conducted between July 1986 and March 1987 in accordance with generally accepted government auditing standards.

Safety Standards Do Not Eliminate All Operational Risks

NRC does not—and is not required to by the Atomic Energy Act—guarantee absolute safety for nuclear power plant operations. NRC recognizes that nuclear plants pose some risk to public health and safety; NRC has programs and activities to improve its standards and minimize the risk. For example, NRC requires plants to have back-up systems; conducts research to identify the causes and consequences of accidents; systematically analyzes older plants to determine whether they meet all current standards and licensing requirements; and identifies possible safety problems affecting the design, construction, or operation of several or a class of plants (generic issues). However, NRC's funding for research activities has decreased, and over the years NRC has identified more possible safety problems than it has resolved. The longer that these issues are unresolved, thereby precluding NRC from improving its safety standards, the longer that plants may operate in a less safe manner.

Similar to NRC, western European countries, Canada, and Japan have developed safety standards for their nuclear power plants. NRC's standards are comparable, according to industry and NRC officials, to those countries' standards, but plant performance was worse in the United States for three performance indicators (capacity, availability, and unplanned power outages[1]). For each indicator, nuclear power plants in this country ranked near or at the bottom of the statistics. Although an industry consensus does not exist to support a direct relationship between performance ratings and safety standards, some industry and NRC experts believe that nuclear plants that are well managed usually perform better and, therefore, are safer. But other NRC staff pointed out that it is not necessarily true that plants with good availability factors are generally safer; some utilities may operate the plants to ensure greater availability rather than safety.

Atomic Energy Act Does Not Require Absolute Safety for the Public

The Atomic Energy Act provides that NRC may issue a license only if it determines that the plant will not endanger the common defense and security or public health and safety. NRC's regulations interpreting the act require that an operating license may be issued only upon finding among other things that "reasonable assurance" exists that the plant will not endanger public health and safety. On various occasions over the past 25 years, the courts have upheld NRC's interpretation of the act The courts reasoned that absolute certainty is not required by the act,

[1]Capacity compares a plant's actual and maximum possible energy output; availability compares actual and maximum plant operating time; and unplanned outages reflect power outages caused by plant shutdowns other than for normal maintenance.

and nuclear safety technology does not permit an absolute guarantee of safety Consequently, according to the courts, NRC must weigh the state of the art, risk of accidents, and other factors before issuing an operating license.

On August 21, 1986, NRC defined in the Federal Register an acceptable level of radiological risk by outlining two safety goals and two quantitative objectives. The two safety goals are that

- individuals should be provided a level of protection such that normal plant operations cause no significant additional risk to life and health and
- societal risks to life and health from normal plant operations should be comparable to, or less than, the risk of generating electricity by competing technologies (e.g., conventional fuels).

The two quantitative objectives to meet these goals are that

- the risk of early death to an average individual in the vicinity of a nuclear power plant accident should not exceed one-tenth of 1 percent (0.1 percent) of the total risk of early deaths from other accidents to which the public is normally exposed and
- the risk of cancer deaths to the population (living near the plant) from normal operations should not exceed one-tenth of 1 percent (0.1 percent) of the risk of total cancer deaths from all other causes.

In its August 1986 policy statement, NRC pointed out that its regulatory practices ensure adequate protection to the public. NRC also said that the safety goals should improve its regulatory practices in a way that could lead to (1) more coherent and consistent regulation of nuclear power plants, (2) a more predictable regulatory process, (3) improved public understanding of regulatory criteria, and (4) enhanced public confidence in the safety of operating plants. Further, NRC's commissioners acknowledged that NRC will need to develop specific guidelines to determine if plants comply with the intent of the goals. On January 2, 1987, NRC's staff sent a memorandum to the commissioners setting forth the proposed guidelines. Since the commissioners intend to request the views of the Advisory Committee on Reactor Safeguards before acting on this issue, NRC staff could not estimate when the final guidelines would be issued.

NRC's Efforts to Improve Its Safety Standards and Minimize Risk

Since NRC recognizes that some degree of risk exists, the construction and operating licenses it issues for power plants specify the actions that designers, builders, and operators must take to minimize the risk. For example, NRC requires margins of safety in design and operating conditions and redundancy in primary and backup equipment to compensate for equipment failures and possible operator errors. In addition, NRC conducts research to determine whether its standards should be strengthened or relaxed and has initiated two programs to assess older plants' compliance with all applicable current standards. Further, on the basis of various safety reviews that NRC conducts and information that licensees submit on plant operations, NRC identifies safety problems that may be generic to a number of plants and may require new or revised standards.

NRC's Defense-In-Depth Concept

According to NRC documents, one mechanism NRC uses to reduce risk is to establish standards for the design, construction, and operation of nuclear power plants under a three-level "defense-in-depth" concept. The first level (prevention) requires utilities to design, build, operate, and maintain nuclear power plants so that they will, with a high degree of assurance, operate without failures that could lead to accidents. According to NRC and industry officials, the utilities design plants on the basis of conservative standards to ensure that they will be safe during all phases of operation. The second level (mitigation of accidents) requires utilities to have procedures and equipment that will enable them to cope with equipment failures or operating errors should they occur. For example, NRC requires utilities to have an emergency cooling system—a back-up water supply—in case a major rupture should occur in the plant's normal cooling system. The third level (keeping radiation releases within the plant) requires utilities to incorporate design features and equipment to protect public health and safety if an accident occurs. For example, NRC requires the plants to have containment structures and systems to minimize the escape of radioactive substances into the environment.

NRC's Research Efforts to Improve Standards

NRC performs research to upgrade its safety standards and obtain better cost/benefit information. NRC conducts three types of research that its staff believe are an essential and integral part of the regulatory process (1) safety research to provide the technical basis for regulatory action to ensure public health and safety, (2) confirmatory research to determine whether the safety margins required by the regulatory action were appropriate, and (3) exploratory research, which changes certain conditions to better understand the causes and consequences of accidents.

For its fiscal year 1987 budget, NRC grouped its research into six areas: problems with older power plants, causes of accidents, consequences of accidents, risk analysis, seismic hazards, and waste disposal. Since nuclear power plants are expected to operate for about 40 years, NRC is trying to determine whether a plant's age could contribute to an accident or could cause the plant's safety systems to become inoperable. In addition, NRC conducts research to (1) enhance its understanding of the physical and chemical processes that could take place inside the reactor during an accident and (2) improve the methodology used to predict the release and transport of radioactive materials if an accident occurs. Further, since NRC knows that a number of older plants have been designed to meet seismic requirements that are below current standards, NRC seeks to determine how well older plants can withstand potential earthquakes. In the waste area, NRC conducts research on the appropriate disposal methods for various types of waste, the most effective way to package the waste to minimize radiation exposures, and how the waste will interact with the environment in which it is ultimately disposed.

Although NRC strives to improve its standards on the basis of the research conducted, its research budget has been decreasing; in fiscal year 1988 it may increase. For fiscal year 1987, NRC expects to have 180 full-time employees in the Office of Nuclear Regulatory Research and spend about $112 million for research activities compared with 226 full-time employees and $150 million in fiscal year 1985. NRC's chairman stated in March 1986 that NRC's research budget will be lower (in real dollars) in fiscal year 1987 than when the agency was formed in 1975, and the reductions in the fiscal year 1987 research budget will mean an end to some research efforts and significant delays in or deferral of others. The chairman also pointed out that the absence of safety information that could be obtained through research will lead to greater conservatism in the regulatory process, such as plant shutdowns and power reductions, in order to ensure that adequate safety margins are maintained. However, the President's fiscal year 1988 budget request to the Congress provides for a 7-percent increase in NRC's nuclear regulatory research budget. Although funds would increase, the number of staff would be reduced from 180 to 172.

