The Good, the Bad, and the Ugly

A Report on Safety in America's Nuclear Power Industry

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The Union of Concerned Scientists (UCS) is dedicated to advancing responsible public policies in areas where science and technology play a critical role. Established in 1969, UCS has created a unique alliance between many of the nation's leading scientists and thousands of committed citizens. This partnership addresses the most serious environmental and security threats facing humanity. UCS is currently working to encourage responsible stewardship of the global environment and life-sustaining resources; promote energy technologies that are renewable, safe, and cost effective; reform transportation policy; curtail weapons proliferation; and promote sustainable agriculture. An independent nonprofit organization, UCS conducts technical studies and public education, and seeks to influence government policy at the local, state, federal, and international levels.

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Executive Summary

Nuclear power plant safety demands constant vigilance. It cannot be taken for granted. Equipment has worn out faster than expected. Electric utility restructuring has forced plant owners to cut costs to be competitive. These need not jeopardize safety, but maintaining it requires careful, unstinting attention.

UCS undertook a study to assess how the nuclear power industry is handling the pressures of aging equipment and shrinking budgets. For our focus group, we selected 10 plants that represent a cross section of the nuclear industry. We monitored information about how owners and staff discovered and responded to incidents at those plants. The conclusions of this report are based on data from November 1996 through January 1998.

The disturbing trend UCS identified was a serious breakdown in quality assurance: the plants' internal auditors, a key element in the quality assurance programs that federal law requires, found *none* of the more than 200 problems reported last year. Plant workers found some problems, inspectors from the Nuclear Regulatory Commission found others, and some became obvious when equipment broke. But the internal auditors did not identify a single problem.

A second significant finding was that far too many of the problems reported at the monitored plants resulted from workers' mistakes (35 percent of reported problems) or poor procedures (44 percent). The gravity of these findings cannot be overemphasized. Human error and faulty procedures were major factors in both the Three Mile Island and the Chernobyl disasters.

In addition to revealing safety concerns afflicting the nuclear industry as a whole, our monitoring efforts also identified safety issues at individual plants. At the LaSalle, Millstone, and Sequoyah plants, problems often remained undetected or uncorrected over a long period of time. Such "hidden" problems seriously erode safety principles based on redundancy. If, for example, an emergency pump breaks, its backup will be of little use if that too has been broken for months.

Not all our findings were bleak, however. Our monitoring program turned up good performance as well as bad. For example, most of the incidents at three of the plants—Surry, Oyster Creek, and Oconee—were minor. They were discovered quickly and fixed properly. These results suggest a healthy regard for the importance of safety at all levels.

Based on these monitoring results, UCS recommends the following:

- Internal auditors need better training or incentives to identify problems.
- Workers need additional training or greater oversight to reduce the number of their errors.
- Procedures need revision to eliminate mistakes prompted by faulty guidelines.
- The Nuclear Regulatory Commission needs to improve its enforcement of federal safety regulations in order to eliminate instances of sustained substandard operation.
- The US Congress should formally review the NRC's regulatory effectiveness to make sure that public health and safety are adequately protected.

The Good, the Bad, and the Ugly

A Report on Safety in America's Nuclear Power Industry

Operational safety is of vital importance at all 104 of the nuclear power plants operating in the United States. According to a 1982 congressional report, an accident at a nuclear plant could kill several thousand people, injure several hundred thousand others, and cost billions of dollars. Thus, safety must be a key consideration for the nuclear power industry.

Safety is not a matter of single incidents. No one error can cause the meltdown of a reactor. Because nuclear power plants are complex systems that include multiple redundancies, many things must go wrong for a major accident to occur. But these safety margins must be maintained in order to provide real security: inspectors and tests must identify faulty equipment, and accurate procedures must guide workers so that they do not make errors. Unfortunately, safety margins are continually challenged. Equipment can wear out more rapidly than expected, and pressure to cut costs can result in poor safety monitoring or slow response to known problems.

The Nuclear Regulatory Commission (NRC) is responsible for monitoring performance and enforcing safety regulations at nuclear power plants. The NRC issues a report card indicating its assessment of each plant's performance every two years and a "Watch List" of troubled plants twice each year. But many observers (most recently the US General Accounting Office) have criticized the NRC's assessment program for failing to detect declining performance in a timely manner. The Institute for Nuclear Power Operations (INPO), a peer group that the industry established after the Three Mile Island accident, assesses plant safety, but its reports are not available for public review. A third body—Public Citizen—also tracks safety at nuclear power plants. In its periodic *Nuclear Lemons* reports, this environmental group lists the 25 worst-performing plants, based on economic and safety indicator criteria.

The Union of Concerned Scientists (UCS) decided that we could not rely on the NRC's assessment program. We cannot review INPO's reports. And Public Citizen offers limited insight into safety practices at plants not on its list of "lemons." We developed our own monitoring program to obtain a broader understanding of safety issues across the nuclear power industry. UCS is less interested in the number of incidents at any particular plant than in how effectively plant owners identify and respond to safety problems. Assessing such performance is key to determining whether safety margins are being maintained or eroded as nuclear power plants age and come under pressure to compete with other technologies.

The UCS Nuclear Safety Monitoring Program

UCS monitors safety margins at 10 nuclear plants. To be certain that our focus group represents the industry as a whole, we chose one plant from each of the nine categories of reactor type and containment design. In addition, we sought diversity in geographic location, utility size, utility structure (private company or public agency), and site configuration (single or multiple reactors). We also selected plants that would allow us to monitor nuclear plant license renewal. Finally, we picked two plants from the largest of the nine classes so that each of our

Focus Group

Calvert Cliffs 1, Maryland
Cooper, Nebraska
Indian Point 3, New York
LaSalle 1, Illinois
Millstone 3, Connecticut
Oconee 1, South Carolina
Oyster Creek, New Jersey
River Bend, Louisiana
Sequoyah 1, Tennessee
Surry 1, Virginia

10 focus group members represents roughly the same number of operating plants.

This representative monitoring approach allows us to determine whether a problem, either in its discovery or in staff response, at a focus group plant might affect a larger population—perhaps all the plants in the same class, all the plants operated by the same owner, or even all operating plants. At the same time, we are able to assess whether problems identified at plants outside our focus group also exist at any of the monitored plants. Such cases indicate a more widespread problem.

