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Ineffective Management and Oversight of DOE's P-reactor at Savannah River, S.C., Raises Safety Concern

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Before the
Committee on Governmental Affairs
United States Senate

Subcommittee on Environment, Energy
and Natural Resources
Committee on Government Operations
House of Representatives

Chairman Glenn, Chairman Synar, and Members of the Committees:

We are pleased to be here today to discuss the recent events surrounding the start-up of the Department of Energy's (DOE) P-reactor at the Savannah River Plant in South Carolina. We will recount the incidents based on the information we have gathered to date, but more important perhaps is what this event tells us about how well DOE is managing the contractors who operate facilities in our nation's nuclear defense complex. In fact, we believe this incident raises questions about who is really in control--DOE or its contractors.

The P-reactor is one of DOE's three remaining operational reactors that produce nuclear material--such as tritium and plutonium--for nuclear weapons. My testimony today is based on our ongoing review, being done at the request of your two committees. You asked that we review the situation at the P-reactor because of unexpected events that led to press reports that the reactor was "out of control" during recent start-up operations. The reactor is currently shut down so that E. I. DuPont de Nemours (DuPont), the contractor that operates the reactors, can address concerns DOE raised about the start-up.

Two events of concern occurred:

-- The reactor was unable to maintain a sustained nuclear reaction during the recent start-up. While the underlying cause was unknown at the time, operations continued until the reactor in effect shut itself down.

-- There was a small power increase, which the operator immediately controlled during the subsequent restart. While this increase was not sufficiently large enough to pose a safety concern, the event has been analyzed, but its cause is not known.

After-the-fact assessment of the incidents now tell us that the P-reactor was not out of control, and that there was no danger to the workers or the public. But of greater importance is that the reactor staff continued the start-up process even though they knew they had a significantly large, unaccounted-for reactivity deficit in the reactor.[1] This action in continuing the start-up without resolving the deficit problem, and DOE's response to dealing with the incident, raise major safety concerns.

The unaccounted-for reactivity was about one and one half times larger than any previous experience at Savannah River, and under the Nuclear Regulatory Commission guidelines for commercial reactors, it would have required immediate assessment and shutdown if the reactivity could not be accounted for. However, the operating procedures for the Savannah River reactors provide no guidance on how to deal with reactivity anomalies, and the responsible supervisor and technical advisor failed to recognize the significance of the problem. This raises a serious question concerning how the operating staff might respond to future unusual or unknown situations.

As I indicated earlier, Messrs. Chairmen, the events also raise concerns about the effectiveness of DOE's management and safety oversight at Savannah River. Major problems include the

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[1]Reactivity is a measure of a reactors nearness to being just able to sustain a steady power level. When the reactivity is zero, power level is neither increasing or decreasing. One of the terms used to describe an amount of reactivity is the "dollar." Normally reactor power increase at a safe rate would require adding a few cents of reactivity. The amount of reactivity unaccounted for during the P-Reactor start-up was $4. This is a very large quantity, which, if it were to be suddenly added to a reactor, would cause a power rate increase so fast that serious reactor damage would occur before the power surge could be ended. It is also an amount that is almost three times greater than the unaccounted for reactivity amount which if it were to remain unaccounted for at a commercial reactor would require a shut down.

adequacy of the Savannah River Operations Office's oversight, the technical specifications that provide operating limits for the reactor, and operator procedures and training. Events subsequent to the incident also raise serious questions concerning the roles of and communication to DOE's Advisory Committee on Nuclear Facility Safety and the Office of the Assistant Secretary for Environment, Safety, and Health (ES&H).

Unfortunately, such issues are not a new phenomenon. We have issued over 30 reports and testimonies in recent years, many of which have identified serious safety concerns in DOE's nuclear defense complex. Others, such as the National Academy of Sciences and the Roddis panel (formed by DOE to review the N-reactor following the Chernobyl accident), have also raised safety concerns about DOE's facilities. While we have been hopeful that DOE has been responding to criticisms in recent years and that it has been making strides in the right direction, the most recent events continue to underscore the serious problems with DOE's having total responsibility for producing nuclear material and ensuring safety without independent oversight. Our findings regarding the latest Savannah River incidents support the need to both strengthen internal management of contractor operations and ES&H oversight of the safety program, and to legislatively establish a strong and independent oversight entity to conduct reviews of DOE's nuclear operations.

Before I discuss these matters further, I would like to provide a brief overview of the P-reactor start-up events that began on August 7, 1988. A more detailed chronology of events is attached to this statement.