NRC's Efforts to Resolve Generic Safety Issues

NRC identifies potential generic issues by monitoring licensee reports on operating experience, the results of its safety-related research, risk assessment analysis, and public concerns. NRC annually screens about 3,000 licensee event reports to identify specific events or trends that may have significant public safety implications and require NRC to develop new standards or to revise existing standards. For example, one generic safety issue involves reactor coolant pump seal failures. NRC found that such failures could increase the probability of a reactor core melt and it wants to identify ways to reduce the frequency of these failures to better ensure the safety of operating plants.

However, NRC's resolution (identification and approval of a solution but not implementation) of generic safety issues—including those designated as having the highest safety significance—can take from several months to 10 or more years. To resolve these issues, NRC may issue new regulations, require plant modifications, or determine that no action is needed. Further, NRC prioritizes generic issues into various categories on the basis of risk and cost estimates. It allocates resources to those with high potential for reducing risk and eliminates issues with little or no safety significance. As of December 1986, NRC had 32 issues in the highest safety significance category compared with 29 at the end of 1983.

In addition, NRC has a backlog of unresolved generic issues, and the prospects for it to promptly reduce the backlog do not seem promising. For example, prior to the March 1979 Three Mile Island accident, this country's most serious nuclear plant accident, NRC had a backlog of about 12 generic issues that had not been resolved. By December 1986, the backlog had increased to 163 (including 32 issues in the highest safety significance category) largely due to a number of issues identified from investigations of that accident and a June 1985 accident at Davis-Besse. Further, in fiscal years 1985 and 1986, NRC records show that it identified 41 new generic issues but resolved or removed only 32. Further, NRC plans to resolve only 28 and 7 in fiscal years 1988 and 1989, respectively. At these rates of identification and resolution, NRC will continue to resolve issues but may never be able to reduce the backlog.

In September 1984, we recommended that the Chairman, NRC, assess ways to eliminate the backlog of unresolved generic issues sooner and that the chairman should determine whether adequate resources are available within the agency for this purpose.[2] NRC staff believe they

[2]See Management Weaknesses Affect Nuclear Regulatory Commission Efforts to Address Safety Issues Common to Nuclear Power Plants (GAO/RCED-84-149, Sept. 19, 1984).

have adequate resources to resolve generic safety issues. In addition, NRC has started to place greater emphasis on resolving these issues. For example, in May 1987 the staff met with the Advisory Committee on Reactor Safeguards to discuss, among other matters, NRC's process to resolve generic safety issues.

NRC's Safety Assessment Programs

Another mechanism that NRC uses to reduce the risks to the public from operating power plants is to systematically assess whether certain older plants meet all applicable standards and licensing requirements and to establish a schedule for plant modifications when the requirements were not met. NRC has had two programs to make this determination—a Systematic Assessment Program and an Integrated Safety Assessment Program. Because safety standards change over time, NRC set up the programs to determine the variance that existed at certain plants between the time the plants received their licenses and when the current standards took effect.

In 1977 NRC began its Systematic Evaluation Program of 10 plants that received operating licenses between 1962 and 1977—Palisades, Michigan; Ginna, New York; Oyster Creek, New Jersey; Dresden 2, Illinois; Millstone 1, Connecticut; San Onofre 1, California; Yankee-Rowe, Massachusetts; Haddam Neck, Connecticut; LaCrosse, Wisconsin; and Big Rock Point, Michigan. Under this program, NRC assessed the plant's compliance with regulatory requirements from the time each plant was licensed until 1978. NRC completed its assessment for nine plants in 1983; it completed the last assessment (San Onofre) in December 1986. The estimated cost for these assessments was $19.2 million.

Our review of NRC's findings for the 10 plants showed that NRC compared current technical positions on safety issues for 137 areas at each plant with those that existed when the plants were first licensed. NRC subsequently deleted between 45 and 54 areas from consideration at each plant because they were being reviewed under other programs (such as research) or certain areas did not apply to particular plants. NRC reviewed the remaining areas, a total of 875 at all 10 plants, and determined that the 10 plants met current safety design criteria in 526 areas but did not meet the criteria in 349 areas. Table 2.1 shows by plant the areas NRC reviewed.

Table 2.1: Number of Areas Reviewed Under NRC's Systematic Evaluation Program

Plant	Original review areas	Areas deleted	Areas reviewed	Areas meeting criteria	Areas nc meetin criteri
Big Rock Point	137	52	85	55	
Dresden 2	137	49	88	54	
Ginna	137	45	92	65	
Haddam Neck	137	47	90	46	
La Crosse	137	54	83	52	
Millstone 1	137	51	86	48	
Oyster Creek	137	54	83	43	
Palisades	137	47	90	59	
San Onofre 1	137	48	89	53	
Yankee Rowe	137	48	89	51	
Total	**1,370**[a]	**495**	**875**	**526**	**34**

[a]NRC initially selected the same 137 areas for each plant

For the 349 areas not meeting the safety design criteria, NRC determined that approximately two-thirds involved acceptable margins of safety, thereby not requiring, in its judgment, any plant modifications. For the remaining 116 areas, NRC required the utilities to take 296 specific actions. As of November 30, 1986, the utilities had reported completing 233 of the 296 actions. Table 2.2 shows the number and status of correc tive actions required for each plant.

Table 2.2: Status of Corrective Actions Under NRC's Systematic Evaluation Program

Plant	Number of actions required	Actions licensee reported completed	Incomplet action
Big Rock Point	19	17	
Dresden 2	22	20	
Ginna	32	23	
Haddam Neck	39	19	
LaCrosse	30	26	
Millstone 1	35	29	
Oyster Creek	36	35	
Palisades	23	23	
San Onofre 1	34	16	
Yankee-Rowe	26	25	
Total	**296**	**233**	[illegible]

According to NRC's Director, Integrated Safety Assessment Program, NI has verified that the utilities have completed 39 of the 233 actions reported as complete. He added that NRC will verify the utilities' actions for the remaining 194 items as part of its routine inspection activities. and NRC expects the utilities to make the necessary plant modifications for the 63 incomplete actions within 2 to 3 years. Although NRC found numerous instances where older plants did not fully meet current safety standards. NRC staff believe the plants provide the public adequate protection. The staff did agree that plant safety would improve once corrective actions are taken for the deficiencies found.

In addition to the Systematic Evaluation Program. in June 1984 NRC initiated an Integrated Safety Assessment Program and planned to review four plants. Because of funding reductions, NRC scaled back its efforts to a pilot program for two plants in Connecticut: Millstone 1 and Haddam Neck. The Integrated Safety Assessment Program substantially expands upon the Systematic Evaluation Program and will result in an implementation plan that prioritizes recommended corrective actions on the basis of plant-specific risk assessments and operating experience reports. NRC also included a threshold concept under this program whereby it would not require corrective action for deficiencies found if. in its judgment. the costs of the corrective action outweighed the safety benefits to be derived. NRC issued a draft report on Millstone 1 in April 1987 and expects to issue its report on Haddam Neck in July 1987. In addition. NRC plans to expand the Integrated Safety Assessment Program to two other plants and complete the analyses in 1989.