To examine safety margins at plants in our focus group, we review publicly available documents, including the NRC reports on the plants and information from the plants' owners. We supplement these reviews with conversations with plant workers, industry consultants, the NRC inspectors resident at the plants, regional and headquarters NRC staff, and citizens living near the plants. In evaluating the information that the owners and NRC officials report about each plant, we use objective performance criteria based on federal regulations.

The Incident Performance Checklist and Scoring System. Nuclear plants contain thousands of pumps, valves, motors, switches, and other components. Plant workers perform thousands of tasks. Each year, equipment breaks, testing reveals deficiencies, and workers make mistakes. These problems are documented in owner and NRC reports. Occasionally, the reports describe successful efforts to improve safety margins. UCS's evaluation program does not simply tabulate the reported problems and successes. Instead, we try to determine what these reports indicate about the performance of plant workers in response to the reported incidents. To do so, we ask questions about each incident and rely on the reports to provide the answers.

UCS's Questions

1. Who identified the problem?
2. How was it identified?
3. Was it evaluated properly?
4. What caused the problem?
5. When was it identified?
6. Had the problem occurred before?
7. If so, had the problem been fixed?
8. If so, was the fix effective?
9. Has the problem been corrected?

Federal safety regulations form the criteria for scoring the answers. When the plant owner's response satisfies the regulations, the score for an answer is zero. When the owner's actions exceed minimum standards, the score is positive. Thus, positive scores reflect commendable actions, such as going beyond correcting a single problem to seek out and correct related problems. When actions do not meet federal regulations, the score is negative.

Consider the second question: How is a problem identified? If the owner finds a problem by efforts that are not required, then we score it +10. If routine methods identify the problem, we award zero points. If an NRC inspector finds it, it receives a –10 score. Answers to most of the other questions are scored in the same way. All answers can earn negative points, but only answers to questions 2 and 9 can earn positive points. Since a problem can have more than one cause, question 4 can have several answers, each of which receives a score.

The total score for performance during an incident is the sum of the scores for the answers to the questions, multiplied by a weighting factor (ranging from 1 to 2), based on the importance of the equipment affected by the problem. Thus the total score for an incident can range from +40 to –260.

Note that the scores, while they reflect the severity of the incident, are not an assessment of its severity. Rather, the scores reflect our assessment of the performance of plant personnel in finding problems and responding to them. Performance involving an incident with potentially serious consequences may receive a positive score if, for example, plant personnel identified and dealt with the problem quickly, thoroughly, and efficiently, then went on to check other points where similar problems might occur. Similarly, performance involving a minor problem might receive a relatively large negative score if plant personnel failed to recognize the problem over several opportunities and, when they did recognize it, failed to correct it. Proper and timely response to problems is the key factor in maintaining safety margins.

More incidents will receive negative performance scores than positive scores, because difficulties must be

reported, while successes may not be. Thus, our review does not capture all the success stories. In addition, there may be few zero scores, since tests and operator actions that satisfy all requirements often go unreported. Since we apply the scoring system equally to all incidents, however, we are able to determine the relative performance of a plant against other members of our focus group. The plants that aggressively seek out and fix problems will have higher scores than those plants that sit back and wait until problems become self-evident.

We minimize the subjectivity in our checklist by not second-guessing the facts that plant owners and NRC inspectors report. For example, if they say an incident's cause was equipment failure, we score the incident on that basis. We do not presume that the equipment failed because of poor maintenance practices. We also minimize subjectivity by applying consistent criteria based on federal regulations to determine such things as whether the correction to a problem was effective. By using consistent criteria, our results provide a meaningful measure of relative performance.

Results from Monitoring the Focus Group

This report covers safety issues during the period from November 1996 to January 1998. For each plant in the focus group, we reviewed about 50 owner and 25 NRC reports. The results for individual plants are in the appendix to this report.

Widespread Quality Assurance Breakdown. The most serious finding of our monitoring program throws the safety of the entire nuclear power industry into question. None of the internal auditors at any of the focus group plants identified a single one of the more than 200 incidents reported last year. These auditors are key elements in the plants' quality assurance programs—programs mandated by federal regulations. Their entire purpose is to detect problems. The results suggest that their focus is misdirected: they are finding minor problems instead of serious safety issues. This widespread breakdown in quality assurance clearly reflects a lack of industry and NRC emphasis on this essential monitoring function.

When Were Problems Identified? A number of problems at a variety of plants went undiscovered until several incidents indicating the same problem had occurred. This underscores the gravity of the breakdown in quality assurance. Overall, only 58 percent of the problems were discovered at the first opportunity, 24 percent at the second opportunity, and 18 percent within a few episodes. If quality assurance at the plants were effective, more problems would be detected and corrected sooner.

Who Identified the Problems? Federal regulations mandate that plant owners inspect and test to find safety problems. In theory, the NRC inspectors should not find any problems—a plant's owners should find them all. In practice, the NRC inspectors identified 16 percent of the problems at the focus group plants. Plant workers detected 15 percent of the problems during testing activities, roughly the same number as the NRC found. Although each plant undergoes thousands of tests each year, the testing seems surprisingly ineffective at locating the problems.

What Caused the Problems? Five causes[1] were responsible for the problems at the focus group plants: poor procedures (44 percent), worker mistakes (35 percent), equipment failures (29 percent), design errors (22 percent), and maintenance problems (9 percent). Since these plants are all at least 10 years old and past the "break-in" phase of operation, procedure revisions and training programs should have reduced the first two problem causes. Poor procedures and worker mistakes are the easiest errors to prevent, yet they persist.

Maintenance activities produced only 9 percent of the problems. This relatively low number probably reflects recent NRC emphasis in this area, culminating in the adoption in July 1996 of the Maintenance Rule, which requires plant owners to set goals for equipment reliability. Plant owners have devoted considerable resources to improving maintenance practices, clearly to good effect. This suggests that regulatory attention that prompts comprehensive industry reaction can successfully reduce problems.

[1] Total exceeds 100 percent because a problem can have more than one cause.

The Good, the Bad, and the Ugly

Incident performance earning the highest and the lowest scores from our evaluation system illustrates the difference between safe operating practices and risky business. The high scores demonstrate that safe performance levels can be achieved, and the low scores show that some plant owners were unable, or unwilling, to do what it takes to meet minimum safety standards. And the NRC merely "watched."

