
March 1998

NUCLEAR WEAPONS

Design Reviews of DOE's Tritium Extraction Facility



**Resources, Community, and
Economic Development Division**

B-279101

March 31, 1998

The Honorable Strom Thurmond
Chairman
The Honorable Carl Levin
Ranking Minority Member
Committee on Armed Services
United States Senate

The Department of Energy (DOE) is responsible for managing the nation's nuclear weapons stockpile, including providing tritium, a gas used to enhance the explosive power of all nuclear weapons currently in the nation's stockpile. Because tritium decays, it has to be periodically replaced in weapons, but DOE has not produced tritium since 1988 and currently has no production capability. The Department is currently using tritium removed from dismantled weapons to replace decayed tritium in active weapons. However, that supply is limited and new tritium production capacity will be needed in 2005.

As part of its plans to provide tritium, DOE will build a Tritium Extraction Facility at its Savannah River Site in South Carolina. The \$383.4 million project, managed by the Commercial Light Water Reactor Project Office at the Savannah River Site, is scheduled for completion in 2005. During 1997, DOE completed the project's conceptual design, issued a conceptual design report, and began the preliminary design for the project. Three different teams reviewed the conceptual design and related documents. At your request, we obtained information on (1) the major comments raised by the three reviews and (2) the process used by DOE to respond to those comments.

Results in Brief

Two of the teams that reviewed the Tritium Extraction Facility's conceptual design found the project's scope, cost, and schedule to be appropriate and found no issues that would necessitate reevaluating the project. The third team made no overall comments on the project. The three teams also had nearly 800 specific comments. Comments that the review teams considered to be significant related to (1) the design of the remote handling and tritium extraction processes (the processes considered to have the highest risk in the project); (2) the need for the project's schedule to allow for contingencies that could occur in process and equipment development; and (3) the adequacy of the level of detail in the conceptual design report.

DOE handled each review team's specific comments differently. For one team, the Savannah River Project Office prepared a response to each comment, and DOE headquarters had three members of the original review team comment on the adequacy of the responses. For comments made by the second team, the Project Office responded to all comments but did not seek the team's review of the responses. For the third review team's comments, DOE responded to each comment, but the design team has not yet reviewed the responses. Overall, DOE made many changes to the conceptual design because of the review teams' comments and appears to have been generally responsive to the comments. However, some comments—such as the one related to a need to include contingencies in the project's schedule—have not been resolved to the satisfaction of the review teams. Nevertheless, DOE approved the conceptual design report and the project entered the preliminary design phase in October 1997.

Background

Tritium, which makes possible smaller, more powerful nuclear weapons, decays at a rate of 5.5 percent per year. Therefore, for nuclear weapons to be capable of operating as designed, the tritium in the weapons must be periodically replaced. DOE used to produce new tritium in its reactors at the Savannah River Site, but the last of these reactors was shut down in 1988 because of safety and operational problems. DOE currently has no tritium production capability, although the Department has been able to meet its requirements for tritium by reusing material recovered from dismantled weapons.

In order to meet currently planned requirements for tritium, a new production capability must be available in 2005. To accomplish this, DOE is pursuing a dual-track program to select the primary production source. The first track is based on using a commercial light water reactor to produce tritium. Target rods containing lithium would be placed in the reactor, and during the reactor's normal operations, some of the lithium would be turned into tritium. Once removed from the reactor, the target rods would be transported to the Tritium Extraction Facility, where the tritium would be removed.

The second track involves building an accelerator as the primary producer of tritium. This device accelerates protons (particles within an atom that have a positive electrical charge) to nearly the speed of light. The protons are crashed into tungsten, releasing neutrons (particles within an atom that have no electrical charge), which can be used to change helium into

tritium. As currently envisioned, this process would not involve the Tritium Extraction Facility.

