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Fact Sheet for the Chairman, Environment, Energy and Natural Resources Subcommittee, Committee on Government Operations, House of Representatives

October 1989

NUCLEAR HEALTH AND SAFETY

Information on a Quality Assurance Problem at DOE's Savannah River Site

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GAO

United States
General Accounting Office
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Resources, Community, and
Economic Development Division

B-236604

October 23, 1989

The Honorable Mike Synar
Chairman, Environment,
Energy and Natural
Resources Subcommittee
Committee on Government Operations
House of Representatives

Dear Mr. Chairman:

In June 1989, you requested that we provide you with information on issues related to the problem with some of the fuel and targets--elements used to make tritium--in the nuclear reactors at the Department of Energy's (DOE) Savannah River Site (SRS). The SRS contractor found that some of the fuel and targets did not have the correct material content for where they were to be placed in the reactor or their material content could not be determined. This is important because if these components are in the wrong place or the material content is wrong by a significant amount, safe reactor operation could be affected. Therefore, we agreed with your office to determine what caused the problem; the effect on reactor safety; the costs to address the problem, including assessing the cause of the problem and actions taken to correct it; and any implications for reactor restart.

Three reactors at SRS--P, K, and L--are the nation's only source of tritium production, an important material used in nuclear weapons. Tritium is produced when reactor fuel, or tubes containing enriched uranium, release neutrons during the fission process which are absorbed by the "targets," or tubes containing lithium, thus converting the lithium into tritium. These fuel and target tubes must be manufactured to very specific standards or specifications. After the individual tubes are manufactured, two fuel and two target tubes are combined to form an "assembly" which is then put into the reactor. Specifications also control which tubes are used for a particular assembly based on their material content and where that assembly is placed in the reactor. These specifications are a key factor in predicting the amount of tritium to be produced and, more importantly, in establishing safe limits for reactor operation.

The Westinghouse Savannah River Company has operated SRS under contract with DOE since April 1, 1989. It replaced E. I. du Pont de Nemours who built the facilities at SRS in the 1950s and operated them until Westinghouse assumed that responsibility.

The SRS contractor--E. I. du Pont de Nemours at the time--notified DOE on September 27, 1988, that the contents of a tube in P reactor were too low for where the specifications said the tube should be in the reactor. DOE immediately told the contractor to stop both assembling the fuel and target tubes and shipping the assemblies to the reactor and directed the contractor to determine the cause and significance of the problem. After analyzing tubes at all three reactors, the contractor found that 174 tubes either did not meet specifications for where they should be in the reactor or it could not be determined if they met specifications because of paperwork problems. An additional 101 tubes, called "tag along tubes," were also affected because they were contained in assemblies that had problem tubes. (Typically, a total of almost 5,200 tubes is required for all three reactors to produce tritium.) Information we developed on the situation is summarized below and presented in more detail in sections 1 and 2.

In summary, we found that:

-- Inadequate quality assurance procedures both at the manufacturing facility and at the reactor area caused the problems. For example, existing procedures did not provide (1) adequate administrative controls to ensure that the assembly of fuel and target tubes met all specifications, (2) independent verification that the required physical examination to compare the tubes for each reactor with the paperwork documenting their content was accurate, and (3) adequate record keeping to ensure that the records of a tube's material contents were updated based on the recalibration of one of the tube's testing devices.

-- According to both DOE and contractor officials, no safety problems resulted from the fuel and target tube problems. There were fuel and target tubes from K and L reactors that did not meet specifications for where they were to be placed in the reactor. The variance from specification was very small and was well within the safety margin established for the reactors. However, DOE and the contractor did not determine that there was no safety impact until the contractor had

analyzed the problem fuel and target tubes, which took several months. For P reactor, the assemblies were already in the reactor when the problem was identified, resulting in the tubes being radioactive. Once the tubes are placed in the reactor, they cannot be tested to verify their contents and DOE cannot determine if they meet specifications. Regardless of whether the contractor can determine if they meet specifications, DOE does not plan to use any of the 275 tubes--174 problem tubes and 101 tag along tubes--for reactor operation.

-- Neither DOE nor the contractor has determined the full cost of addressing this problem. The contractor determined that the cost to replace the problem and tag along tubes was about $731,000. However, the contractor has not developed cost information for production overhead related to this replacement cost; staff time expended to investigate, report, review, and correct the problem; or staff time to retest each tube in the inventory. In addition, no estimate has been made of the costs associated with closing assembly and shipping operations for the 1 year it took to resolve the problem.