NRC's Standards Are Comparable to Other Countries' Standards; Plant Operating Performance Differs

According to industry experts and NRC staff. NRC's safety standards are generally comparable to those of western European countries, Canada. and Japan. However, plant performance—as measured by capacity. availability, and unplanned power outages—was better in those countries than for reactors operating in the United States. Of the 12 industry and government officials we contacted. no one knew—or had conducted—a detailed country-by-country comparison of all safety standards. However, the officials agreed that NRC's standards are generally comparable to those of Canada, the Federal Republic of Germany. France, Great Britain, Japan, and Sweden. Further, these experts did not cite specific standards that would indicate that plants in the United States were not operating safely.

NRC staff pointed out that for many years, the United States was the only country that had standards. As a result, most western European countries, Canada, and Japan copied these standards and then modified some to meet their own special needs In addition, some smaller coun-tries, such as Belgium, tend to rely heavily on NRC's standards, and Taiwan has adopted NRC's standards without modification. NRC staff explained that differences occur not necessarily because of how a country writes a standard but rather in how they are applied or because of different reactor designs.

For example, each country may have a standard that a nuclear power plant must be able to withstand the worst flood in the last 100 years Since the severity of the worst flood can vary from country to country the plants could be constructed differently and still comply with the standard. In addition, NRC's Chief, Operating Reactor Programs Branch said that newer plants in countries such as the Federal Republic of Germany and France use newer control room technology designs and better circuitry and components than plants in the United States. In these areas, the applicable standards could differ.

However, NRC staff did provide us some examples of how and why specific foreign countries' standards are more stringent than NRC's. For example,

- the Federal Republic of Germany requires that the containment buildi withstand greater impacts from barges and airplanes because the plar are generally located near large population centers, whereas reactors i this country are generally located in sparsely populated areas:
- France requires a special venting system to reduce the likelihood of ra ation escaping from the containment building due to an accident: how-ever, its emergency protection zone is less than NRC's 10-mile requirement; and
- Japan has stronger preventative maintenance programs, more built in "fail safe" systems, and stricter seismic conditions because of its sma geographical area and greater susceptibility to earthquakes than this country.

With the exception of a representative from the Union of Concerned Scientists, industry and IAEA officials we talked with supported NRC's views about safety standards. They pointed out that similarities exist among the countries' standards and differences are primarily due to national or local requirements. On the other hand, the Union of Concerned Scientists' representative said that some countries (such as the Federal Republic of Germany) require plants to incorporate all safety features possible within available technology, whereas NRC does not that Sweden requires a venting system to screen out radiation, whereas NRC does not.

In order to resolve whether NRC's standards are comparable, we contacted IAEA to determine whether it had compared NRC's safety standards with those of other countries. Although IAEA assists its 112 members to ensure the safe use of nuclear energy and has developed safety guidelines, IAEA does not compare safety standards among its member countries. In addition, IAEA, as an international organization, does not want to make judgments concerning which of its members have superior or inferior safety standards.

Foreign Reactors Perform Better Than Those in This Country in Some Instances

Although we could not specifically determine whether NRC's safety standards were comparable to standards set by Great Britain, Canada, France, Japan, the Federal Republic of Germany, and Sweden, we were able to compare plant performance in three areas—capacity, availability, and unplanned power outages—among the countries. We found that the plants located in the six countries had better operating records than those in the United States.

According to some experts we talked to, and scientific journals we reviewed, enough information exists to indicate that some correlation can be made between safety and plant performance. For example, an Atomic Industrial Forum report Nuclear Industry, December 1986, stated that the availability performance indicator represents an indirect safety index because poor availability is related to defective equipment, operations, or regulations. In addition, a vice president from the Institute of Nuclear Power Operations (a group funded by the industry to oversee plant safety) told us that nuclear plants that are well managed are usually better performers and, thus, safer. On the other hand, NRC staff pointed out that one has to be careful when using performance indicators because it is not necessarily true that plants with good availability factors are generally safer. Some utilities may operate the plants with greater emphasis on availability than safety.

For calendar years 1982 through 1985, nuclear power plants in this country were at or near the bottom of the statistics for the three performance indicators. According to one NRC commissioner, the United States has far too many plants that fail to meet acceptable performance standards.

Capacity Factor

A nuclear power plant's capacity factor reflects the ratio of energy that a plant produces during a given period to the energy that the plant could have produced at maximum capacity under continuous operation during the same period. In calendar years 1983 to 1985, the average capacity factor for the six foreign countries and the United States was between 65 and 69 percent. Plants in the United States had capacity factors ranging from 54 to 56 percent. Table 2.3 shows that U.S. plants had the lowest operating capacity for calendar years 1983 to 1985.

Table 2.3: Capacity Factor for Calendar Years 1983, 1984, and 1985

Country	(percent) 1983	1984	1985
Britain	(a)	(a)	
Canada	74	69	[illegible]
Federal Republic of Germany	72	79	85
France	58	62	64
Japan	70	72	[illegible]
Sweden	60	76	68
United States	54	56	55
Average of countries	65	69	69

[a]Comparable data not available

Source: Nucleonics Week

Availability Factor

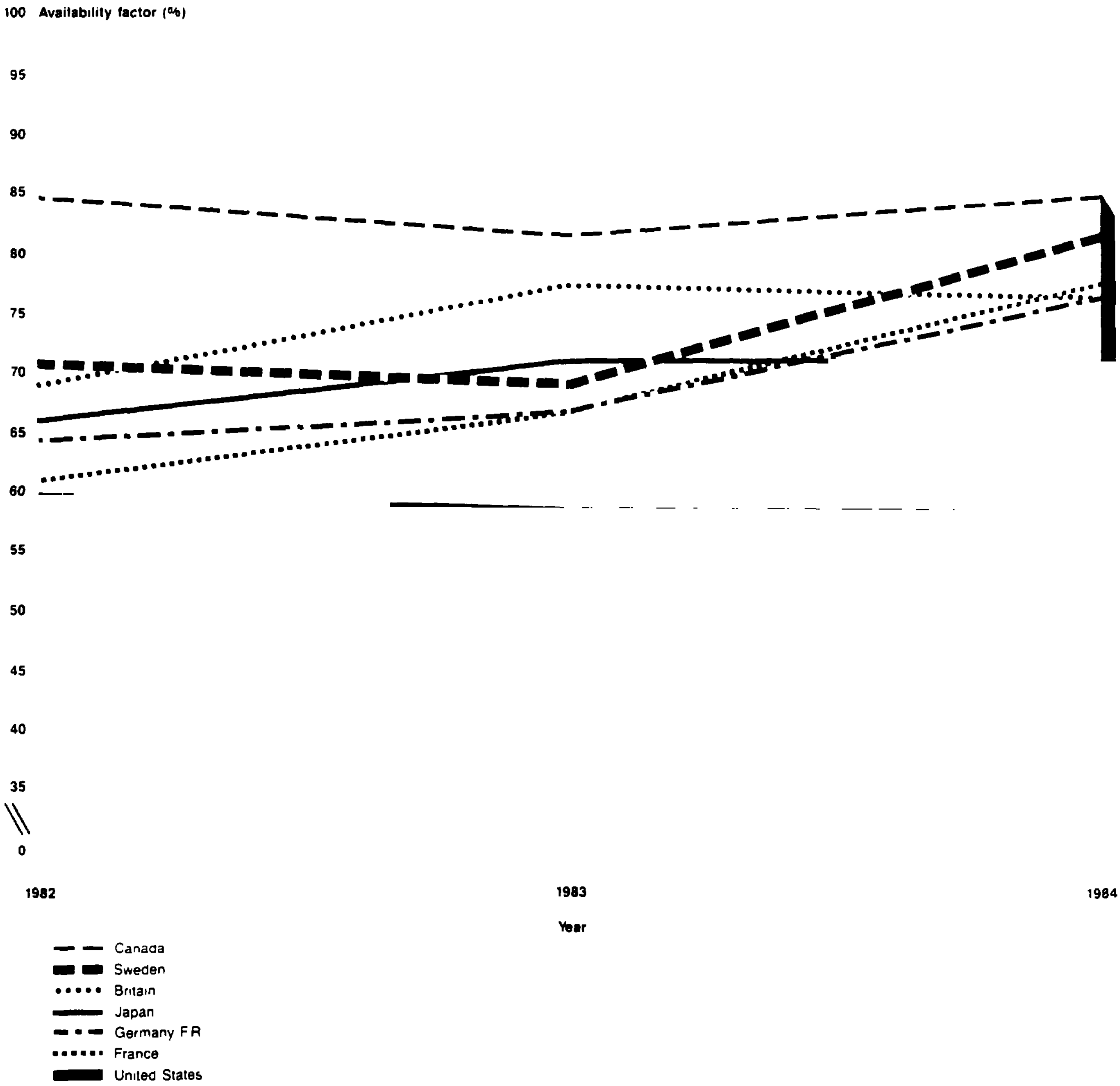
Availability reflects the ratio of hours that a plant was available to operate to the number of hours that it actually operated. Table 2.4 shows that U.S. plants had the lowest availability rating for calendar years 1982 to 1984.