DOE's current plan is to choose one of the two tracks in late 1998. If the commercial-light-water-reactor track is chosen, the accelerator will be pursued to the point of establishing an engineering design for it, but it will not be built. If the accelerator track is chosen, the accelerator will be built and operated and, as a backup, all aspects of the commercial light water reactor option will be completed—with the exception of the actual production of tritium. The target rods will be produced, agreements with utilities for the use of their reactors will be signed, and the Tritium Extraction Facility will be built.

Thus, under both tracks, DOE intends to build the Tritium Extraction Facility. Construction of the facility—to be managed by the Commercial Light Water Reactor Project Office at the Savannah River Site—is currently estimated to cost \$383.4 million and is scheduled for completion in 2005.¹ The Tritium Extraction Facility project completed the conceptual design phase in October 1997. The preliminary design, currently being developed, is scheduled to be completed in June 1998.

The conceptual design for the Tritium Extraction Facility was reviewed by three teams—the “Red Team,” the “Independent Review Team,” and the “Formal Design Review Team.” Although there is no requirement for such reviews, they were requested by DOE headquarters’ Office of Commercial Light Water Reactor Production and the Project Office at Savannah River to increase their confidence in the conceptual design of the facility before proceeding to the preliminary design phase. All teams reviewed drafts of the conceptual design and/or the conceptual design report. Table 1 shows how many and what type of participants each team had, what the team was chartered to do, and when the review was performed.

¹To finish purifying the tritium gas (after extraction and processing in the Tritium Extraction Facility), an existing facility at Savannah River, the Tritium Recycle Facility (Building 233-H), will have to be modified. The modifications will cost an estimated \$36.46 million in addition to the \$383.4 million estimate for the Tritium Extraction Facility. These modifications are scheduled for completion in the third quarter of fiscal year 2004.

Table 1: Characteristics of the Review Teams

| Review team | Members | Charter | Time frame of review |
|---------------------------|--|--|---|
| Red Team | 10 members (9 from private firms and universities and 1 from DOE) | Review the conceptual design, concentrating on its scope and breadth Determine the conceptual design's appropriateness Recommend ways to reduce costs, risks, and workers' exposure to radiation and to increase efficiency, workability, and safety | February through July 1997 (Report issued in July 1997) |
| Independent Review Team | 4 members (DOE employees not directly associated with the project) | Provide suggestions to improve the conceptual design report | Early June 1997 (Report issued on June 12, 1997) |
| Formal Design Review Team | 19 members (Westinghouse and laboratory personnel) | Evaluate the project's baseline performance and operational requirements Evaluate the scope of work for the conceptual design in comparison with the baseline requirements Evaluate the technical adequacy of plans to mitigate risks associated with the higher-risk strategies | December 1996 and January 1997 (Report issued on Jan. 30, 1997) |

Review Teams' Comments

Two of the three teams that reviewed DOE's conceptual design for the Tritium Extraction Facility made overall comments in their final reports. The Red Team and the Formal Design Review Team expressed a favorable opinion overall of the facility's design and the related documentation. According to the Red Team, the conceptual design's scope, cost, and schedule are appropriate; the technical concept and approach are sound; all major risks have been identified; and the building is constructible and, in general, appears to comply with DOE's current requirements. The Formal Design Review Team reported that it did not identify any significant items that could not be corrected with three documents due to be completed after the team's review—the Facility Design Description, the System Design Description, and the Conceptual Design Statement of Work. The Independent Review Team did not make any overall comments on the conceptual design.

In addition to the overall comments made by two of the review teams, all three teams made a number of specific comments. The Red Team had 34 comments (see app. I for a listing of the Red Team's major comments), and the Independent Review Team had 60 comments (see app. II for a

listing of the Independent Review Team’s major comments). The Formal Design Review Team made 691 specific documentary and technical comments on the conceptual design and related documents—none of which it considered to be major impediments to the design and construction of the Tritium Extraction Facility. The specific comments made by all three review teams covered a wide range of topics, including the design of specific systems, the design and construction schedule, life-cycle costs, the method of contracting for the design and construction, and the level of detail in the supporting documentation and in the conceptual design report.