The Good. Under the UCS rating system, a positive score indicates that the actions taken during an incident exceeded the minimum performance standards set out in the federal safety regulations. Of the more than 200 problems reported for the focus group plants, performance during just 15 of them received positive scores. Performance at the five incidents summarized below received the highest scores. These incidents reflect a healthy—and necessary—attitude toward nuclear safety. These thorough responses not only resolved the problems completely, but also effectively eliminated the likelihood of future problems.

- ☺ ***Proactive Inspections at Oyster Creek:*** In 1997, staff at Oyster Creek inspected the plant's emergency cooling system after the owners of the Nine Mile Point Unit 1 facility, which is similar in design to the Oyster Creek plant, reported problems with its cooling system. Although the problems had not surfaced at Oyster Creek and the NRC had not required any inspections, the plant's owners proactively initiated a search and were prepared to correct deficiencies if any existed. No problems were found. ***Score: +25***

- ☺ ***Training Video at Surry:*** The training group at Surry developed a video during 1997 that describes reactor control problems experienced at other plants. The video covers the procedures and design features that prevent those problems from occurring at Surry. This was a creative and effective method of conveying lessons learned at other plants to Surry's operators. ***Score: +25***

- ☺ ***Containment Integrity at Surry:*** During an inspection at the time of a 1997 refueling shutdown, Surry's managers identified a small hole in the containment building that wasn't properly covered. Even though the problem was minor, they stopped all refueling work until staff had corrected it and had completed a search for similar problems. No other problems were found. ***Score: +20***

- ☺ ***Component Defect Warning at River Bend:*** After finding numerous defects in a 1997 shipment of components, the owner of the River Bend plant contacted the parts manufacturer. The manufacturer determined that an entire batch of parts had been faulty. When the plant staff learned that another nuclear power plant had also received components from this batch, the system engineer at River Bend called and warned his counterpart at that plant. ***Score: +20***

- ☺ ***Thorough Repair at Cooper:*** During a 1997 test, a valve did not operate properly. Initially, Cooper's owners determined that the valve's failure did not need to be reported to the NRC because the failed condition satisfied the plant's operating license. Later, plant workers determined that this section of the operating license contained an error dating from changes to the license in the early 1980s. The probing assessment that went beyond the convenient answer and uncovered the truth offset the fact that the mistake had remained undetected for over a decade. ***Score: +18.8***

The Bad and the Ugly. Performance that receives a negative score under our rating system indicates that actions taken in response to an incident failed to meet the minimum performance standards set out in the federal safety regulations. Unfortunately, performance responding to most of the more than 200 incidents reported at the focus group plants received negative scores. In five cases, incident performance received scores equal to or lower than -100. These five all

involved repetitive problems with safety equipment that had been tolerated and left uncorrected for years—in one case, for decades. This lack of action raises serious questions about how all the inspections and testing conducted by plant workers and NRC inspectors over so many years could fail to identify these safety problems.

☹ ***Bad Switches at LaSalle:*** In late 1996, a flawed control switch caused one of the two pumps that circulate cooling water through the reactor to malfunction. Since then, nearly 1,150 other switches, affecting virtually every emergency system in the plant, have had to be replaced because they could also be faulty. In 1979, General Electric notified LaSalle's owners that more than 100 suspect control switches needed replacement, but the warning was ignored. One of the switches GE identified actually caused a safety problem in 1990, but only that single switch was replaced. The switch problems surfaced again during 1995, but the switches were still not replaced. Thus, LaSalle's owners ignored repeated warnings of widespread equipment deficiencies affecting several safety systems throughout a 17-year period. ***Score: -130***

☹ ***Old Circuit Breakers at Cooper:*** In 1997, NRC inspectors discovered that the owners of the Cooper nuclear power plant were not performing maintenance on the circuit breakers controlling power to emergency equipment every five years as specified by the manufacturer. A breaker failure in 1987 had prompted the plant's owners to begin a maintenance program, but this effort ended in 1994 with 25 percent of the breakers unexamined. The potentially degraded breakers included those that must close in order for the emergency diesel generators to supply power to safety equipment and others that must close in order for the emergency pumps that cool the core to start. These breakers had not been overhauled since their installation 23 years earlier. ***Score: -110***

☹ ***"Missed" Safety Valves at LaSalle:*** In 1997, NRC inspectors discovered that actions taken in response to a 1992 NRC fire safety warning at the LaSalle nuclear power plant had not corrected the problem. A fire in the control room could have disabled 15 safety valves. LaSalle's owner had initially informed the NRC that a fire would not affect the valves. After the NRC raised the concern again in 1997, the plant's owner modified the valves to protect them from a fire. ***Score: -110***

☹ ***Unreviewed Work Backlog at LaSalle:*** In 1997, NRC inspectors discovered that LaSalle's owners had not reviewed many of the plant's backlog of 1,380 work requests, which covered every emergency system, to determine whether the affected equipment might be broken. Plant workers file work requests when inspections and testing indicate possible equipment problems. Some requests were two and three years old, indicating that the plant had been operating during those years with safety equipment that may have been broken. ***Score: -100***

☹ ***Recurring Drain Problem at Sequoyah:*** During a refueling shutdown in early 1997, operators of the Sequoyah nuclear power plant drained the piping connected to the reactor vessel. The system that monitors the level of water in the reactor vessel was not used. During the draining, two separate, low-level alarms sounded, but went unheeded. The water level was mistakenly lowered below the top of the reactor head, a dangerous situation because it could disrupt the cooling for the reactor core. This same thing had happened *twice* at Sequoyah during 1993, but the procedure changes and other corrective actions from those events had not yet been completed by 1997, when operators repeated the mistake. ***Score: -100***

The Upshot

These incidents were near misses. Safety equipment intended to protect the public during an accident broke, and procedures proved inadequate. The significance of these near misses must not be discounted simply because an accident did not occur. Safety margins must be maintained at *every* nuclear power plant at *all* times to assure that backup is available and functioning when needed.