Table 2.4: Availability Factor for Calendar Years 1982, 1983, and 1984

Country	(Percent) 1982	1983	1984
Britain	68.8	76.9	76.1
Canada	84.8	81.7	84.6
Federal Republic of Germany	64.4	66.4	76.1
France	60.8	66.4	[illegible]
Japan	66.0	70.6	70.4
Sweden	70.6	68.9	81.5
United States	59.7	58.0	57.9
Average of countries	67.9	69.8	[illegible]

Source: International Atomic Energy Agency, Vienna, Austria, 1986

Figure 2.1: Power Plant Availability Performance (1982 84)



Source International Atomic Energy Agency, Vienna, 1986

Although the average nuclear plant availability for some countries between calendar years 1982 and 1984 has generally been increasing, the same is not true for plants in this country. Figure 2.1 shows the trends of the six countries and the United States for this time period.

Unplanned Power Outages

This performance indicator reflects power outages (scrams) caused by plant shutdowns other than for normal maintenance. Scrams may indicate unsatisfactory safety conditions, equipment malfunctions, inadequate maintenance, or poor operating practices.

Generally, the rate of scrams in this country has decreased slightly over the last 4 years. According to NRC's Director of Nuclear Reactor Regulation, scram rates for U.S. plants showed an average of 6.5 scrams per reactor per year in 1983, an average rate of 5.9 in 1984, and 6.0 scrams in 1985. In addition, NRC's preliminary review of the 1986 data indicates that the rate has decreased to 5.1 scrams per plant per year.

In comparison, the average reactor scram rates for France and Sweden between 1983 and 1985 were comparable to scram rates for this country; the Federal Republic of Germany's were 2 to 5 times lower; and Japan's, more than 10 times lower. According to NRC's Director, Nuclear Reactor Regulation, plant operating records in Germany and Japan are impressively better than plant operating records in the United States.

Conclusions

NRC sets standards intended to provide the public with reasonable assurance that nuclear power plants operate safely, but these standards do not necessarily ensure that safety problems cannot—and will not—occur. Recognizing the risk that operating plants pose to the public, NRC strives to improve existing standards or issue new ones when its various regulatory activities identify design, construction, or operating problems. NRC does this through its research, systematic assessment, and generic issues programs.

However, NRC may take many years to develop a solution for a generic issue, and the backlog of unresolved issues is increasing. In 1984 we recommended that NRC assess ways to eliminate the backlog of unresolved generic issues sooner. NRC has started taking actions to do so; it funds those issues with the highest safety significance first. Nevertheless, the longer that these issues remain open, the greater the likelihood that plants could experience problems that may adversely affect public health and safety.

In addition, although NRC's standards are generally comparable to those of western European countries, Canada, and Japan, plant performance in this country for three industry indicators was lower. Some industry experts and NRC staff believe that better performing plants are usually safer. Others point out, however, that high-performing plants may not necessarily be safer.

NRC Should Develop Plant Shutdown Guidelines

NRC does not assess each plant's safety performance against all applicable standards. Because of the volume and complexity of the standards and limited staff resources, NRC conducts only limited compliance inspections. Over the years, NRC's inspection activities have been criticized by various groups. In 1979 the President's Commission on the Three Mile Island Accident raised numerous concerns about NRC's inspection program. We have also identified weaknesses in this program.[1]

In addition, the Atomic Energy Act allows NRC to order a utility to cease plant operations when NRC does not have reasonable assurance the plant can operate safely. However, NRC lacks guidelines to determine when to shut a plant down. In fact, in congressional hearings, NRC's commissioners could not agree on the specific types of problems that could pose undue public health and safety risk such that NRC would implement its statutory authority and shut a plant down. Further, in the few instances where NRC has ordered a shutdown, it did not take the same action earlier or for other plants even though a basis seemed to exist for NRC to do so.

In 1979 NRC ordered utilities to shut down four plants to determine whether they could meet NRC's seismic standards. Subsequently, NRC identified other plants where it had similar concerns but did not order them to shut down. Also, on March 31, 1987, NRC ordered the Peach Bottom plant in Pennsylvania to shut down because NRC found evidence that control room personnel were asleep on the job. NRC had a similar concern almost 2 years earlier but did not order a shutdown.

We reviewed the operating history of five other plants and found that they operated for many years with significant safety problems. NRC knew of the problems. Ultimately, for four of the plants, the severity of the problems caused the utilities—not NRC—to stop plant operations and/or a safety incident occurred that made continued operation impossible. The absence of guidelines to determine whether a plant should be closed may have contributed to the prolonged operation of these plants.

[1] See Better Inspection Management Would Improve Oversight of Operating Nuclear Plants (GAO/RCED-85-5, Apr. 24, 1985) and Oversight of Quality Assurance at Nuclear Power Plants Needs Improvement (GAO/RCED-86-41, Jan. 23, 1986).

NRC's Inspection Program

NRC periodically inspects each operating plant to ensure that the utility operates the plant safely and in accordance with NRC regulations. NRC carries out its inspection responsibilities using a three-tiered management approach. NRC's headquarters develops inspection and enforcement policies, standards, and guides; provides technical advice and assistance to its five regional offices; conducts special investigations; and issues notices of violations, civil penalties, and enforcement orders for deficiencies found. NRC's regional offices have overall responsibility to implement the policies and procedures established and to conduct special investigations of a plant's maintenance, surveillance, and quality assurance program.