OVERVIEW OF P-REACTOR RESTART EVENTS

The P-reactor began a new fuel cycle to produce tritium in June 1987. In April 1988, with the reactor already containing

about 70 percent of the tritium it was to produce, DOE shut the reactor down to assess whether reactor bracing and supports complied with seismic criteria. While DOE had planned for the reactor to be out of service for about 2 weeks for this assessment, there were more seismic concerns found than anticipated, which shut the reactor down for about 4 months.

After ensuring the seismic upgrades were complete, DOE's Savannah River Operations Office approved restart of the reactor. The start-up, which began on August 7, 1988, is a methodical and slow process. First, the safety rods were completely raised out of the reactor core to a position where they could be quickly dropped back into the reactor to shut it down in an emergency. Second, reactor operators appropriately positioned the partial length control rods, which are used to maintain a uniform nuclear reaction. Prior to the restart, a DuPont engineer had calculated the position of the partial length control rods. Finally, once the partial rods were in position, the reactor operators began repositioning the full length control rods until the reactor became "critical," or in other words, sustained a nuclear chain reaction.

The calculation used to set the partial rods also included a prediction of what the control rod position would be when the reactor would become critical. For this start-up, the actual point of criticality differed from the prediction by a substantial margin. The reactor operators called the discrepancy to the attention of their supervisor; it was discussed with the engineer who made the prediction and was in the control room. However, even though the discrepancy was about one and one half times as large as had been previously experienced, there was no resolution of the discrepancy before operations continued, and neither DuPont management nor DOE was alerted to the problem being experienced.

Once criticality was reached, full length control rods continued to be repositioned until the power was increased to about

90 percent of its authorized operating limit.[2] Subsequently, it became clear that as xenon, which is the product of the nuclear reaction, built up, the reactor could not sustain that power level. The full length control rods had been repositioned to their procedural limit and operating procedures did not allow the partial rods to be repositioned fast enough to sustain steady power. As a result, reactor power continued to decrease and the operators shut it down at about 5 a.m. on August 9.

After the reactor was shut down, a nuclear physicist in DuPont's Savannah River Laboratory determined that the start-up problem--the large reactivity deficit and the resulting inability to overcome the further loss of reactivity caused by xenon buildup--was the result of an erroneous calculation. The calculation had not included the decay of tritium to helium-3, incorrectly calculated the remaining effect of xenon and samarium from previous operations, and omitted the effect of three control rods that were left in the reactor.

DOE was notified of the reactor shutdown when it happened, and, on the basis of DuPont's explanation, DOE approved reactor restart on the same day, August 9. DOE also told DuPont to do a better job of reporting such anomalies to its own management and to DOE, and to respond more conservatively when future unknown situations occur. On August 10, there was a small power increase that was well within operating limits and that was immediately corrected by the reactor operator. This power increase was not reported to DOE until the next day.

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[2]The reactors are authorized to operate at about 50 percent of their design limits because of concerns about the adequacy of the emergency core cooling system in the event of a serious accident. Therefore, the figure cited is 90 percent of the 50 percent.

The DOE Savannah River Operations Office's reaction to the start-up events evolved from a discussion of its concerns with DuPont on August 9 to a very strong letter to DuPont on August 17 that laid out their concerns. DOE had four basic concerns. First, operating staff did not have the "tools" to compare the predicted reactivity state of the reactor with the actual reactivity. Further, the effectiveness of Dupont's independent oversight function, technical support to reactor operations, and system for reporting events to DuPont management and DOE were unsatisfactory. DOE asked DuPont to respond within 48 hours to these concerns. In the meantime, DOE required them to maintain stable reactor power and do nothing further until the problems were solved. After receipt of the letter, DuPont recommended, and the Operations Office concurred, that the reactor be shut down immediately so that DuPont could concentrate on addressing DOE's concerns. The reactor was shut down on the evening of August 17.

INADEQUATE MANAGEMENT OF REACTOR RESTART AND COMMUNICATION WITH THE CONTRACTOR

The Savannah River Operations Office's review of the reactor restart, and the initial lack of direction to DuPont in terms of corrective actions continue to support the need for more effective DOE management of contractor operations.

The reactor start-up on August 7 was a unique event that neither DuPont nor DOE properly analyzed before the start-up. What makes it unique is the combination of a 4-month downtime with 70 percent of the tritium produced still in the reactor. This combination had never occurred in the operational history of any of the Savannah River reactors. The Savannah River Operations Office's Operational Readiness Review--required for reactor start-up--focused on whether the seismic upgrades were completed as planned rather than on performing a more comprehensive review that would at least have assessed the unique core conditions.