What's Required

⇒ Plant owners need to examine their staff and procedures to determine whether the problems we identified across all monitored plants are also problems at their plants. They should consider whether they need to

- provide better training or incentives to assure that internal auditors identify problems.
- provide their workers with additional training or greater oversight to reduce the incidence of human error.
- revise procedures to eliminate mistakes prompted by faulty guidelines.

⇒ The NRC should rigorously and consistently enforce federal regulations that require nuclear plant owners to implement effective quality assurance programs and minimize the number of problems caused by poor procedures and plant staff errors. When a plant is unable or unwilling to comply, the NRC must step in and stop unsafe operation. Because of the great danger to the public and the environment, substandard performance cannot be tolerated at any nuclear plant.

⇒ The US Congress should formally review the NRC's regulatory effectiveness to make sure that public health and safety are adequately protected. This congressional inquiry should happen now. It should not be deferred until after the next major reactor accident.

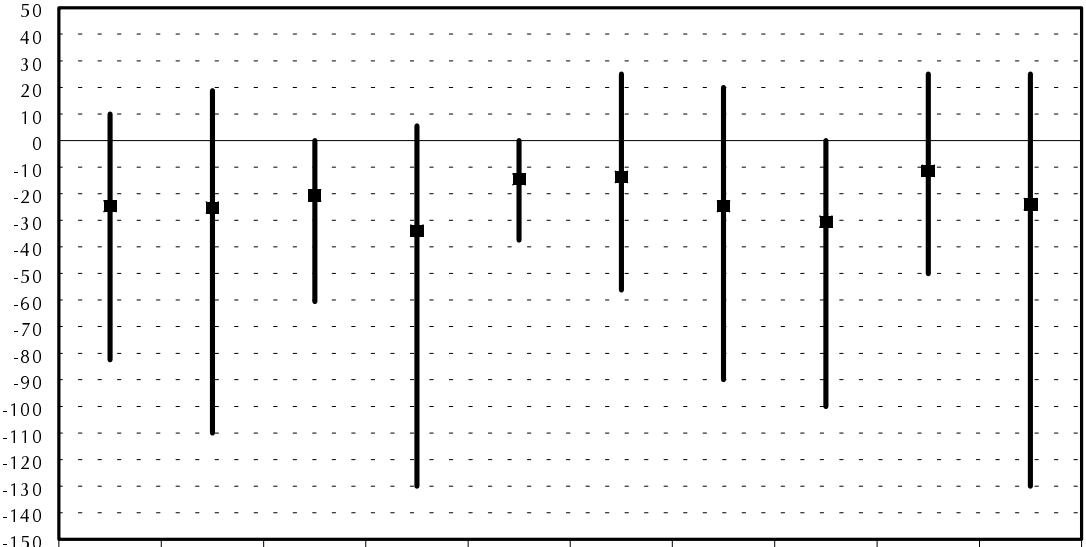
Appendix

Incident Performance at Individual Plants in the UCS Focus Group

Although the UCS monitoring program does not focus on individual plant performance, we are able to make comparisons between performance at the plants in our focus group and the average across that group. In examining each plant, we focus primarily on the incidents where performance received the highest (best) and lowest (worst) scores. These establish a plant's performance range, indicating strengths and weaknesses and suggesting what the owners are consistently doing right and wrong. While we also average the scores for a plant's incidents, this number is of less value because many instances of good or routinely accurate performance will not appear in the reports. However, the average does indicate the plant's performance relative to other plants in the focus group.

The following chart graphs the data we obtained by scoring incident performance at the focus group plants. Each line shows the range of scores at a plant. The top of the line marks the highest score given to performance in response to an incident at the plant, the bottom of the line marks the lowest incident performance score, and the dot marks the average for performance across all incidents at the plant. Millstone Unit 3 does not appear on the chart, since it remained shut down during the entire report period. The line furthest to the right shows the highest and lowest incident performance scores for the entire focus group, as well as the average performance across all incidents in the group.

The following pages discuss the results for each of the focus group plants individually.



	Calvert Cliffs	Cooper	Indian Point 3	LaSalle	Oconee	Oyster Creek	River Bend	Sequoyah	Surry	Focus Group
Best	10.0	18.8	0.0	5.5	0.0	25.0	20.0	0.0	25.0	25.0
Worst	-82.5	-110.0	-60.5	-130.0	-37.5	-56.3	-90.0	-100.0	-50.0	-130.0
■ Average	-24.7	-25.2	-20.7	-33.8	-14.5	-13.6	-24.7	-30.5	-11.4	-23.9

Incident Performance at Calvert Cliffs Unit 1 Nuclear Power Plant

The Baltimore Gas & Electric Company operates Calvert Cliffs Unit 1, as well as the neighboring plant, Unit 2. This nuclear power plant, which is 40 miles south of Annapolis, Maryland, has a generating capacity of 835 megawatts. Unit 1 is a pressurized water reactor supplied by Combustion Engineering. It is the first nuclear plant to apply for a 20-year extension to its 40-year operating license.

Operating License Issued: July 31, 1974
License Expiration Date: July 31, 2014

Monitoring Results

Calvert Cliffs' average incident performance score was slightly below the average for the focus group. At Calvert Cliffs, testing was less effective in identifying problems than it was at other plants. Testing activities revealed only 5 percent of the problems at the plant, whereas on the average such activities located 15 percent of the problems.

One incident at the plant was particularly troubling because it indicated an improper approach to safety regulations. To perform maintenance while the plant was running, workers blocked open a watertight door that prevents a flood from spreading to affect equipment in other areas. The plant's operating license allows this door to be open for only 24 hours. If it is open for longer, the plant must be shut down. Workers twice closed the door briefly—to reset the length of time the door had been open—then reopened it to continue work. The NRC found that the door was closed for only 6 minutes in a 49-hour period. This action shows a blatant disregard for safety requirements.