NRC also has at least one inspector assigned full-time at each of the 107 operating plants to monitor day-to-day operations. The resident inspectors (1) perform routine or planned inspections of the plant's safety program and (2) assess the cause of unusual occurrences or safety events reported by the licensee, the response and/or corrective action taken, and whether the event could be generic to other plants. In addition, NRC requires that the resident inspectors spend approximately 20 percent of their time independently evaluating licensee's safety programs.

Finally, NRC requires the utilities to establish a plant-specific quality assurance program that covers all aspects of the plants' safety systems, including training and self-assessment requirements. The utilities also conduct inspections, and NRC selectively checks to ensure that the utilities are adequately inspecting and taking corrective action when they find violations of regulations and procedures.

Regulatory Requirements

NRC has (1) mandatory, legally binding regulations and operating license technical specifications and (2) nonbinding guidance to ensure safe construction and operation of nuclear power plants. As explained in chapter 1, NRC uses various staff interpretations to assist the utilities in complying with the regulations. However, NRC allows the utilities to determine how they will comply with the regulations established. To illustrate, NRC's regulations require that a power plant design conform to General Design Criteria contained in 10 CFR 50, Appendix A. Since the General Design Criteria set out engineering goals rather than precise requirements for power plant construction, the utilities select the specific methods, procedures, systems, and components that they want to use to comply with the requirements. The utilities must demonstrate to NRC that the alternatives selected ensure safe plant operations.

In addition, NRC allows utilities to make design changes during construction or requires utilities to backfit plants; that is, add, eliminate, or modify structures, systems, or components after the construction permit has been issued. Because (1) plant designs differ—the 107 plants operating as of May 1987 involve designs by 20 different architect engineers, 6 different steam system suppliers, and 26 different construction contractors—(2) utilities can select different systems and components to fit their own particular set of circumstances, and (3) both the utility and NRC can make or require design changes after construction begins. NRC does not have specific standards applicable to all aspects of plant operations.

Because NRC does not have specific standards applicable to all aspects of plant operations, NRC inspects only a selected sample of utility operations, evaluates the sample for compliance, and extrapolates the results to make a judgment about the entire plant. To carry out its responsibilities, NRC has established 162 procedures for its inspectors to follow. NRC divides these procedures in the following manner: 73 basic, 24 minimum, and 65 supplemental.

NRC requires that the resident inspectors assess plant operations for each of the 73 basic procedures (1) either daily, weekly, monthly, or annually, depending on the procedure involved, (2) in connection with scheduled plant maintenance activities, such as refueling, or (3) in reaction to unplanned events, such as unscheduled reactor shutdowns. The minimum procedures are mandatory inspection requirements and are essentially the same as the basic procedures except for designated annual inspections that do not have to be conducted under certain circumstances. The 65 supplemental procedures cover a variety of specialized inspections in some of the same areas covered by the basic procedures, such as fire protection, radiation protection, and equipment calibration. NRC allows its inspectors, supervisors, and managers to decide the specific procedures and the frequency of these types of inspections on the basis of staff availability or problems at a plant.

Inspection Activities

NRC's inspection approach has been criticized for many years. For example, the 1979 President's Commission on the Three Mile Island Accident pointed out that

- inspectors frequently failed to conduct independent evaluations of plant operations.

- inspectors did not understand NRC's manuals and did not evaluate the appropriate sample of safety-related issues, and
- NRC relied heavily on industry records to oversee inspection and enforcement activities.

As a result of these conclusions, NRC instituted improvements to its inspection program. For example, NRC began the Systematic Assessment of Licensee Performance Program (SALP) to periodically evaluate plant operations and develop improvement programs. Initially, NRC expected to conduct a SALP evaluation about every 6 months, now it expects to do so between 12 and 18 months but not exceeding 18 months. NRC's SALP reports generally summarize the inspections NRC makes during an assessment period, rate the utility in 10 to 12 plant areas, and show trends in the plants' performance. In addition, NRC has allowed regional program managers to tailor inspection plans for each plant and requires inspectors to spend more time independently testing and observing plant operations rather than reviewing utility records.

Although NRC had taken actions to improve its inspection program, in 1985 and 1986 we found that more needed to be done.[2] We noted that

- NRC did not follow the required inspection procedures because of insufficient inspection program resources;
- resident inspectors generally believed they could not fulfill NRC's program requirements;
- inspection requirements had increased; 40 percent of the inspectors said they did not have enough time to ensure compliance with regulations; and
- NRC allowed plants with marginal inspection ratings to operate for many years without requiring an improvement program to correct the deficiencies found.

The trend in program resources and workload indicates that the problems we reported in 1985 and 1986 may continue today. In fiscal years 1984 and 1985, NRC implemented or proposed over 90 regulations. In addition, as of May 1987, NRC had issued operating licenses to 107 plants compared with 76 during 1983—an increase of 31 in about 3 years. Therefore, NRC must inspect more operating plants and enforce more safety standards than in the past. Further, NRC's 1987 budget estimate

[2]See Better Inspection Management Would Improve Oversight of Operating Nuclear Plants (GAO/RCED-85-5, Apr. 24, 1985) and Oversight of Quality Assurance at Nuclear Power Plants Needs Improvement (GAO/RCED-86-41, Jan. 23, 1986).

shows inspection and enforcement staff increasing by 5 to a total of 1,136 in fiscal year 1987 but decreasing to 1,088 in fiscal year 1989. One senior resident inspector told us that it is impossible to determine whether the utility complies with all regulations and technical specifications. He said that the utility employs about 2,000 people and he can neither ensure that they comply with all safety procedures nor investigate the causes of, and corrective actions taken for, the numerous licensee event (reactor scrams and safety system failures) reports issued each year for his plant. According to NRC, in 1986 the number of licensee event reports ranged from 3 to 93 per plant; the average was 27 per plant.

During NRC's fiscal year 1987 appropriations hearings, its chairman stated that reduced funding levels will cause NRC to perform less regulatory oversight activities and the agency's capability to respond to—and resolve—safety issues from unexpected events will diminish. In this regard, the Congress reduced the President's $405 million budget request by $4 million. Some of the reductions occurred in the following areas:

- $200,000 for the Integrated Safety Assessment Program.
- $400,000 to complete 40 safety evaluations at operating reactors, such as reviewing the safety significance when utilities want to change their technical specifications.
- $200,000 to conduct special inspections planned in the areas of surveillance, quality assurance, fire protection, physical security, radiological safety, and emergency preparedness.
- $1.7 million to conduct research related to structural degradation occurring in operating plants.

NRC Takes Years to Require Effective Corrective Action

We reviewed the operating history of five plants where NRC repeatedly identified significant safety problems but was slow to require effective corrective action. In four of the five cases, the utilities—not NRC—shut the plants down following either a serious safety event or the utilities' determining that unsafe conditions existed that needed to be corrected. Each of the five cases is discussed below.

Davis-Besse

The Davis-Besse plant, located in Oak Harbor, Ohio, received an NRC operating license in 1977. In 1979 NRC inspected the plant and recommended that the utility install a third auxiliary feedwater pump to correct a design deficiency that NRC concluded could contribute to a core melt during an accident. The pump was needed to provide a reliable water supply for the steam generator. NRC recommended this action to ensure that problems similar to some that occurred during the Three Mile Island accident would not occur at Davis-Besse. However, NRC allowed the utility time to analyze alternatives such as upgrading procedures and control systems before taking the required corrective action. In 1984, 5 years later, the utility agreed to install the third pump by late 1985. However, before the pump was installed, the plant experienced a series of equipment failures and operator errors in June 1985 such that

- one main feedwater pump became inoperable,
- the utility could not activate another feedwater pump, and
- the auxiliary feedwater system became inoperable.