Comments that the review teams considered to be significant and that we believe cover issues that could affect the success of the project related to

- the design of the remote handling and tritium extraction processes,
- the need to include contingencies in the schedule, and
- the level of detail in the conceptual design report.

Remote Handling and Tritium Extraction Processes

The remote handling system for the Tritium Extraction Facility, the means by which nearly all facility processes and maintenance, including moving tritium target rods and opening them, will be controlled from a separate (remote) room. The extraction process involves heating the target rods in a furnace and removing the tritium and other gases from them. Project officials do not consider design and construction of these systems to be high-risk, but they do believe that they are the highest-risk tasks involved in the project.

The Red Team reported that the remote handling and tritium extraction processes include risks that need to be addressed in the near term. The team found that a plan to mitigate the risks was not evident and that the subsystems to manipulate and open the target rods had not been demonstrated. The team believed that the time and cost to engineer and develop the processes would be greater than the estimates in the conceptual design report. Similarly, in a comment it deemed “significant,” the Independent Review Team stated that the target rod handling process was overly complex. The team proposed an alternative method and suggested that it be discussed in the conceptual design report.

The Red Team and the Independent Review Team consider DOE’s actions and responses to the comments on the remote handling and tritium

extraction processes to be generally adequate.² According to Red Team members and the chairman of the Independent Review Team, much has changed since their reviews were conducted. Design alternatives have been developed and changes have been made in the conceptual design report that have satisfied the intent of the comments.

Schedule

The Independent Review Team indicated a need to consider contingencies, to provide allowances for unforeseen delays, in the schedule—just as they are addressed in cost estimates. The chairman of the team told us that it was specifically concerned with the plans for a mock-up of the remote handling process and a prototype of the tritium extraction furnace—believing that any problems with them could delay the project overall because the tasks run concurrently with the development of the detailed design. The chairman explained that although the conceptual design report now contains more detail on the project’s schedule, it still does not include contingencies. Because he believes this feature to be very important, he considers DOE’s response to this comment to be inadequate.

DOE officials informed us that they believe there is no need for the schedule to include contingencies. The Tritium Extraction Facility’s schedule is based on a 5 day per week, 8 hour per day work schedule. The option of working multiple shifts and/or weekends, as necessary, offers adequate flexibility to respond to schedule issues.

Level of Detail in the Conceptual Design Report

All three review teams made numerous comments suggesting adding additional information and detail to the conceptual design report and related documents. The suggestions concerned requirements, design detail, equipment, analyses, schedules, risks, and planned operations. The Red Team concluded that the conceptual design package was insufficient to permit an architect engineering firm to independently proceed with the preliminary design.

Since the three teams reviewed the draft conceptual design, the Project Office has provided considerable additional information in the issued conceptual design report. Furthermore, according to program officials, DOE never intended for an architect engineering firm to develop the preliminary design independently, but rather for the firm to work with the

²Although DOE did not provide the Independent Review Team an opportunity to review the Project Office’s responses to the team’s comments, we provided a copy of the responses to the chairman of the team and obtained his views on their adequacy.

Project Office to develop the design. After reviewing the final conceptual design report, the Red Team and the chairman of the Independent Review Team consider their comments about the level of detail to be resolved. The Formal Design Review Team has yet to review DOE's actions subsequent to its review.

DOE's Process for Handling Review Teams' Comments

Although one of the review teams was chartered by DOE headquarters and two were chartered by the Savannah River Project Office, the purpose of obtaining the independent reviews of the conceptual design was similar in all three cases—to provide confidence in the adequacy of the Tritium Extraction Facility's conceptual design. Nevertheless, there were no uniform guidelines established for these reviews, and the comments made by each of the review teams were handled differently. In addition, DOE and the Project Office did not reach closure with any of the review teams prior to initiating the preliminary design phase.