Operational Readiness Reviews are, among other things, to ensure that facilities can be operated safely, will perform as designed, and that adequate consideration has been given to all hazards. In spite of the uniqueness of the situation, no attention was given to changes that had occurred within the core. A preliminary report by a member of DOE's Advisory Committee on Nuclear Facility Safety who subsequently reviewed the events, questioned the adequacy of DOE's Operational Readiness Review. The report also questioned why DOE personnel were not present in the control room to observe the restart, since it was unusual and the reactors have been under increased scrutiny for several other safety concerns.

Further, the inaccurate reactivity calculation that led to the reactor's inability to sustain operations at power was not reviewed within DuPont. DuPont procedures call for a peer-reviewed calculation for a start-up where reactivity is expected to be different, such as when new fuel or new targets are added. However, DuPont and DOE officials told us that the calculation really was not required for the August 7 start-up because the core had not been changed while the reactor was shut down. Neither DuPont nor DOE thought to consider that natural changes--tritium decay--would occur in the core. A DuPont reactor physicist told us that such decay and its effect could have been calculated if anyone had thought to consider the implications for reactor start-up of the large quantity of tritium that had been sitting in the reactor for the 4-month period. As a lesson learned from this event, DuPont plans to revise the procedures governing start-up to require calculations and peer review of those calculations for all start-ups.

The Operations Office approved restart on August 9 based on DuPont's explanation of the start-up problems without an independent assessment or a complete understanding of the explanation and without knowing how DuPont was going to address DOE's safety and communications concerns.

Let me first address the assessment of the start-up problems. DuPont presented its assessment of the cause of the reactor start-up problems in a meeting with Operations Office officials on August 9. DuPont's assessment was based on an analysis performed by a reactor physicist in the DuPont Laboratory who calculated the effect of the decay of tritium to helium-3. The Operations Office Manager told us that he agreed to restart the reactor on the basis of his Safety Branch's concurrence with DuPont's assessment. However, our discussions with Safety Branch and DuPont officials indicate that prior to the meeting no one in DuPont or DOE reviewed the analysis or its methodology. The methodology for the analysis was not even documented until after that meeting. DOE also did not discuss the analysis with the physicist who prepared it and did not question whether DuPont had reviewed other possible causes for the event. In fact, the Safety Branch Chief told us that his group did not have the technical expertise or resources to verify the analysis. While DOE was aware that other errors besides the helium-3 had been made, it was not until August 15 that they found out that this resulted in the reactivity deficit being about twice what they thought it was on August 9. It appears, therefore, that the Operations Office relied totally on DuPont's assessment of the situation, without complete information or any independent assessment or check of its own.

In the August 9 meeting, DOE also raised two concerns--a safety issue and a communications issue. DOE told DuPont that reactor operation with the level of uncertainty that had been experienced in the P-reactor start-up was unacceptable. DOE believed this to be an important safety issue and told DuPont that in the future, the reactor should be put "on hold" while an unknown situation is analyzed. However, DOE provided no further direction at that meeting, did not ask DuPont how it planned to change its mode of operation to address the safety concern, or establish any time frames for corrective action. Operations Office officials

also told DuPont that the current threshold for reporting anomalous events to DOE was too high. However, these DOE officials did not establish a new level of reporting at the meeting; nor did they ask DuPont to develop one.

In providing his evaluation of the events, DOE's Deputy Assistant Secretary for Safety, Health and Quality Assurance, has stated that since 1983 standard requirements in the commercial sector for any restart after an unplanned shutdown include a review of the reason for shutdown, including an on-site safety review committee's assessment of the event. For the P-reactor event, however, he noted that his onsite technical team believed that the DOE Savannah River Operations Office's safety involvement was almost non-existent and that it relied almost totally on the contractor for a technical assessment of the events.

TECHNICAL SPECIFICATIONS, PROCEDURES, AND TRAINING NEED TO BE UPGRADED

This event raises questions about the adequacy of the technical specifications for the Savannah River reactors and operator procedures and training to handle anomalous situations. DOE Order 5480.6 states that technical specifications should meet the Code of Federal Regulations, Title 10, Part 50.36, and be similar to those prepared for commercial nuclear facilities. According to a Nuclear Regulatory Commission (NRC) official, technical specifications for all commercial reactors require that actual reactivity performance be compared with expected performance during start-up. The prediction must match the actual performance within certain limits that are defined in the technical specifications. If the parameters are not met, specific actions are required. Such actions vary from reactor to reactor, depending on the nature of the discrepancy. For example, no additional power increases may be made until reasons for the discrepancy are understood.