In October 1985 and May 1986 hearings before the Subcommittee on Energy Conservation and Power, House Committee on Energy and Commerce, NRC admitted that although the equipment problems posed an undue risk to public health and safety, the agency waited too long to require the utility to install the third pump. NRC also admitted that its inspection and enforcement program failed to identify the potential for the extensive equipment failures that subsequently occurred, even though the plant's operating performance had declined since 1982. After the June 9, 1985, event and the subsequent shutdown of the plant, NRC did not allow it to restart until December 1986.

Rancho Seco

The Rancho Seco plant, located near Sacramento, California, received an operating license in August 1974. On December 26, 1985, the plant experienced a significant incident that resulted in a loss of power and the subsequent shutdown of some safety systems. One of the plant's non-safety-related systems failed because of a loss of power. As a result, the plant experienced a drop in operating pressure and temperature that could have increased the potential for cracks to develop in the reactor vessel. In February 1986, an NRC incident investigative team concluded that the fundamental causes for the drop in pressure were design weaknesses and vulnerabilities in the plant's integrated control system[3] and in the equipment controlled by that system.

In its report, the team stated that the weaknesses and vulnerabilities were largely known to the utility and the NRC staff because of prior

[3]A nonsafety-related system that coordinates a variety of plant equipment to balance steam production and steam use.

events at the plant and other similar plants, related analyses, and studies. For example, in the first year of operations (1974), the plant experienced several integrated control system power reductions. Power was also lost at Rancho Seco in 1978 and 1979 and at two other similarly designed plants in 1979 and 1980. As a result, in August 1979 the plant's designer, Babcock and Wilcox, completed an analysis showing that the integrated control system power supplies are vulnerable to a single failure with significant consequences (the December 1985 event was initiated by a single failure). In its report, Babcock and Wilcox pointed out that the integrated control system power supplies had a high failure rate and corrective actions should be taken to enhance plant operations. Also, around 1979 NRC staff performed an extensive study regarding integrated control system power losses and made 22 recommendations to mitigate the problems at Rancho Seco and other plants.

According to NRC's incident investigative team's report of the December 1985 event, the early events indicated that improvements needed to enhance the integrated control system's reliability procedures to mitigate a loss of power had not been developed, and the 1979 recommendations had not been implemented at Rancho Seco. Although the report stated that NRC staff had concerns about these issues for as long as 8 years, NRC did not ensure that the utility implemented the actions required. Following the December 1985 event causing the plant to be shut down, most of the 1979 recommended corrective actions were taken. As of May 1987, NRC has not authorized the plant to restart.

Pilgrim

The Pilgrim plant, located in Plymouth, Massachusetts, received its operating license in September 1972. NRC inspections of the plant between July 1, 1983, and October 31, 1985, showed that NRC cited the plant for 52 violations and imposed civil penalties totalling $90,000. Most of the violations were in the areas of plant operations, surveillance, and radiological controls. In addition, the Pilgrim plant has had a long history of management problems that have largely gone uncorrected.

Beginning in 1972, three conditions at Pilgrim led NRC to conclude that serious deficiencies existed in the utility's control of certain safety-related activities. For example, the utility (1) did not comply with regulations, (2) violated the plant's technical specifications, and (3) knowingly operated the plant between 1972 and 1981 at higher than authorized operating temperatures. In mid-1981, a special NRC inspection team found that the utility's management personnel lacked knowledge in, and an understanding of, the plant's quality assurance program and that management exercised limited oversight and involvement in this area. When inspections and incidents continued to occur indicating weaknesses in the plant's operation, NRC fined the utility $550,000 in January 1982. In addition, NRC's systematic assessments over the years have shown that the utility improved plant performance in specific areas but subsequently fell back to a marginal performance rating. On April 12, 1986, the utility shut the plant down.

Shortly thereafter, at July 1986 hearings before the Subcommittee on Energy Conservation and Power, House Committee on Energy and Commerce, it was brought out that

- NRC allowed the plant to operate despite serious management failings,
- the management problems at Pilgrim largely went uncorrected despite criticism from NRC,
- NRC's February 1986 systematic assessment report showed that the utility had not taken action to improve plant performance and could not sustain an acceptable level of plant performance, and
- the Institute of Nuclear Power Operations' reports cited many "long-standing" management problems.

Brunswick

The Brunswick plant, located at Southport, North Carolina, received an operating license for one reactor in December 1974 and for another in November 1976. Between July 1980 and January 1983, NRC found a number of problems at the plant in four technical areas—plant operations, maintenance, fire protection, and quality programs and administrative controls—and gave the plant the lowest assessment rating it could give for two consecutive rating periods. Although NRC was aware of the problems in 1980, it was not until December 1982 that it ordered the utility to implement a program to improve the plant's management, operations, and quality assurance program.

In addition, in 1982 the utility found that the plant's management had not conducted periodically required surveillance tests to calibrate instruments and test pumps and valves to ensure that the plant operated safely. Subsequently, in July 1982 NRC inspected the plant, confirmed the utility's findings, and identified other problems. NRC found that the utility did not (1) conduct required surveillance tests on the second reactor even though it found that these tests were not performed on the first reactor, (2) perform routine inspections of equipment, such as pumps, valves, and switches, and (3) calibrate monitoring instruments. As a result, NRC fined the utility $160,000 in 1982 and $600,000 in 1983. According to an NRC Region II official, neither the utility nor NRC had detected these other regulatory violations even though some had existed at both reactors since they began operating—about 8 years for one and 6 years for the other.

Browns Ferry

The Browns Ferry plant, located in Decatur, Alabama, received operating licenses for three reactors in December 1973, August 1974, and August 1976. Between 1981 and 1984, NRC identified 652 inspection violations and assessed the utility over $413,000 in civil penalties. In addition, NRC periodically conducted systematic assessments of the plant's compliance with current regulations, standards, and technical specifications. The assessment conducted for the period February 1983 to April 1984 showed that although the plant's overall performance was acceptable, major safety problems existed and that the utility—the Tennessee Valley Authority (TVA)—was not taking vigorous action to correct the deficiencies identified. During the systematic assessment, NRC met 13 times with TVA management and pointed out that TVA

- did not identify the causes of operating problems and did not take appropriate corrective action;
- filled key management positions with personnel having only minimal experience in reactor operations;
- failed to develop procedures to ensure that regulatory requirements were met; and
- lacked an effective quality assurance program, including employee training in operating procedures and regulatory compliance.

In January 1984, TVA began taking action to correct the deficiencies. For example, TVA stopped refueling activities until it reevaluated its management controls and training programs. In addition, TVA sent a letter to its nuclear power operations manager stating that immediate action was required to elevate the plant's regulatory performance to a level consistent with NRC's requirements and calling for numerous changes to plant operations, such as radiological controls, maintenance, security and safeguards, quality assurance, and refueling operations. Further, in mid-1984, TVA developed a Regulatory Performance Improvement Plan that described actions and schedules needed to ensure the safe operation of the plant. On July 13, 1984, NRC sent TVA an order to confirm that the utility would expeditiously complete the initiatives spelled out in its Regulatory Performance Improvement Plan.