Neither DOE nor the Project Office at the Savannah River Site initially responded to all of the Red Team's comments. In April 1997, on the basis of a briefing provided by the Red Team, DOE headquarters selected 10 items that it believed to be most important and that required action before the beginning of the preliminary design phase. On October 31, 1997, the Project Office sent a letter to DOE headquarters describing the actions taken in response to the comments selected by headquarters and one other item added by DOE officials at Savannah River. For 8 of the 11 comments, the Project Office analyzed the comments and formally documented its responses. The Project Office took no action on two of the comments, deferring action until later in the project. The Project Office disagreed with one comment.³

On December 2 and 3, 1997 (after DOE's October 31, 1997, approval to proceed to the preliminary design phase), DOE headquarters officials took a team composed of three former Red Team members to the Savannah River Site to determine what had been done in response to all 34 comments contained in the team's report. The Project Office prepared a list of the actions taken, and the three members of the Red Team concluded that, overall, the Project Office had been responsive to the comments. They concluded that the conceptual design had been completed with the level of detail required by DOE orders and concurred with the decision to proceed with the preliminary design. DOE project officials informed us that they

³This comment was the one asserting that there was insufficient information in the conceptual design report to allow an architect engineering firm to do the preliminary design.

intend to also have a panel similar to the Red Team review the project's design at the conclusion of the preliminary design phase.

The Project Office handled the Independent Review Team's comments differently. On July 31, 1997, prior to the initiation of the preliminary design phase, the Project Office formally responded to all 60 of the team's comments. Neither DOE nor the Project Office transmitted the responses to members of the Independent Review Team, and their review of the responses was not solicited. However, we asked the chairman of the Independent Review Team to review the Project Office's responses. The chairman considers the responses to 55 of the comments to be adequate and to 5, inadequate. One of these five comments involves the project's schedule, as discussed earlier. The chairman does not consider the other four to be significant.

The Project Office handled the Formal Design Review Team's comments in a different manner still. By October 31, 1997, the Project Office had reviewed each of the Formal Design Review Team's 691 comments and recommended 454 for closure—that is, that the Project Office's actions satisfied the comments. A number of the comments recommended for closure (about 12 percent) pertained to work at Building 233-H that will be conducted as part of another project. These comments will be forwarded to the office managing that project for consideration and disposition. According to the Project Office, the 237 outstanding comments will be dealt with during the preliminary design phase of the project.

The original intention was for the Formal Design Review Team to review the Project Office's responses and for the chairman of the team to issue a "closure" memo (1) stating that the team had reviewed and agreed with the Project Office's responses to its comments and (2) endorsing the conceptual design. As of January 1998, the Formal Design Review Team had not reviewed the Project Office's responses and the chairman had not issued such a memo. Project Office officials informed us that relevant action plans will be completed by the spring of 1998, at which time the chairman could issue the memo.

Conclusions

Given the overall favorable responses to the Tritium Extraction Facility's conceptual design, it may have been prudent to proceed with the preliminary design phase in October 1997. However, the intent of having independent reviews was to enhance confidence in the conceptual design, and numerous concerns were identified, some of which the review teams

considered to be important. None of the various approaches for handling the review teams' comments resulted in reaching closure with the teams before the start of the preliminary design phase. A structured, consistent approach to resolving comments and obtaining concurrence would have helped ensure that the project received the maximum benefit from the reviews. Such a structured approach could apply in the future, as DOE intends to have an independent team review the Tritium Extraction Facility's design after the preliminary design work is completed.

Recommendation

We recommend that the Secretary of Energy establish guidelines for formally responding to and reaching closure within a reasonable time frame on comments made during future independent design reviews of the Tritium Extraction Facility project.

Agency Comments and Our Evaluation

We provided a draft of this report to DOE for its review and comment. Overall, DOE agreed with the facts contained in the report and concurred with the recommendation. DOE stated that it is instituting a tracking system in which all action items will be included with due dates and responsibility assignments for tracking and disposition.