-- According to DOE officials, the fuel and target problems will not affect the restart of the K reactor (currently targeted for fall 1990). The contractor is fully documenting the nonproblem tubes for each reactor in accordance with commercial industry standards, but that process will not be complete for K reactor prior to scheduled restart. Therefore, DOE has directed the contractor to use tubes from the inventory that have all been retested to verify their contents and fully documented. According to DOE officials, the restart schedule will not be adversely impacted if the contractor begins to assemble those tubes beginning in early November 1989. DOE believes that operations will resume by that time. Further, DOE has not decided what to do with the assemblies at the K reactor that the contractor is documenting. Options range from using them for the next production cycle to replacing them at an approximate cost of $8 million.

DOE approved a new quality assurance program the contractor developed to address this problem on October 4, 1989. Approval is contingent upon completion of several administrative items. DOE told us those items will be

completed shortly, and the contractor can resume assembly and shipping operations upon their completion.

The technical experts we talked with pointed out that although there was no safety problem, this is another in a series of incidents at SRS pointing out poor internal controls and management inattention to safety. We have noted similar problems in the past.[1] As one example, in our testimony in September 1988, we raised questions about DOE's attitude toward safety and its management and oversight of its contractors in regard to the aborted attempt to restart the P reactor in August 1988. The Secretary of Energy, who took office subsequent to these events, has acknowledged these past problems and has begun to make changes within DOE. The Secretary believes these changes will strengthen DOE's ability to manage its contractors and make safety a first priority. While this is commendable, it is too early to assess the results of his actions.

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To respond to your concerns, we interviewed officials of DOE's Savannah River Operations Office and Westinghouse Savannah River Company; SRS site representatives for DOE's Office of the Assistant Secretary for Environment, Safety, and Health; and the Chairman of DOE's Advisory Committee on Nuclear Facility Safety, which advises the Secretary of Energy on nuclear safety matters. We also reviewed pertinent DOE and contractor reports, memorandums, and letters. In addition, we obtained views on the problem, particularly the safety implications, from our nuclear engineer and a nuclear physicist we consulted who is familiar with the characteristics of nuclear reactor fuel and targets. We performed the work for this fact sheet between July and October 1989 and discussed the facts presented with cognizant DOE officials.

As arranged with your office, unless you publicly announce its contents earlier, we plan no further distribution of this fact sheet until 30 days from the date of this letter. At that time, we will send copies to the Secretary of

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[1]Management and Safety Issues Concerning Doe's Production Reactors at Savannah River, S.C. (GAO/T-RCED-87-5, Mar. 12, 1987) and Ineffective Management and Oversight of DOE's P-reactor at Savannah River, S.C., Raises Safety Concern (GAO/T-RCED-88-68, Sept. 30, 1988).

Energy and other interested parties. Copies will also be made available to others upon request. Please call me at (202) 275-1441 if you have any questions about this fact sheet. Major contributors to this fact sheet are listed in appendix I.

Sincerely yours,

Keith O. Fultz
Director, Energy Issues

CONTENTS

ABBREVIATIONS

DOE	Department of Energy
GAO	General Accounting Office
SRS	Savannah River Site

SECTION 1

QUALITY ASSURANCE PROBLEMS WITH FUEL AND TARGET TUBES AT SAVANNAH RIVER SITE

The nuclear reactors at Savannah River Site (SRS) in Aiken, South Carolina, produce tritium, among other things, for weapons. Fuel and target tubes are used in the reactor to produce tritium, and the contractor manufactures the tubes in a facility on site. The contractor develops specifications that identify which tubes can be used for a particular assembly based on their material content and where that assembly is placed in the reactor. These specifications are important because they predict the amount of tritium to be produced and establish the safe limits for reactor operation. In September 1988, the contractor identified a problem with some of the fuel and target tubes and determined that the problem had been caused by a number of inadequate quality assurance procedures. The contractor has since developed a new quality assurance program to meet commercial industry standards, and DOE approved the program on October 4, 1989, pending the completion of five administrative requirements.