Other Plants Operated by Baltimore Gas & Electric

Calvert Cliffs 2	Lusby, Maryland

Other Pressurized Water Reactor Plants Built by Combustion Engineering

Arkansas Nuclear 2	Russellville, Arkansas
Calvert Cliffs 2	Lusby, Maryland
Fort Calhoun	Fort Calhoun, Nebraska
Millstone 2	Waterford, Connecticut
Palisades	South Haven, Michigan
Palo Verde 1, 2, & 3	Wintersburg, Arizona
San Onofre 2 & 3	San Clemente, California
St. Lucie 1& 2	Hutchinson Island, Florida
Waterford 3	Taft, Louisiana

	Calvert Cliffs	Focus Group
Incident Performance Scores		
Best	10.0	25.0
Worst	-82.5	-130.0
Average	-24.7	-23.9
When Were Problems Identified?		
First chance	60%	58%
Second chance	25%	24%
Within a few chances	15%	18%
After several tries	0%	0%
Who Identified the Problems?		
NRC inspectors	25%	15%
QA inspectors	0%	0%
Testing	5%	15%
Review of event at another plant	5%	3%
All other causes	65%	66%
What Caused the Problems?		
Equipment failure	30%	29%
Personnel error	40%	35%
Inadequate procedure	45%	44%
Inadequate maintenance	5%	9%
Design error	25%	22%

Incident Performance at Cooper Nuclear Power Plant

The Nebraska Public Power District operates the Cooper nuclear power station. The plant, located 23 miles south of Nebraska City, Nebraska, has a generating capacity of 764 megawatts. Cooper is a boiling water reactor with a Mark 1 containment supplied by General Electric. The Nebraska Public Power District, a state agency, does not operate any other nuclear plants.

Operating License Issued: January 18, 1974
License Expiration Date: January 18, 2014

Monitoring Results

Cooper's average incident performance score was slightly below the focus group average. The plant's weakest area was in identifying problems. Degraded conditions at Cooper were found at the first or second opportunity 73 percent of the time, compared with the focus group's average of 82 percent. Because problems were not found promptly, they could not be resolved promptly.

Cooper received one of the best and one of the worst incident performance scores within the focus group. This apparent contradiction reflects the plant's status. The plant demonstrated declining performance during 1995 and 1996 and the owners initiated improvement efforts. The high score resulted from a thorough evaluation of a benign condition that revealed a more serious problem. The low score resulted when the NRC uncovered a breakdown in emergency equipment maintenance.

One incident prompted UCS to notify the NRC. Equipment used to examine spent fuel in the pool where it is stored had the wrong settings. As a result, the spent fuel could come closer to the surface of the pool than is safe and than regulations allow. Cooper corrected the settings, but didn't realize that the problem might have caused workers to receive higher radiation exposures. The NRC found that, because of the incorrect settings, workers might have received three times more radiation than expected.

Other Plants Operated by the Nebraska Public Power District

none

Other Boiling Water Reactor Mark 1 Plants Built by General Electric

Browns Ferry 1, 2, & 3	Decatur, Alabama
Brunswick 1 & 2	Southport, N. Carolina
Duane Arnold	Palo, Iowa
Edwin I. Hatch 1 & 2	Baxley, Georgia
Fermi 2	Newport, Michigan
Hope Creek	Salem, New Jersey
James A. FitzPatrick	Scriba, New York
Peach Bottom 2 & 3	Delta, Pennsylvania
Vermont Yankee	Vernon, Vermont

	Cooper	Focus Group
Incident Performance Scores		
Best	18.8	25.0
Worst	-110.0	-130.0
Average	-25.2	-23.9
When Were Problems Identified?		
First chance	48%	58%
Second chance	24%	24%
Within a few chances	27%	18%
After several tries	0%	0%
Who Identified the Problems?		
NRC inspectors	18%	15%
QA inspectors	0%	0%
Testing	18%	15%
Review of event at another plant	3%	3%
All other causes	61%	66%
What Caused the Problems?		
Equipment failure	27%	29%
Personnel error	33%	35%
Inadequate procedure	36%	44%
Inadequate maintenance	6%	9%
Design error	27%	22%

Incident Performance at Cooper Nuclear Power Plant

The Power Authority of the State of New York operates Indian Point Unit 3. The plant, which is 24 miles north of New York City, has a generating capacity of 965 megawatts. Indian Point 3 is a four-loop pressurized water reactor supplied by Westinghouse. The Power Authority, a state agency, also operates one other nuclear power plant.

Operating License Issued : April 5, 1976
License Expiration Date: December 15, 2015

Monitoring Results

Indian Point 3's average incident performance score was slightly above the focus group's average. Beginning in early 1993, it had been shut down for three years while the owners corrected longstanding equipment, procedure, and training deficiencies. The plant's performance last year indicates that considerable improvements have been made.

Performance at one incident, however, suggests that more work remains to be done. During a shutdown last year, workers tested an important cooling-water system. The test data showed that some of the throttle valves in the system needed adjustment to achieve optimum cooling. The NRC found that many of the throttle valves were not in the positions specified in the approved procedures. It turned out that operators had started the plant using a draft procedure that had not been reviewed or approved. The rush to start operations had been placed ahead of safety.

Other Plants Operated by the Power Authority of the State of New York

James A. Fitzpatrick	Scriba, New York

Other 4-Loop Pressurized Water Reactor Plants Built by Westinghouse

Alvin W. Vogtle 1 & 2	Waynesboro, Georgia
Braidwood 1 & 2	Braidwood, Illinois
Byron 1 & 2	Rockford, Illinois
Callaway	Fulton, Missouri
Comanche Peak 1 & 2	Glen Rose, Texas
Diablo Canyon 1 & 2	Avila Beach, California
Indian Point 2	Buchanon, New York
Millstone 3	Waterford, Connecticut
Salem 1 & 2	Salem, New Jersey
Seabrook	Seabrook, New Hampshire
South Texas Project 1 & 2	Palacios, Texas
Wolf Creek	Burlington, Kansas

	Indian Point 3	Focus Group
Incident Performance Scores		
Best	0.0	25.0
Worst	-60.5	-130.0
Average	-20.7	-23.9
When Were Problems Identified?		
First chance	58%	58%
Second chance	26%	24%
Within a few chances	16%	18%
After several tries	0%	0%
Who Identified the Problems?		
NRC inspectors	11%	15%
QA inspectors	0%	0%
Testing	21%	15%
Review of event at another plant	5%	3%
All other causes	63%	66%
What Caused the Problems?		
Equipment failure	37%	29%
Personnel error	26%	35%
Inadequate procedure	53%	44%
Inadequate maintenance	5%	9%
Design error	16%	22%

Incident Performance at LaSalle Unit 1
Nuclear Power Plant

The Commonwealth Edison Company operates LaSalle Unit 1. The plant, which is 11 miles southeast of Ottawa, Illinois, has a generating capacity of 1,036 megawatts. Unit 1 is a boiling water reactor with a Mark 2 containment supplied by General Electric. Commonwealth Edison also operates a second unit at LaSalle, as well as eight other plants.