DOE had two specific comments. First, DOE stated that our report inferred that the Department began the preliminary design prematurely because not all of the review teams' comments were resolved. As stated in our draft report, given the overall favorable responses to the conceptual design, we believe it may have been prudent to proceed with the preliminary design phase. However, as a general practice, we believe that to maximize the usefulness of a design review team's comments, DOE should present the team with responses to each comment and reach closure with the team on how and when the comment will be resolved. By responding to the design review team's comments in this manner, DOE would ensure agreement by all parties on the appropriate timing and proper course of action required to resolve the problems noted. In cases in which DOE disagrees with the comment, this type of formal response process could open a dialogue that could convince the design review team that no action is required or would at least provide a record of the reasons why DOE and the design review team chose to disagree.

Second, DOE expressed the opinion that addressing contingencies in the schedule, as advocated by the Independent Review Team, is not a major concern. However, the chairman of the Independent Review Team still

believes that the lack of this feature is significant. Both DOE and the Independent Review Team's perspectives are presented in our report. We believe that this disagreement demonstrates why DOE needs a formal procedure for dealing with design review teams' comments. In this case, DOE did not provide the Independent Review Team with responses to its comments, and there was no effort made to discuss and document areas of disagreement. As a result, the comment has not been resolved. The full text of DOE's comments is included as appendix III.

Scope and Methodology

To obtain information on the major comments made by the review teams, we obtained and reviewed the teams' reports. For the Independent Review Team, we also obtained the Project Office's formal responses to the comments contained in the report. In its report, the Red Team formally listed its comments, and DOE had not initially formally responded to them. As a result, we analyzed the Red Team's report to create a list of major comments, which we presented to DOE. DOE and members of the Red Team reviewed that list and agreed that it comprised the major comments of the report. DOE and the Red Team members then used our list during their December 1997 review of the Project Office's responses to the Red Team's report. We obtained the results of that review. At the time of our review, the Project Office had not formally responded to the Formal Design Review Team's comments.

To obtain information on the process DOE used to respond to the comments raised by the review teams, we reviewed the review teams' charters; correspondence between the review teams, the Project Office, and DOE; and the teams' reports and related documents. We also discussed the processes with DOE and Project Office officials and representatives from the review teams. We conducted our review from October 1997 through February 1998 in accordance with generally accepted government auditing standards.

As arranged with your offices, unless you publicly announce its contents earlier, we plan no further distribution of this report until 30 days after the date of this letter. At that time, we will send copies of the report to the Secretary of Energy; the Secretary of Defense; and the Director, Office of Management and Budget. We will also make copies available to others on request.

If you or your staff have any questions about this report, please call me at (202) 512-8021. Major contributors to this report include William F. Fenzel, Assistant Director, and Kenneth E. Lightner Jr., Senior Evaluator.

A handwritten signature in black ink that reads "Gary L. Jones". The signature is written in a cursive style with a large, stylized "G" and "J".

Gary L. Jones
Associate Director, Energy,
Resources, and Science Issues

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Abbreviations

| | |
|-----|---------------------------|
| DOE | Department of Energy |
| GAO | General Accounting Office |