BACKGROUND

SRS produces and processes nuclear material for weapons. Currently, its three nuclear reactors--P, K, and L--are the only source of tritium production, which is a critical material for nuclear weapons. None of the reactors are operating while DOE and the contractor make a number of changes to upgrade safety and management oversight. SRS is operated by Westinghouse Savannah River Company which replaced E. I. du Pont de Nemours, which built and operated SRS until April 1, 1989, when Westinghouse took over. The Savannah River Operations Office is the DOE organization located at SRS responsible for managing and overseeing contractor activities.

Tritium is produced when reactor fuel, or tubes containing enriched uranium, release neutrons during the fission process that are absorbed by the "targets," or tubes containing lithium, thus converting the lithium into tritium. After this process, the target and fuel elements are left to cool in a water basin. Subsequently, the targets are "processed" to extract tritium. These fuel and target tubes must be manufactured to very specific standards or specifications.

Fuel and target tubes for the SRS reactors are fabricated and assembled in the manufacturing facility known as the M-Area. Typically, for the reactor to produce tritium, a total of 1,728 tubes is needed. After the individual tubes are manufactured, the

tube contents are verified with a nuclear test gauge.[1] Then, two fuel and two target tubes are combined to form an "assembly," which is then put into the reactor. The contractor also develops specifications that identify which tubes can be used for a particular assembly on the basis of their material content and where that assembly is placed in the reactor. These specifications are a key element in predicting the amount of tritium to be produced and, more importantly, in establishing the safe limits for reactor operations. This is important because if a tube's material content is significantly wrong or tubes are in the wrong location, safe reactor operation could be affected.

A typical tritium reactor "charge," called a Mark 22, consists of 432 assemblies, each containing four tubes--an outer target tube, outer fuel tube, inner fuel tube, and inner target tube. In addition, each tritium charge includes other components such as "blanket" assemblies--which are placed on the outside perimeter of the charge to absorb excess neutrons--and control rods that maintain proper reactivity within the reactor. These components also contain lithium and consequently produce tritium.

On the basis of DOE's requirements for tritium, the contractor determines the specifications for a Mark 22 charge and prepares a "matchlist," identifying the content of uranium for fuel tubes or lithium for target tubes acceptable for each assembly. "Matching" each reactor charge involves selecting the individual fuel and target tubes from inventory that will satisfy all specifications when assembled. When matching a reactor charge, tubes with a particular uranium or lithium content may not be available in inventory. Each time this happens, the contractor repeats the matching calculations to ensure that all specifications are satisfied and reissues the matchlist. It is, therefore, important that the most up-to-date matchlist is always used to decide the right tubes for each assembly. Once the charge is assembled and delivered to the reactor, data on the final matchlist are used by reactor personnel to assign each assembly to a specific reactor position and to make calculations necessary for restarting the reactor.

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[1]The nuclear test gauge measures the amounts of uranium and lithium in fuel or target tubes. Periodically the gauge must be recalibrated to ensure accurate readings. In some cases when the tubes are already in assemblies, the amount of uranium or lithium in tubes already in the inventory must be recalculated--to ensure all tubes in the inventory are standardized--after the gauge is recalibrated.

PROBLEM FUEL AND TARGETS IDENTIFIED

In September 1988, the contractor notified DOE that the material content of a tube in the P reactor was too low for where the specifications said it should be in the reactor. DOE issued a Stop Work Order for the assembly and shipping operations until it could determine the significance of the problem and directed the contractor to investigate the situation.

On the basis of that investigation, the contractor identified other tubes in P, L, and K reactors that were either out of specification for the particular charge, or whose contents were indeterminate. Indeterminate means that either the paperwork could not be found or the true content of some tubes could not be determined because two or more records existed with different uranium or lithium content data for a given tube. A total of 174 fuel or target tubes were affected. Table 1.1 shows the breakdown of these tubes by reactor. In addition, 101 "tag along" tubes were affected because they were in assemblies containing one or more of the problem tubes.

Table 1.1: Problem Tubes by Reactor

	Reactors			
	K	L	P	Total
Outer targets	19	1	2	22
Inner targets	52	42	57	151
Outer fuel	1	0	0	1
Inner fuel	0	0	0	0
Total	72	43	59	174

Source: Department of Energy, Savannah River Operations Office.

INADEQUATE QUALITY ASSURANCE PROCEDURES

The contractor determined that quality assurance procedures were not adequate to detect the problems with the fuel and target tubes. The contractor believed, and DOE agreed, that since the procedures were the same at each reactor, analyzing one reactor for procedural problems would be sufficient.