Operating License Issued: August 13, 1982
License Expiration Date: May 17, 2022

Monitoring Results

LaSalle Unit 1 was shut down during the entire monitoring period. Commonwealth Edison shut down both units at LaSalle in September 1996 in order to resolve a large volume of problems involving equipment and procedures that were not functioning as intended. The restart of the units, initially expected in 1997, has been deferred while the owner struggles with problems at several of its plants.

Although the plant remained shut down during the entire monitoring period, there were plenty of incidents for UCS to evaluate as the plant's owners and NRC inspectors probed the depths of the problems. As its history suggests, Unit 1 performed significantly below average focus group levels. In fact, it turned in the worst average incident performance score of any focus group plant. Design errors caused 42 percent of the problems at LaSalle 1, compared with 22 percent for the focus group as a whole. Problems of this type are alarming because they usually indicate that unsafe conditions have existed at the plant since its construction and have remained undetected for the entire period of operation, in this case for 15 years.

Longstanding unsafe conditions were also reflected by the fact that LaSalle required more opportunities to identify problems. On average, the focus group identified problems at the first or second opportunity 82 percent of the time. At LaSalle, that rate was only 72 percent. No plant owner can promptly fix a problem it delays finding.

Other Plants Operated by Commonwealth Edison

Braidwood 1 & 2	Braidwood, Illinois
Byron 1& 2	Rockford, Illinois
Dresden 2 & 3	Morris, Illinois
Quad Cities 1 & 2	Cordova, Illinois

Other Boiling Water Reactor Mark 2 Plants Built by General Electric

Limerick 1 & 2	Pottstown, Pennsylvania
Susquehanna 1 & 2	Berwick, Pennsylvania
LaSalle County 2	Seneca, Illinois
Nine Mile Point 2	Scriba, New York
Washington Nuclear 2	Richland, Washington

	LaSalle 1	Focus Group
Incident Performance Scores		
Best	5.5	25.0
Worst	-130.0	-130.0
Average	-33.8	-23.9
When Were Problems Identified?		
First chance	42%	58%
Second chance	28%	24%
Within a few chances	28%	18%
After several tries	3%	0%
Who Identified the Problems?		
NRC inspectors	11%	15%
QA inspectors	0%	0%
Testing	6%	15%
Review of event at another plant	0%	3%
All other causes	83%	66%
What Caused the Problems?		
Equipment failure	6%	29%
Personnel error	31%	35%
Inadequate procedure	53%	44%
Inadequate maintenance	3%	9%
Design error	42%	22%

Incident Performance at Millstone Unit 3 Nuclear Power Plant

The Northeast Nuclear Energy Company operates Millstone Unit 3. Located 3 miles from New London, Connecticut, this plant has a generating capacity of 1,137 megawatts. Unit 3 is a four-loop pressurized water reactor supplied by Westinghouse. Northeast Nuclear Energy operates three other nuclear power plants, two of them the other units at Millstone.

Operating License Issued:	January 31, 1986
License Expiration Date:	November 25, 2025

Monitoring Results

All three Millstone units have been shut down since March 1996, when the plant was featured on the cover of *Time*.[2] The owner shut the plants down in order to resolve extensive problems involving equipment and procedures that were not functioning as intended. Because Millstone Unit 3 did not operate during the entire monitoring period, we were unable to assess incident performance. When the plant resumes operation, we will begin our monitoring.

However, before beginning our current monitoring program, UCS had examined the problems that caused Millstone Unit 3 to shut down. We found that the plant had operated for many years with serious flaws in its auxiliary feedwater and recirculation spray systems. In order to cool the reactor core sufficiently during an accident, the auxiliary feedwater system must provide additional water to the steam generators to replace water lost through the accident. Damage to this vital system contributed to the severity of the Three Mile Island accident. The recirculation spray system must operate after an accident in order to cool the reactor core and the containment. If this system does not operate, radioactivity released in an accident could escape to the atmosphere. Since these flaws went uncorrected for a long period, people living near Millstone may have been protected as much by luck as by the plant's safety features.

Other Plants Operated by Northeast Nuclear Energy

Millstone 1 & 2	Waterford, Connecticut
Seabrook	Seabrook, New Hampshire

Other 4-Loop Pressurized Water Reactor Plants Built by Westinghouse

Alvin W. Vogtle 1 & 2	Waynesboro, Georgia
Braidwood 1 & 2	Braidwood, Illinois
Byron 1 & 2	Rockford, Illinois
Callaway	Fulton, Missouri
Comanche Peak 1 & 2	Glen Rose, Texas
Diablo Canyon 1 & 2	Avila Beach, California
Indian Point 2 & 3	Buchanon, New York
Salem 1 & 2	Salem, New Jersey
Seabrook	Seabrook, New Hampshire
South Texas Project 1 & 2	Palacios, Texas
Wolf Creek	Burlington, Kansas

[2] Only three nuclear plants have appeared on the cover of *Time*—Three Mile Island Unit 2, Chernobyl Unit 4, and Millstone Unit 3.

Incident Performance at Oconee Unit 1 Nuclear Power Plant

The Duke Power Company operates Oconee Unit 1. The plant, located 30 miles west of Greenville, South Carolina, has a generating capacity of 846 megawatts. Unit 1 is a pressurized water reactor supplied by the Babcock & Wilcox Company. Duke Power also operates two other units at Oconee, as well as four plants elsewhere.

Operating License Issued: February 6, 1973
License Expiration Date: February 6, 2013

Monitoring Results

Oconee's average incident performance score was significantly better than that of the focus group. Oconee was the only focus group plant that identified every reported problem at the first or second opportunity. On average, focus group plants identified only 82 percent of their problems at the first or second chance.