It is very apparent from NRC's assessments of the Browns Ferry plant that problems grew progressively worse starting in 1980. Each NRC assessment conducted after March 1980 showed lower performance ratings. NRC's assessment (through February 1984) showed that the plant received the lowest possible rating in six categories compared with two categories in March 1980. The number increased to seven categories in NRC's assessment through May 31, 1985. On March 19, 1985, TVA ceased operations at all three of the Browns Ferry's reactors because of continued problems. As of May 1987, all three units were still down.

NRC Lacks Guidelines to Shut Down Plants

The Atomic Energy Act and NRC's implementing regulations allow NRC to withdraw a plant's operating license if the utility cannot achieve and/or maintain adequate levels of protection such that continued operations could endanger public health and safety. However, NRC lacks guidelines to determine when to shut a plant down. As a result, plants such as Davis-Besse, Rancho Seco, Pilgrim, Brunswick, and Browns Ferry operate with chronic safety problems until either an incident occurs that forces a shutdown or the utility stops operations to correct problems. In addition, in the few cases where NRC ordered shutdowns, its actions looked inconsistent because NRC did not take the same action for other plants with similar problems.

Over the last 25 years, NRC has ordered only five operating plants (seven reactors) to shut down.[4] However, NRC did not take this action earlier or for other plants with similar problems. On March 13, 1979, NRC's Director, Office of Nuclear Reactor Regulation, ordered four plants—Beaver Valley, Pennsylvania; James A. Fitzpatrick, New York; Maine Yankee, Massachusetts; and Surry, Virginia—to shut down to determine whether they could meet NRC's seismic regulations. NRC's 1979 annual report stated that NRC shut the plants down because reasonable assurance did not exist that a severe earthquake would not cause an accident, damaging emergency core cooling systems and preventing safety systems from shutting down the plants. NRC subsequently identified other plants where it had similar concerns, but NRC did not order the utilities to close them. Rather, NRC directed the utilities to confirm that plant designs could meet seismic requirements.

In addition, on March 31, 1987, NRC's Executive Director for Operations ordered the Peach Bottom, Pennsylvania, plant to shut down. NRC took this action because it found evidence that control room personnel were

[4]In 1981 and 1982 NRC suspended the construction permits for two other plants.

asleep on the job and the utility's compliance since 1983 with regulatory procedures and the plant management's attention to operating practices had been poor. NRC concluded that it lacked reasonable assurance that the plant operated in a safe manner. However, after an NRC inspector observed a worker sleeping in the control room on June 10, 1985, NRC did not order the plant to shut down.

According to NRC's Chief, Operating Reactor Programs Branch, when NRC finds a significant safety violation that could result in an enforcement order to cease operations, NRC first talks to utility officials to resolve the matter. If the utility does not agree to take corrective action, NRC can issue a "show cause order" requiring the utility to demonstrate why the plant should not be shut down. According to the Operating Reactor Programs Branch Chief, utilities have shut plants down after receiving the show cause order rather than waiting until NRC issues an order for them to do so. For the Davis-Besse, Rancho Seco, Pilgrim, Brunswick, and Browns Ferry plants, NRC did not send the utilities show cause orders; instead safety incidents or the utilities themselves caused the shutdowns.

Commissioners Cannot Agree on When Plants Should Be Shut Down

NRC's commissioners do not agree on the specific types and/or degree of safety problems that could endanger public health and safety such that NRC should require the utility to cease operations at a plant. During May 1986 hearings before the Subcommittee on Energy Conservation and Power, House Committee on Energy and Commerce, all of NRC's commissioners were asked to define undue risk.

NRC's Commissioner James Asselstine said that the agency should have shut Davis-Besse down before the equipment failures led to problems and the subsequent shut down of the reactor on June 9, 1985. The Commissioner also said that he could not understand how anyone could argue that the series of breakdowns and the widespread failures of performance throughout the plant's safety system did not pose an undue risk to public health and safety. The other commissioners were not as decisive. Commissioner Lando Zech was not aware of any incident occurring during 1985 for any nuclear power plant that constituted undue risk. Commissioner Frederick Bernthal said that he did not believe, up until the point where the plants start to have a series of failures, that it was time for NRC to shut the plant down. The then Commission Chairman Nunzio Palladino stated that no undue risk exists because the plants have equipment, trained personnel, and procedures to cope with a wide variety of incidents. Commissioner Thomas Roberts did not give an answer concerning what constituted undue risk.

NRC Has Information on Plant Safety

NRC has a number of ways to obtain information about plant safety. For example, about every 12 to 18 months (not to exceed 18 months), NRC conducts a comprehensive SALP evaluation for 10 to 12 management and plant operation areas. The SALP process integrates information concerning how the utility directs, guides, and provides resources to ensure plant safety and allows NRC and the utility to direct their attention to those safety areas that need improvement. As part of this review, NRC gives each of the areas a ranking of one, two, or three—a one indicating that the utility's management is safety-oriented and a three indicating that although the utility meets regulatory standards, its overall performance is marginal.

NRC also gathers information on plant performance in various categories, such as capacity, availability, and unplanned power outages. As pointed out in chapter 2, although performance indicators do not necessarily indicate plant safety, they do show trends in plant operations that could be used to assess both plant management and safety. In fact, NRC's Chairman Zech has said that NRC needs to develop performance indicators to assess when a plant's performance might prove an undue public health and safety risk. In this regard, NRC initiated a Performance Indicator Program late in 1986 to provide quarterly reports on six performance indicators such as significant events, safety system failures, and forced outages. According to NRC staff, the indicators will provide input to management decisions regarding individual plant safety and performance. As part of this program, NRC senior managers plan to meet regularly to discuss low- performing plants.

However, NRC's Director, Office of Nuclear Regulatory Research, pointed out that the agency could not develop a "cookbook" to decide when a plant should be shut down because each plant's license contains specific criteria for NRC to determine if unsafe conditions exist. Therefore, NRC must assess any deviation from the license on a case-by-case basis giving consideration to overall plant design, operating personnel, and management. The Director also pointed out that the utilities have primary responsibility to ensure safe plant operations and to identify areas of noncompliance with NRC requirements and operating technical specifications and licenses.

Conclusions

NRC conducts only limited inspections of utilities' compliance with rules and regulations; NRC relies heavily on the utilities to operate plants safely. In addition, NRC's resident inspectors make judgments about the entire plant on the basis of a limited sample of utility procedures they inspect. Once a significant safety incident occurs, NRC increases its oversight and assesses the causes of the incident and corrective action proposed.

However, NRC allowed some plants to operate for many years with significant safety problems, and NRC's commissioners cannot agree on what constitutes adequate levels of protection and undue public health and safety risk, such that NRC would shut plants down that do not meet these legislative requirements. Although we agree with NRC that the ultimate decision to shut a plant down should be made on a case-by-case basis, we believe that NRC needs a mechanism to alert the industry that plants would be shut down when safety or management problems approach a specified threshold.

To date, NRC's decisions on whether to shut plants down or permit continued operation look inconsistent. In the few instances where NRC ordered operating plants to shut down, it did not take the same action for other plants with similar problems. In addition, in the five cases we reviewed, the plants operated for many years with chronic safety problems; NRC did not require prompt, effective action. Ultimately, for four of the plants, a safety incident occurred that made continued operations impossible or the utilities shut the plants down when the problems grew severe.