The contractor's analysis identified the following key causes of the problem:

-- Up-to-date matchlists were not used to assemble the charge and to check the charge at the reactor. Existing procedures did not provide adequate administrative controls to ensure that matchlist revisions were reviewed, approved, and documented. Frequently, revisions, which are required routinely, were often initiated verbally or by handwritten annotations to the matchlist. No procedure was in place at the time to ensure that all employees were using the same version of the list.

-- No independent or second-party verifications were made for several key steps in the process of putting together assemblies and putting those assemblies in the reactor. For example, one person physically compared the 1,728 tubes with the matchlist in accordance with existing procedures--a tedious process subject to human error.

-- There had been poor record keeping--two or more records existed showing different uranium or lithium contents for a given tube. This was because records had not been adequately updated to show recalculation of tube contents based on recalibration of the nuclear test gauge. Most of the problem tubes that were indeterminate had been in the inventory since 1982 and 1983. The nuclear test gauge had been recalibrated twice since 1983. Some tubes in the inventory could not be retested because they had already been put in assemblies. Therefore, a mathematical computation was used to determine tubes' contents. However, since these calculations were inadequately documented, the tube contents could not be verified.

IMPLEMENTATION OF A NEW QUALITY ASSURANCE PROGRAM

After analyzing the problem, the contractor proposed a new quality assurance program for the manufacturing facility. DOE reviewed the contractor's proposal and identified a number of administrative requirements, such as improvements in training and procedure control, that should be included as part of the program. DOE also informed the contractor that the Stop Work Order would remain in effect until the administrative requirements had been met. However, DOE permitted a "limited release from the Stop Work Order" to allow replacement tubes to be assembled for testing in the L reactor, which was needed to support restart activities.

After reviewing the contractor's response to the administrative requirements, DOE informed the contractor on October 4, 1989, that the approval of the Stop Work Order would be contingent upon completion of several administrative items which, according to DOE, should be completed shortly. According to the Savannah River Operations Office Deputy Manager, the contractor is in the process of implementing the new quality assurance program.

The contractor believes the new program will bring the manufacturing facility up to commercial standards. To assist in implementation, the contractor brought in one of its senior production managers from its commercial nuclear fuel manufacturing facility.

A key feature of the new quality assurance program is the certification of all manufactured products. According to the contractor's Vice President and General Manager for Operations, this certification package will include process data sheets that will accompany each product through all manufacturing and in-process inspection steps. Trained and qualified personnel will review the completed data sheets to verify that all product requirements have been satisfied. This review will be documented in a certification report that will be issued before the materials are placed in the reactor. The Vice President and General Manager added that other improvements to the program requested by DOE include such items as documenting performance indicators for the manufacturing area, developing procedures to train personnel prior to restart of assembly operations, and assurances that all operating procedures will be reviewed before use. According to the Savannah River Operations Office's Chief, Reactor Materials Branch, the branch will monitor the contractor's actions as it implements the new program. Additionally, the Savannah River Operations Office's Quality Assurance Branch will periodically review the contractor's operations.

SECTION 2

IMPLICATIONS OF FUEL AND TARGET TUBE PROBLEMS

Out-of-specification fuel and target tubes could have implications for the safety of reactor operations and the cost of conducting operations at SRS. The specifications for where the tubes should be placed in the reactor and the material content of the tube for that location are directly linked to establishing safe operating limits for a particular charge. Although some tubes were found not to be within those specifications, all were within the safety margin for reactor operations. Regarding cost, neither DOE nor the contractor has determined the full cost of addressing the problem. For example, overhead and personnel costs have not been determined. In addition, DOE has not decided what to do with the existing K reactor charge, and until that decision is made, the full cost of addressing this problem cannot be determined. Further, according to DOE officials, the restart schedule for K reactor will not be adversely affected if the assembly and shipping operations resume by early November 1989, which DOE believes they will.

DOE IDENTIFIED NO SAFETY PROBLEMS

According to both DOE and contractor officials, no safety problems resulted from the fuel and target tube problems. When determining safe operating limits of a reactor charge, the contractor determines the composition of the charge based on the uranium and lithium content of each fuel and target tube, respectively, how they fit together in an assembly, and finally where the tubes are placed in the reactor. In a worst case scenario, a large variance from that charge composition could create a problem in controlling the fission process in the reactor. However, variances from specifications that the contractor found represent less than a 1 percent change in reactor operating limits--which is well within the safety margin established for the reactors.