The incident at Oconee in which performance received the lowest score involved workers lifting material to the roof of the reactor building while the plant was operating. The material was being stored on the roof in preparation for an upcoming refueling shutdown. An NRC inspector observing this work questioned the prudence of lifting heavy loads over emergency equipment. Plant workers determined that a dropped load could break a vital pipe that provides additional water to the reactor during an accident. This pipe can also be used to provide water to the spent fuel pool. Thus, breaking the pipe could drain the spent fuel pool, causing its irradiated fuel assemblies to become uncovered. The uncovered fuel assemblies, which remain highly radioactive and still produce considerable heat, could melt down or expose plant workers to more radiation than allowed by health regulations.

Because Oconee's general performance was consistently strong, this incident suggests that the staff's approach to temporary plant activities lacks the rigor that they apply to routine activities. Poor oversight of temporary activities has long been an industry problem. Oconee's owners need to prevent similar problems by extending their effective control over day-to-day operations to temporary activities.

Other Plants Operated by Duke Power

Oconee 2 & 3	Seneca, South Carolina
Catawba 1 & 2	Clover, South Carolina
McGuire 1 & 2	Cornelius, North Carolina

Other Pressurized Water Reactor Plants Built by Babcock & Wilcox

Arkansas Nuclear 1	Russellville, Arkansas
Crystal River	Red Level, Florida
Davis-Besse	Oak Harbor, Ohio
Oconee 2 & 3	Seneca, South Carolina
Three Mile Island 1	Harrisburg, Pennsylvania

	Oconee 1	Focus Group
Incident Performance Scores		
Best	0.0	25.0
Worst	-37.5	-130.0
Average	-14.5	-23.9
When Were Problems Identified?		
First chance	83%	58%
Second chance	17%	24%
Within a few chances	0%	18%
After several tries	0%	0%
Who Identified the Problems?		
NRC inspectors	17%	15%
QA inspectors	0%	0%
Testing	17%	15%
Review of event at another plant	0%	3%
All other causes	67%	66%
What Caused the Problems?		
Equipment failure	17%	29%
Personnel error	17%	35%
Inadequate procedure	50%	44%
Inadequate maintenance	33%	9%
Design error	17%	22%

Incident Performance at Indian Point 3 Nuclear Power Plant

The GPU Nuclear Corporation operates the Oyster Creek nuclear power plant. This plant is 9 miles south of Toms River, New Jersey. It has a generating capacity of 619 megawatts. Oyster Creek is a boiling water reactor with a Mark 1 containment supplied by General Electric. It is the oldest operating nuclear plant in the United States. GPU Nuclear also operates the Three Mile Island Unit 1 plant and operated Three Mile Island Unit 2 until its accident.

Operating License Issued: July 19, 1974
License Expiration Date: July 19, 2014

Monitoring Results

The average score for incident performance at Oyster Creek was significantly better than the focus group average. The proactive behavior of plant staff is particularly praiseworthy. They discovered 11 percent of the plant's problems by reviewing problems reported by other plants and then checking to see whether they existed at Oyster Creek. On average, focus group plants identified only 3 percent of their problems through such proactive efforts. These initiatives earned Oyster Creek one of the top five incident performance scores among the focus group.

Another indication of Oyster Creek's effective self-assessment was that they found most of the reported problems themselves. The NRC found only 8 percent of their problems, compared with a 15 percent average NRC discovery rate across the focus group.

On the other hand, Oyster Creek was not free from serious problems. In September 1996, workers mistakenly dumped 133,000 gallons of slightly radioactive water into Barnegat Bay. This volume of water took hours to leave the plant, during which time various workers missed several opportunities to detect and stop the flow. The volume of water discharged to the bay represents about half the capacity of the tank it came from. Too many workers missed this problem for too long.

Other Plants Operated by GPU Nuclear

Three Mile Island 1	Harrisburg, Pennsylvania

Other "Old" Boiling Water Reactor Plants Built by General Electric

Nine Mile Point 1	Scriba, New York
Dresden 2 & 3	Morris, Illinois
Millstone 1	Waterford, Connecticut
Monticello	Monticello, Minnesota
Pilgrim	Plymouth, Massachusetts

	Oyster Creek	Focus Group
Incident Performance Scores		
Best	25.0	25.0
Worst	-56.3	-130.0
Average	-13.6	-23.9
When Were Problems Identified?		
First chance	69%	58%
Second chance	23%	24%
Within a few chances	8%	18%
After several tries	0%	0%
Who Identified the Problems?		
NRC inspectors	8%	15%
QA inspectors	0%	0%
Testing	19%	15%
Review of event at another plant	12%	3%
All other causes	62%	66%
What Caused the Problems?		
Equipment failure	42%	29%
Personnel error	23%	35%
Inadequate procedure	38%	44%
Inadequate maintenance	8%	9%
Design error	15%	22%

Incident Performance at River Bend Nuclear Power Plant

Entergy Operations Incorporated operates the River Bend nuclear power plant, which is located 24 miles from Baton Rouge, Louisiana. This plant, which has a generating capacity of 936 megawatts, is a boiling water reactor with a Mark 3 containment supplied by General Electric. Entergy acquired River Bend in a merger with Gulf States Utilities, its builder and initial operator, nearly 10 years ago.

Operating License Issued:	November 20, 1985
License Expiration Date:	August 29, 2025

Monitoring Results

The average performance score for incidents at River Bend was slightly below the average for the focus group. Over the monitoring period, workers caused 68 percent of River Bend's problems, compared with 35 percent across the focus group. This is an alarming rate of worker error. On the plus side, performance during one incident at River Bend received one of the best five scores, for identifying faulty parts and notifying another plant that had also received the parts. And testing activities revealed 27 percent of the problems at River Bend, compared with only 15 percent for the focus group as a whole.

Despite a testing program that appears to be generally effective, one serious incident at the plant involved testing. In December 1995, the pump cooling the pool in which spent fuel is stored failed a test. Entergy deemed this failure acceptable because the pool's temperature was below specified limits. However, the pump also failed the next two times it was tested. In 1996, the NRC asked whether the pump could cool the pool when ambient temperatures peaked. Workers then found that the pump would not have provided adequate cooling under such circumstances. Thus, even though the testing program clearly indicated the problem, River Bend's staff tolerated this unsafe condition.