The technical specifications for the Savannah River reactors contain no such requirements. DuPont told us that its slow, methodical start-up procedures, which are different from the commercial reactors, do not require the comparison of actual to predicted criticality. However, an ES&H official and an NRC official told us it is always important to understand the reactivity condition in the core. They said the comparison is a useful check and balance to alert the operators to an unknown situation that requires assessment. In its August 17 letter, DOE required that the technical specifications be changed to provide for the comparison and that limiting conditions associated with reactivity controls be developed.

While DOE has required a change to the technical specifications to address reactivity anomalies before the reactor can restart, we must note that the reactor has operated since October 1986 under technical specifications that, as a whole, DOE concluded "were not fully consistent with industry standards" and recommended that improvements be made. While we have not analyzed the technical specifications, our limited review found them to be significantly different than what would be found for a commercial reactor.

We understand that revisions to the technical specifications are underway and were expected to be completed by October 1988. However, the July 1988 status report on the project states that because of higher priority work, the revisions are now scheduled for completion in March 1989. However, the official at DuPont's Savannah River Laboratory responsible for the project stated he was not optimistic that the March date would be met.

In addition to inadequate technical specifications, this event has highlighted the need for improvement in reactor operator procedures and training. For example, the Deputy Assistant Secretary for Safety, Health and Quality Assurance stated that the

procedures do not adequately guide the operators in abnormal situations, nor do they require assessments of potential safety implications prior to restart. In addition, the October 1986 Technical Safety Appraisal, prepared by DOE's Office of Nuclear Safety within ES&H, recommended that the knowledge of certified reactor operators and supervisors in the areas of reactor technology be expanded. This recommendation was based on an assessment that the depth of knowledge in such areas as thermodynamics, fundamental heat transfer, reactor kinetics, and operating characteristics was below the norm. The same recommendation was first made in 1981 by DOE's task force to assess the implications of the Three Mile Island accident. While DuPont has provided some training in these areas, it is currently developing a training program that it believes will be comparable to the commercial sector. This program is scheduled to begin in the third quarter of 1989.

THE ROLE OF OVERSIGHT ORGANIZATIONS

I would now like to address the role of oversight organizations in this event. The Advisory Committee on Nuclear Facility Safety was established in response to the National Academy of Sciences' recommendation that DOE needed an independent oversight review function. The Committee's role as the P-reactor events unfolded was nonexistent because the Chairman was not notified until 7 days after DOE became aware of the restart problems. According to DOE officials, the ES&H organization had been established within DOE to be the formal link with the Advisory Committee. However, the Committee Chairman told us he believed that he also had an informal, explicit agreement with the Manager of the Operations Office to inform the Committee of pertinent issues at Savannah River. In expressing his concern to the Manager of the Operations Office that he was notified of the restart problems by a newspaper reporter, the Chairman stated that given DOE's apparent reluctance to provide information in a timely way,

it would not surprise him, and in fact it may be necessary to amend proposed legislation establishing an independent oversight board to provide the board more power.

The Office of the Assistant Secretary for ES&H was directly involved in assessing the start-up events at the P-Reactor. Onsite representatives of the Office of the Assistant Secretary for ES&H, who are at Savannah River to enhance that Office's ability to obtain information directly about facility operations, collected data concerning the events and reported them to ES&H. However, the onsite representatives were not invited to the key meeting on August 9 at which DuPont described the reasons for the restart problems. The Operations Office Manager told us that not inviting them was an oversight. Attendance at the meeting would have provided firsthand information concerning the reasons for the restart problems and the basis for approving a new start-up.

The Acting Deputy Assistant Secretary for Safety, Health and Quality Assurance sent a technical team[3] to Savannah River on August 12 to assist the onsite representatives in obtaining the facts concerning the events. Once their investigation was complete, the onsite contingent--composed of the technical team and the onsite representatives--sent their findings and recommendations to the Assistant Secretary and discussed them with the Operations office staff on August 15. The onsite contingent recommended shutdown of the P-reactor.