The determination that no safety problem existed was not readily apparent to DOE or the contractor because some tubes had to be matched to the correct paperwork, and the indeterminate tubes from L and K reactors had to be tested to determine if the contents were correct for the particular charge. This determination took several months. To be tested, the assemblies had to be cut apart so that the individual tubes could be retested by the nuclear test gauge. Cutting the assemblies apart means for the most part that the tubes cannot be used again; however, the tubes can be melted down and extracted materials can be used to fabricate other tubes.

The contractor has not been able to determine that all problem tubes in the P reactor meet the specifications for the charge because the contractor had already put the assemblies in the reactor, making them radioactive. Once the tubes are placed in the reactor, they cannot be retested with the nuclear test gauge to determine their content. Regardless of whether the contractor can determine if they meet specifications, DOE does not plan to use any of the 275 tubes--174 problem tubes and 101 tag along tubes--for reactor operation.

We discussed DOE's and the contractor's conclusion of no safety problem with our technical consultants; the Chairman of DOE's Advisory Committee on Nuclear Facility Safety; and DOE Environmental, Safety and Health Site Representatives at SRS. Each of the individuals agreed that there was not a safety issue, but they believed that this incident pointed out another example of the historical lax attitude toward safety that we and others have reported on over the last few years.

COST IMPLICATIONS

Neither DOE nor the contractor has determined the total cost of addressing the fuel/target problem. We requested that DOE develop the total cost, and it did provide us with the cost of replacing the fuel and target problem tubes as well as the tag along tubes. The contractor estimated that it would cost about $730,000. The breakdown by reactor and type of tubes is shown in table 2.1. The costs shown in the table do not include overhead.

Table 2.1: Estimated Cost to Replace Problem Fuel and Target Tubes

	Tubes replaced				
	Problem tubes	Tag along tubes	Total	Cost per tube	Total cost
Outer target	22	10	32	$1,100	$ 35,200
Inner target	151	28	179	1,100	196,900
Outer fuel	1	31	32	7,800	249,600
Inner fuel	0	32	32	7,800	249,600
Total	174	101	275		$731,300

Source: Department of Energy, Savannah River Operations Office.

However, the contractor has not developed other cost information, which would include personnel costs incurred to retest all existing tubes in the inventory with the nuclear test gauge, study the problem, make and evaluate recommendations concerning the

solution to the problem, and develop and implement a revised quality assurance program. Further, no estimate has been made of the costs associated with closing assembly and shipping operations for the 1 year it took to resolve the problem.

An additional uncertainty in developing cost data to represent the total cost of the problem is the status of the existing K reactor charge. Although the "problem" assemblies have been removed, DOE has decided not to use that charge when the reactor restarts. This is because DOE does not believe the contractor will have completed the paperwork process to certify the tubes' contents according to commercial nuclear industry standards prior to the scheduled restart. Instead, DOE has directed the contractor to assemble another charge. In regard to the existing charge, DOE has not decided what to do with it. Options range from using the charge for the next production cycle to replacing the entire charge. DOE could not provide us with estimates for each option available but could tell us that the replacement cost for a new charge was approximately $8 million. The DOE Savannah River Operations Office Deputy Manager does not believe that the remainder of the existing K reactor charge will need to be replaced.

In addition to the problems with the tritium charges, the comprehensive records search initiated after the tritium fuel and target problem was identified found discrepancies in the historical records of three plutonium charges. The problems identified were similar to those identified with the tritium charges. A total of 31 fuel and target tubes had indeterminate contents and, according to the contractor, will be replaced. Replacement cost data were not available for these tubes, according to the leader of DOE Savannah River Operations Office's task team investigating the incident, but the task team leader added that there were no current plans to produce plutonium until the mid-to-late 1990s.

REACTOR RESTART IMPLICATIONS

DOE officials do not believe that the fuel and target problems will affect the restart of the K reactor (currently targeted for fall 1990). DOE has directed the contractor to construct a new charge using assemblies that contain tubes from the inventory which have all been retested to verify their content and fully documented. Therefore, the Stop Work Order must be lifted on the assembly and shipping operations for the contractor to be able to construct assemblies. DOE officials told us that this will not affect the restart schedule if those assembly operations begin by early November 1989, and DOE believes that operations will resume by that time.

APPENDIX I

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