Other Plants Operated by Entergy

Arkansas Nuclear 1 & 2	Russellville, Arkansas
Grand Gulf	Port Gibson, Mississippi
Waterford	Taft, Louisiana

Other Boiling Water Reactor Mark 3 Plants Built by General Electric

Clinton	Clinton, Illinois
Grand Gulf	Port Gibson, Mississippi
Perry	North Perry, Ohio

	River Bend	Focus Group
Incident Performance Scores		
Best	20.0	25.0
Worst	-90.0	-130.0
Average	-24.7	-23.9
When Were Problems Identified?		
First chance	64%	58%
Second chance	18%	24%
Within a few chances	18%	18%
After several tries	0%	0%
Who Identified the Problems?		
NRC inspectors	18%	15%
QA inspectors	0%	0%
Testing	27%	15%
Review of event at another plant	0%	3%
All other causes	55%	66%
What Caused the Problems?		
Equipment failure	41%	29%
Personnel error	68%	35%
Inadequate procedure	32%	44%
Inadequate maintenance	9%	9%
Design error	5%	22%

Incident Performance at River Bend Nuclear Power Plant

The Tennessee Valley Authority operates Sequoyah Unit 1. The plant, which is 10 miles northeast of Chattanooga, Tennessee, has a generating capacity of 1,117 megawatts. Unit 1 is a pressurized water reactor supplied by Westinghouse, featuring an ice condenser containment design. The Tennessee Valley Authority, a federal agency, also operates a second unit at Sequoyah, as well as four other nuclear power plants.

Operating License Issued: September 15, 1981
License Expiration Date: September 15, 2021

Monitoring Results

The average score for incident performance at Sequoyah made it the lowest performer of any of the focus group plants. The most troubling finding was that the NRC, not the staff, identified many of the problems. The NRC found 30 percent of the plant's problems, compared with only 15 percent for the focus group as a whole. This suggests that Sequoyah's self-assessment programs are ineffective.

Another disturbing finding was that maintenance activities caused 26 percent of Sequoyah's problems, compared with a focus group average of only 9 percent. Clearly, maintenance needs considerable improvement.

Sequoyah also compared poorly with the focus group average on problems caused by worker error (48 percent compared with 35 percent) and poor procedures (56 to 44 percent). These should be the easiest problems to prevent, particularly at a plant that has been operating for nearly 17 years.

Other Plants Operated by the Tennessee Valley Authority

Browns Ferry 1, 2, & 3	Decatur, Alabama
Sequoyah 2	Soddy-Daisy, Tennessee
Watts Bar	Spring City, Tennessee

Other Pressurized Water Reactor Ice Condenser Plants Built by Westinghouse

Catawba 1 & 2	Clover, South Carolina
Donald C. Cook 1 & 2	Bridgman, Michigan
McGuire 1 & 2	Cornelius, N. Carolina
Sequoyah 2	Soddy-Daisy, Tennessee
Watts Bar	Spring City, Tennessee

	Sequoyah	Focus Group
Incident Performance Scores		
Best	0.0	25.0
Worst	-100.0	-130.0
Average	-30.5	-23.9
When Were Problems Identified?		
First chance	61%	58%
Second chance	22%	24%
Within a few chances	17%	18%
After several tries	0%	0%
Who Identified the Problems?		
NRC inspectors	30%	15%
QA inspectors	0%	0%
Testing	9%	15%
Review of event at another plant	0%	3%
All other causes	61%	66%
What Caused the Problems?		
Equipment failure	30%	29%
Personnel error	48%	35%
Inadequate procedure	57%	44%
Inadequate maintenance	26%	9%
Design error	13%	22%

Incident Performance at Surry Unit 1
Nuclear Power Plant

The Virginia Power Company operates Surry Unit 1. The plant is located 17 miles northwest of Newport News, Virginia. It has a generating capacity of 801 megawatts. Unit 1 is a three-loop pressurized water reactor supplied by Westinghouse. Virginia Power operates a second unit at Surry and two additional nuclear power plants.

Operating License Issued: May 25, 1972
License Expiration Date: May 25, 2012

Monitoring Results

Surry had the best performance of any focus group plant. Plant staff did not rely on the NRC to identify problems at the plant. The NRC found *none* of the reported problems, as compared with 15 percent of the problems across the entire focus group. Just as important, Surry workers identified problems at the first opportunity 69 percent of the time, compared with a focus group average of 58 percent. Staff error caused only 20 percent of the problems, compared with 35 percent across the focus group. These are strong indications of good performance.

Plant incidents revealed 19 percent of the problems at Surry, compared with a focus group average of 29 percent. These data suggest that the workers at Surry effectively seek out and prevent potential problems rather than waiting for something to happen. "*Don't fix it if it ain't broke*" may be a catchy slogan, but "*Fix it before it breaks*" is a much better policy from a nuclear safety perspective.

Other Plants Operated by Virginia Power

North Anna 1 & 2	Mineral, Virginia
Surry 2	Gravel Neck, Virginia

2-Loop and 3-Loop Pressurized Water Reactor Plants Built by Westinghouse

Kewaunee	Carlton, Wisconsin
Point Beach 1 & 2	Two Rivers, Wisconsin
Prairie Island 1 & 2	Red Wing, Minnesota
R. E. Ginna	Ontario, New York
H. B. Robinson 2	Hartsville, South Carolina
Joseph M. Farley 1 & 2	Dothan, Alabama
Shearon Harris	New Hill, North Carolina
Turkey Point 3 & 4	Florida City, Florida
Virgil C. Summer	Parr, South Carolina
Beaver Valley 1 & 2	Shippingport, Pennsylvania
North Anna 1 & 2	Mineral, Virginia
Surry 2	Gravel Neck, Virginia

	Surry 1	Focus Group
Incident Performance Scores		
Best	25.0	25.0
Worst	-50.0	-130.0
Average	-11.4	-23.9
When Were Problems Identified?		
First chance	69%	58%
Second chance	25%	24%
Within a few chances	6%	18%
After several tries	0%	0%
Who Identified the Problems?		
NRC inspectors	0%	15%
QA inspectors	0%	0%
Testing	25%	15%
Review of event at another plant	6%	3%
All other causes	69%	66%
What Caused the Problems?		
Equipment failure	44%	29%
Personnel error	19%	35%
Inadequate procedure	38%	44%
Inadequate maintenance	13%	9%
Design error	19%	22%