ES&H's handling of its onsite contingent's shutdown recommendation is somewhat confusing. Let me elaborate on our conversations with the ES&H officials involved. The Assistant Secretary told us that on August 16 he concurred in the shutdown

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[3]The team consisted of one engineer from ES&H, two engineers from Battelle, Pacific Northwest Laboratory, and one nuclear physicist from EG&G, Idaho, Inc., Idaho National Engineering Laboratory.

recommendation made by his onsite contingent and asked his staff to prepare an order to shut down the P-reactor. However, there appeared to be a communications breakdown between the Assistant Secretary and the onsite contingent. The two members of the onsite contingent involved in the conversations told us they were not aware that the Assistant Secretary concurred with their recommendation. Instead, they thought they had been asked by ES&H at Headquarters to work with the Operations Office to resolve the problem. Further, they believed that a consensus had been agreed to within DOE that the Operation Office's proposed "show cause" letter was the correct approach. Therefore, in what they thought was support for the consensus position, the onsite contingent advised the Assistant Secretary that they no longer recommended immediate shutdown. On the basis of this stated withdrawal of support for shutdown, the Assistant Secretary told us he then decided not to go forward with the shutdown order. Further, the Assistant Secretary told us that the next day, after discussions with the Chairman of the Advisory Committee on Nuclear Facility Safety, he called the Savannah River Operations Office manager and told him that while he was not ordering shutdown, he believed the P-reactor should be shut down.

Deciding to shut down a reactor or any other nuclear facility within the defense complex is a serious decision. The Assistant Secretary for ES&H must make a determination that "clear and present danger" or an imminent threat exists before he/she can order such a shutdown. Therefore, to properly make such an important determination there must be precise and clear communications between all parties involved--those asking for and providing input. It is evident that was not the case as ES&H made its decisions concerning shutdown during the P-Reactor event.

OBSERVATIONS

After analyzing the incident and talking to several participants and knowledgeable officials, we believe that the P-reactor events posed no danger to workers or the public. The fact that there was no danger can now be seen in hindsight. However, at the time of the event, no one recognized the potential significance of the unaccounted-for reactivity. They forged ahead without understanding what had caused it, and therein lies the safety problem. Further, DOE's actions in addressing the events raise questions about its attitude towards safety and its management and oversight of its contractors. In its initial meeting with DuPont after the start up problem had been identified, the Operations Office raised an important safety problem--that the reactor operators may not know how to handle future anomalous situations--but it did not direct DuPont to take any specific action. In addition, the start-up problems hinged on an erroneous calculation that had not been reviewed within DuPont. However, the Operations Office approved restart on the basis of an analysis that had not been reviewed within DuPont or analyzed by DOE. After another event--the power surge--and further assessments, DOE took stronger actions by sending DuPont a show cause letter on August 17 requiring it to address a number of specific concerns.

We believe these events could have been avoided had DOE responded to deficiencies it identified earlier. For example, there are two outstanding recommendations from ES&H's Technical Safety Appraisal that directly relate to these events: revise inadequate technical specifications and improve reactor technology training. The training recommendation was first made in 1981 and again 1986, and the one on technical specifications was made in 1986. Action on both recommendations has been delayed because of "higher priority work," and is not expected to be completed until sometime in 1989. This delay raises questions about DOE's timeliness in addressing safety-related recommendations and whether

the status of these recommendations will be factored into the decision to restart the P-reactor.

This is not the first time that concerns have been raised about the effectiveness of DOE's safety oversight. For example, we have identified problems with DOE's safety analysis reports, important documents that are designed to show that DOE facilities are safely designed, constructed, and operated. Further, we have found that production was given priority over safety at DOE's Fernald facility in Ohio. We also found that concern about the adequacy of the emergency core cooling system at the Savannah River reactors led to reductions in operating power.

As far back as March 1981, DOE's task force to assess the implications of the Three Mile Island accident concluded that DOE relied too heavily on its contractors to provide the full measure of independent safety assurance. In its October 1987 report, the National Academy of Sciences repeated the same conclusion by questioning DOE's "technical vigilance," noting that DOE has tended to defer almost exclusively to its contractors that operate its production reactors and has placed undue reliance on them to assure safe operations. Among its recommendations the Academy believes that ES&H should have more direct involvement in resolving key safety issues in a timely and effective way. While ES&H was directly involved in the P-reactor safety issues, it's decision-making process on the shutdown recommendation was unclear.

In addition, since 1981 we have continually recommended independent oversight of DOE's nuclear activities. DOE resisted the need for this oversight until the National Academy of Sciences' recommendation, and in response to it established the Advisory Committee on Nuclear Facility Safety to provide DOE with technical advice on its nuclear facilities. However, we view the Committee as an extension of DOE's own safety oversight program rather than as a separate and distinct entity. We note that the Committee was

first advised of the P-Reactor events by a newspaper reporter rather than by DOE. This lack of timely communication with the Committee during such events raise questions as to the extent to which DOE is willing to allow the Committee to exercise its oversight role.