Recommendation

We recommend that the Chairman, NRC, develop guidelines to use as a framework in deciding the types and/or degree of safety problems that constitute undue risk such that NRC would consider shutting a plant down.

NRC Does Not Consolidate Safety Violation Information

Between fiscal years 1981 and 1986, NRC found 12,170 violations of its safety standards. Of these violations, NRC classified 477 as the more significant. NRC has three basic enforcement actions by which to require utilities to take corrective action. It has imposed the most severe enforcement action—a legally binding enforcement order—in 16 instances. However, NRC headquarters does not consolidate the regional information to evaluate safety trends and or determine the status of corrective actions taken by the utilities.

Violations Found

NRC's resident inspectors and regional offices conduct routine or special inspections to ensure that utilities operate their plants in compliance with NRC's regulations and guidelines. Since NRC's regulatory requirements have varying degrees of safety significance, NRC categorizes utility violations by five levels of severity to show their relative importance within seven areas—reactor operations, facility construction, safeguards, health physics, transportation, emergency preparedness, and miscellaneous matters. NRC assigns severity level I to violations that are the most significant, such as those involving high-potential safety risk (release of radioactivity off-site greater than 10 times the limits set by the licensee's permit), and severity level V to violations that are the least significant, such as first-time violations having little safety significance.

Once NRC finds a violation and determines the severity, it can take one or more of three types of enforcement actions. NRC can issue a Notice of Violation, impose a civil penalty (fine), or issue an enforcement order. NRC issues a Notice of Violation when the licensee does not comply with NRC requirements (statute, regulation, license condition, or technical specification). The notice can encompass more than one violation found during the inspection. NRC staff estimates that the agency issues about 1,000 notices each year.

If NRC finds significant safety or technical specification problems, repetitive violations, or noncompliance as documented in a Notice of Violation, NRC can impose a civil penalty on the utility. However, by statute the utility can contest the civil penalty imposed by submitting a written response to NRC. As a result of the response, NRC may mitigate, remit, or continue the civil penalty. In fiscal year 1980, when NRC's current enforcement policy went into effect, the maximum daily civil penalty that NRC could assess increased from $5,000 to $100,000 per violation.

NRC also uses administrative mechanisms such as bulletins and confirmatory action letters to supplement its enforcement program. From January 1981 to April 1987, an NRC official estimated that NRC issued 150 to 200 confirmatory action letters. In addition, in serious cases, such as when a utility does not comply with NRC requirements or refuses to correct a problem, NRC can issue an enforcement order requiring the utility to stop operations. NRC can also suspend or revoke the utility's license with an enforcement order. The orders can be issued in lieu of, or in addition to, civil penalties. NRC's enforcement policy states that it can issue enforcement orders in conjunction with civil penalties to achieve immediate corrective action.

NRC can issue an enforcement order when the licensee interferes with the conduct of an inspection or investigation and/or has not fully responded to another enforcement action, civil penalty, or Notice of Violation. It can also issue such orders when it wants to

- remove a threat to public health and safety, such as the licensee's failure to adequately plan, supervise, and control activities that could increase worker radiation exposures and
- stop construction because (1) further work could preclude or significantly hinder NRC's identifying a safety-related system or component problem or (2) the licensee's quality assurance program does not ensure that construction activities are conducted properly.

Table 4.1 summarizes, for fiscal years 1981 through 1986, the number and types of violations found and enforcement actions issued by NRC.

Table 4.1: NRC Enforcement Actions: Fiscal Year 1981 Through 1986

	FY 1981	FY 1982	FY 1983	FY 1984	FY 1985	FY 1986
Violations cited[a]						
Level I (most severe)	12	0	2	0	1	2
Level II	425	6	17	3	4	5
Level III	209	94	107	106	158	148
Level IV	393	821	984	1 310	1 352	1 251
Level V (least severe)	1 135	960	880	690	691	404
Total	**2,174**	**1,881**	**1,990**	**2,109**	**2,206**	**1,810**
Civil penalties						
Number of actions	21	30	47	36	38	43
Amounts proposed	$1 357 000	$3 245 000	$3.553 125	$2 642 500	$3 361 500	$3 247 500
Amounts imposed	$549 000	$1,178 000	$1 536 500	$520 000	$750.425	$400.000
Amounts paid	$1 087 185	$3 019 000	$3 159 625	$1 748.500	$2.286 425	$2 052 500
Enforcement orders	2	1	0	8	3	2

[a]NRC staff informed us that it does not have a strong quality control/assurance program to ensure that the severity level information was entered correctly on its Enforcement Action Tracking and 766 Systems particularly levels I through III

FY = fiscal year

Source Computer runs from NRC's Enforcement Action Tracking and 766 Systems

As shown in table 4.1, most of the violations NRC issued between fiscal years 1981 and 1986 fell into levels IV and V, the violations of least safety significance. Since NRC encourages and supports licensee initiatives to identify and correct problems, NRC generally does not issue civil penalties for a violation that the licensee has identified and reported to NRC or that is classified as a level IV or level V violation. In addition, between fiscal years 1981 and 1986, NRC issued 16 enforcement orders. The enforcement orders required utilities, in part, to

- change or modify equipment, procedures, or management controls;
- gain better management control, provide individual accountability, and establish an environment for continued plant-operating improvements; and
- implement programs to achieve basic improvements in management, operations, and quality assurance.

NRC officials told us they issued the enforcement orders because utilities were not giving sufficient management attention to safety-related activities or NRC had identified significant operating deficiencies. In addition, NRC issued enforcement orders when the licensee had a poor history of regulatory compliance or the licensee failed to adequately plan or implement design modifications that could affect public health and safety. None of the 16 enforcement orders required the utility to cease operations until improvements could be made.

NRC Cannot Determine Status of Corrective Actions

NRC headquarters does not consolidate information on corrective actions taken by the utilities. Under its decentralized management, NRC relies on its regional offices to ensure that utilities take corrective actions regarding violations found. A regional office official told us that NRC headquarters could obtain these data from each regional office.

According to NRC's Chief, Operating Reactor Programs, Division of Inspections Program, an "open items" (unresolved violations) tracking system exists at each of NRC's five regional offices for each utility under the office's purview. One senior resident inspector told us that the NRC regional offices track corrective actions using the "open items" system, and the information is updated monthly. The resident inspector also said that two lists are prepared: one for all violations and one solely for open items.

We also discussed this matter with a staff member in NRC's Resource Management and Analysis Branch who told us that headquarters tracks inspection reports prepared by the regional offices primarily to determine when the offices send their inspection results to the utilities. This system also allows headquarters to determine when its regional offices acknowledge and accept the licensee's response for corrective actions. The system does not, however, specify the corrective action proposed or taken by the licensee or that NRC has verified that the licensee took the appropriate action to correct the violations.

Conclusions and Recommendation

Each year NRC finds thousands of violations of its safety standards. A system exists whereby NRC relies on each regional office and resident inspector to track the violations to ensure that the utilities take corrective action. NRC headquarters does not routinely consolidate this information.

We believe that consolidated information would be useful for NRC management and its commissioners to better oversee the agency's various regulatory programs. Such information could also allow NRC on a nation-wide basis to evaluate safety trends, corrective action taken, and the effectiveness of its inspection and enforcement programs.

Therefore, we recommend that the Chairman, NRC, annually develop consolidated information for all operating plants showing the status of corrective actions planned or taken by the utilities.

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