In summary, we believe there are three critical elements for an effective safety management and oversight program in DOE--strong line management responsibility and accountability for safety, an effective ES&H organization to oversee how the line management is carrying out its role, and an independent organization outside the control of DOE that oversees the agency's internal safety program. Given the numerous and significant problems with the nuclear defense complex, we think it particularly important that each of these components carry out its responsibilities in a comprehensive and effective manner to ensure that the complex is operated in a safe manner. We believe that DOE's actions responding to the P-Reactor events raise questions about the effectiveness of the first two of these elements, and highlight the continuing need for independent oversight.

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In conclusion, Mr. Chairmen, we believe DOE's credibility as a self-regulator becomes more suspect as these types of events continue to occur. Frankly, it appears that the contractors are really in control, rather than DOE. We now believe we may have been too optimistic in the past year or so about DOE's progress in addressing environmental, safety, and health issues. The events we have described today indicate that a complacent attitude still exists within DOE and that the nature of the DOE/contractor relationship is such that we can continue to ask, "When will DOE take control?" A change in attitude will be needed to answer that question. We believe such a change is one of the most difficult problems DOE faces and can best be summed up by the following

September 1988 statement from DOE's Deputy Assistant Secretary for Safety, Health and Quality Assurance: "There are currently some senior managers within the Department with an attitude toward production reactor safety, which on the face seems to be similar to that which existed in the space program prior to the Challenger accident." This statement was contained in the Deputy Assistant Secretary's September 16, 1988, memo assessing the safety implications of the P-Reactor events.

We continue to believe that DOE must make a commitment to and implement a strong internal safety program to ensure that safety concerns are addressed in an effective and timely manner. External, independent oversight is also critical to provide the Congress and the public the assurance they need that existing facilities as well as upgraded or new facilities are safe.

We would be pleased to respond to any questions.

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CHRONOLOGY OF EVENTS

P-REACTOR OPERATIONS, AUGUST 7-17, 1988

This chronology is based on information we have gathered as of September 28, 1988. We reviewed the chronologies prepared by DuPont, DOE's Savannah River Operations Office, and the Deputy Assistant Secretary for Safety, Health, and Quality Assurance, ES&H. We also discussed the events with DuPont officials and DOE officials from the Savannah River Operations Office, and offices of the Assistant Secretaries for ES&H and Defense Programs. We note that the chronology provides more than one view on what occurred in certain instances. It is difficult to reconcile these views because documentation describing events and decisions was lacking, or not precise; and individuals involved in the same meeting or discussion placed different interpretations on positions proposed or decisions made.

The times noted in the chronologies are approximate and the key to the abbreviations used in the chronology are listed below.

ABBREVIATIONS

DOE-SR	DOE's Savannah River Operations Office
RTD	DuPont's Reactor Technology Department--Reactor Technical Support Group
SRP	Savannah River Plant
ES&H	Office of the Assistant Secretary for Environment, Safety, and Health
HQ	DOE Headquarters, Washington, DC
ES&H Resident	ES&H staff onsite at Savannah River to provide information on operation to ES&H-HQ
DuPont	E.I. du Pont de Nemours and Company, contractor who operates SRP

CHRONOLOGY OF P-REACTOR RESTART EVENTS

1988 Date	Time	Activity or Milestone
April 10	12:40 pm	Reactor shut down to evaluate seismic supports. 70 percent of the tritium to be produced remained in the reactor core. Initial estimate of downtime was 2 weeks but it lasted 4 months. Combination of long downtime and large percentage of tritium remaining in the core had never been experienced at SRP.
August 6	Late eve.	DOE-SR Manager signed authorization for reactor restart after DOE-SR completed its Operational Readiness Review. Review did not include assessment of implications of unique core conditions.
August 7	12:10 am	Approval from DuPont Day Supervisor to start up.
	3:30 am	DuPont Day Supervisor and RTD engineer present in control room--DOE-SR not present for start-up, nor required by policy to be there.
	5:00 am	Begin withdrawal of safety rods that are put into a fully withdrawn position where they can be quickly dropped into the reactor to shut it down in case of an emergency.
	6:00 am	Safety rod withdrawal complete.
	7:00 am	Started setting partial control rods. On the basis of information supplied by the RTD engineer, the partial rods are positioned to maintain uniform power in the core.
	9:00 am	Completed setting partial rods and started withdrawal of full length control rods. The full length rods are slowly repositioned until the reactor becomes critical--a sustained nuclear chain reaction.

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11:10 am	Reactor predicted to go critical when rod configuration reached 1,700 veeder units (veeder unit is a measurement of the position of the control rods). Brief discussion between Day Supervisor and the RTD engineer on why they missed going critical at the predicted point. No one else outside the control room was contacted.
	Operators in the control room recognized that they had missed the predicted criticality point, but that it was not unusual and all other instruments showed that start-up was proceeding normally.
	Start-up operations continued. RTD engineer began to review his calculation.
12:00 Noon	Reactor critical (at 700 veeder units versus predicted 1,700 veeder units). Difference of 1,000 veeder units in this instance was equivalent to about $4 in reactivity that was unaccounted for in the core. This was significant because if this amount of reactivity were suddenly added to the core it would cause a power increase that could not be controlled immediately and would result in damage to the reactor.
3:00 pm	Reached 20 percent of authorized power (193 megawatts).
7:00 pm	Control Room Supervisor called DuPont Operations Superintendent (standard operating procedure every Sunday evening) and missed criticality prediction was discussed. Superintendent did not consider it a safety issue because he knew of no explanation whereby that much reactivity could be hidden or reappear.
11:10 pm	Reached 60 percent authorized power (525 megawatts).

August 8	8:10 am	Reached 90 percent authorized power (890 megawatts).
		RTD staff investigate difference in predicted and actual critical rod configurations.
	4:00 pm	Reactor power was falling. Decision was made to withdraw partial rods to compensate. RTD staff decided which rods should be withdrawn.
	10:00 pm	Begin to withdraw partial rods per procedure. Procedural withdrawal occurs at slow pace.
August 9	2:30 am	Operations supervisor called RTD Supervisor at home to obtain instructions about what to do since the power in the reactor was continuing to fall. He told him to continue pulling partial rods out of the reactor to compensate for the poison buildup.
	3:30 am	Partial rods continue to be withdrawn. Removing partial rods at the slow pace could not override the poison building up in the reactor; therefore, reactor power could not be sustained.
	4:50 am	All full length control rods were fully withdrawn to their procedural limits, reactor power decreased to 20 megawatts at which time the reactor was manually shut down.
	5:00 am	Operations supervisor notified DOE-SR Reactors Branch Chief and DuPont's Reactor Operations Superintendent of reactor shutdown. SRP Emergency Operations Center also notified of shutdown, and it contacted DOE-SR Manager, Assistant Manager for Operations, and Assistant Manager for ES&H. (Those notifications are standard operating procedure for shutdowns.)
	Day Shift	RTD working with DuPont Savannah River Laboratory to investigate reasons for

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lack of reactivity. Laboratory used more sophisticated charge design computer code to calculate the effect of tritium decay to helium-3.

7:00 am — DOE-SR becomes aware of missed prediction during start-up. DOE-SR reviewed P-reactor operating staff log books and talked to RTD. DOE-SR engineer talked to RTD later in the day and was told that major source of calculational error was helium-3 build-in from tritium decay and was told the amount of unaccounted for reactivity it represented. He was also told that, while helium was the most significant, other errors had been made but he did not ask the associated amount of unaccounted for reactivity.

8:00 am — ES&H onsite representative informed his superior in ES&H-HQ of shutdown and proceeded to establish facts. Several calls to ES&H-HQ with information that day.

4:00 pm — Meeting between DOE Operations Office management and DuPont management to discuss the cause of the start-up problem (onsite ES&H not invited to meeting because of oversight). DuPont attributed the problem to the tritium in the targets decaying to helium-3. The helium-3 was not considered in the restart of the reactor. This was equivalent to about $2 dollars of reactivity.

DOE-SR Safety Branch supported DuPont position because the Savannah River Laboratory agreed with DuPont operations on the cause of the problem. DOE did not perform independent verification calculations or analysis.

Agreement reached that a lower threshold for reporting anomalies to DOE was needed and more conservatism

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		needed in reactor operations. However, no new thresholds defined nor level of conservatism specified.
		DOE and DuPont reached agreement to restart, and DP/HQ and Acting Assistant Secretary, ES&H-HQ notified of restart.
	6:00 pm	Started safety rod withdrawal.
	11:30 pm	Reactor critical (630 veeder units)--within about 40 veeder units of predicted rod configuration.
August 10	7:00 am	Reached 60 percent authorized power (720 megawatts).
	11:30 am	The initial information we received stated that all four high-level flux monitors showed increased power of about 2 percent. DOE-SR told us the actual increase was 0.5 percent to 0.7 percent. Power increased at a rate of about 20 megawatts per minute. Operator immediately adjusted by inserting control rod to compensate.
August 11	7:00 am	DuPont management notified of power increase in phone call.
		DOE-SR became aware of power increase by reading DuPont daily report.
	11:00 am	ES&H resident notifies Acting Deputy Assistant Secretary for Safety, Health and Quality Assurance, ES&H, of power increase. Acting Deputy decides to immediately send an ES&H technical team to investigate events.
	12:00 noon	ES&H resident met with DOE-SR Manager to express concern about events.
August 12	8:30 am	DOE-SR, ES&H resident, and DuPont officials met to discuss events. Operations Office reiterated concern about need for more prompt reporting, and agreement was reached that anomalies would be reported through an informal reporting system that already

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		existed between DOE and DuPont. Anomaly or threshold was still not defined.
	11:00 am	ES&H-HQ technical team together with onsite representatives (ES&H team) starts investigation.
August 13		ES&H team interviewed DuPont employees involved in event. DOE-SR staff sat in on interviews.
August 14		ES&H team continued assessment through weekend.
August 15	8:00 am	Assistant Secretary for ES&H returned from vacation, briefed on events at 9:30 staff meeting.
	2:00 pm	DOE-SR became aware that difference between actual point of criticality and predicted point was larger than previously identified--$4 not $2. Results of interviews by ES&H team show that reactor technical and operating staff would not change operating approach if faced with same situation in the future.
	4:00 pm	ES&H team recommended P-reactor shutdown to Assistant Secretary for ES&H on the basis of this new information.
	5:30 pm	ES&H team delivered copy of report containing shutdown recommendation to DOE-SR nuclear safety manager and left copy in DOE-SR Manager's office.
		Report containing ES&H team recommendation transmitted to Acting Deputy Assistant Secretary for Safety, Health, and Quality Assurance. He took copy to Assistant Secretary, ES&H.
	10:00 pm	ES&H resident returned earlier call from Assistant Secretary, ES&H. ES&H resident reported that situation did not require P-reactor to be shut down that evening.

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August 16	10-12:00 am	DOE-SR meets to determine response to events.
	11:00 am	ES&H chronology discusses conference call between Assistant Secretary for ES&H, his principal deputy, acting deputy for Safety, Health and Quality Assurance, and ES&H technical team, to discuss basis for shutdown recommendation. The Assistant Secretary remembers only one call about noon. ES&H chronology for this conference call states that ES&H team concluded that "clear and present danger" did not exist, although serious inadequacies were found.
	12:00 noon	Conference call involving same ES&H individuals, DOE-SR Manager, and Acting Assistant Secretary for Defense Programs to reach agreement on appropriate response to events. Giving DuPont a "show cause" letter was recommended by Operations Office. Following the conference call, the Assistant Secretary for ES&H told us he directed his staff to prepare a shutdown order because he determined that the situation at Savannah River met the "clear and present danger" criteria that gave him the authority to shut down the plant. Our discussion with the ES&H team indicates they did not realize that ES&H-HQ supported their position. Rather, they believed that a consensus had been reached within DOE, and they had been told by ES&H-HQ they should work with DOE-SR to come up with a solution.
	4:00 pm	In a conference call between Acting Assistant Secretary for Defense Programs, Deputy Assistant Secretary for ES&H, ES&H team, and DOE-SR manager

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	reach agreement on "show cause" letter to DuPont. ES&H team amend their recommendations and support DOE-SR "show cause" letter proposal.
	The ES&H team indicated to us that, they believed they were being "backed in a corner" to support the DOE consensus opinion; consequently, they withdrew recommendation for shutdown.
	The Assistant Secretary for ES&H told us that when informed of technical team's recommendation change, he called them to obtain an explanation. On the basis of their explanation, he decided not to issue the shutdown order.
5:00 pm	DOE-SR initiated new procedure by placing DOE Nuclear Safety Engineer on duty 24 hours a day in P-reactor control room.
6:00 pm	DuPont provided draft copy of "show cause" letter.
August 17	Final "show cause" letter given to DuPont.
	Assistant Secretary for ES&H called the Chairman of DOE's Advisory Committee on Nuclear Facility Safety. According to the Assistant Secretary, the Chairman told him that it would be best if the reactor were shut down. On the basis of this discussion, the Assistant Secretary called the Manager, DOE-SR, and advised him that he thought the reactor should be shut down. DOE-SR officials told us the decision had already been made to shut down when the manager receive this call.
6:00 pm	Recommendation by DuPont to shut reactor down to address concerns raised in the letter, complete maintenance and testing activities, and refuel the reactor. DOE concurred. Shutdown estimated to be 48 days.

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