Status of Major Comments by the Red Team

| Major comments | Status |
|--|---|
| Implementation of the integrated technical and management approach for the design, construction, and start-up of the Tritium Extraction Facility as described in the Systems Engineering Management Plan is poor and inconsistent. Critical decisions appear to have been made without the benefit of sufficient analysis of the alternatives. | Partially closed. Essential processes are in place; additional analysis has been either documented or is in process. |
| Two recognized risks, the tritium extraction and remote handling processes, represent major vulnerabilities that need to be mitigated in the near term. A plan to develop the tritium extraction process and to mitigate risks is not evident. The subsystems for handling and opening the target rods are not proven applications of existing technology. Much of the remote handling will be first-of-a-kind applications. Each represents significant uncertainties, in terms of scope, cost, and schedule. The time and cost to engineer/develop the applications will be greater than the current plan estimates. | Partially closed. An action plan for the tritium extraction and remote handling processes has been prepared. A proven mechanical system for tritium extraction has been incorporated into the conceptual design. Corrective action plans for the subsystems are being implemented. The cost to develop remote handling operations could still be significant. |
| There are no clear limits for releases of radioactivity, requirements for confinement systems, or goals for minimizing workers' exposure. | Partially closed. A report defining requirements has been issued. Guidelines for minimizing workers' exposure are being established. |
| The conceptual design package is not an adequate basis to start preliminary design. It is insufficient to permit an architect engineering firm to independently proceed with the preliminary design. | Closed. DOE completed an assessment of its readiness to proceed to the preliminary design. The team agreed with DOE's decision to proceed. |
| It is not evident that DOE has reviewed the lessons learned from other projects and applied them to the Tritium Extraction Facility project's conceptual design and plan. | Partially closed. The lessons learned from other projects have been identified and evaluated and are being incorporated into the project design and project implementation processes. |

Note: From reviewing the Red Team's report, we compiled a list of the team's major comments, with which DOE and members of the team concurred. The status of these comments is as described by the three team members that met on December 2 and 3, 1997, to review DOE's responses to the comments. The status summaries (closed or partially closed) are the result of our analysis of the team members' description of each comment's status. The three team members concluded that, overall, the Project Office had been responsive to the comments.

Status of Major Comments by the Independent Review Team

| Major comment | Status |
|--|---|
| The conceptual design report should be a more stand-alone document. | Closed. Additional information has been added to the conceptual design report. |
| The remote handling process is overly complex. | Closed. Improvements have been made to the design for the remote handling process. |
| A section devoted to the project's schedule should be added to the conceptual design report. | Open. Additional information on the schedule was added to the conceptual design report; however, the schedule does not include contingencies, which represents a high risk. |
| There should be a section in the conceptual design report that discusses applicable design and construction codes and standards. | Closed. References to applicable design and construction codes and standards have been added to the conceptual design report. |
| Any segment of the facility should be designed totally in-house or totally subcontracted. | Closed. DOE plans a joint effort by the Project Office and an architect engineering firm. The Independent Review Team's chairman now agrees with this approach. |
| The life-cycle cost analysis should include the number of target rods that must be processed to meet the facility's production requirements. | Open. The life-cycle cost analysis does not yet include the number of extractions required to meet the production requirements. The staffing levels proposed are excessive. The team's chairman no longer considers this a major comment. |
| The Process Development Program (a program to develop facility processes by using prototypes and mock-ups) should be accelerated. | Closed. While the program has not been accelerated, DOE has recognized the risk to the project's cost and schedule and will attempt to mitigate the risk. |

Note: The Independent Review Team's major comments appeared in its final report. The status of the comments is as described to us by the team's chairman.

Comments From the Department of Energy



Department of Energy

Washington, DC 20585

March 12, 1998

Ms. Gary Jones
Associate Director
Energy, Resources, and Science Issues
Resources, Community, and Economic
Development Division
U.S. General Accounting Office
Room 2962
Washington, D.C. 20548

Dear Ms. Jones:

The Department of Energy is providing comments on the General Accounting Office draft report, GAO/RCED-98-75, entitled "Design Reviews of DOE's Tritium Extraction Facility." Your draft report was reviewed by the major Department of Energy organizations involved in the management of the Tritium Extraction Facility design and construction. The Departmental organizations providing comments on the report include Defense Programs and the Savannah River Operations Office.

GENERAL COMMENTS:

Based on the comments received from these organizations, the Department agrees with the statement of facts contained within the report. However, the apparent assumption that all comments by the review team(s) needed to be resolved prior to initiation of preliminary design seems to lead to an inference that the Department began preliminary design prematurely. Please be aware that a detailed readiness review was conducted by the Savannah River Site contractor, Savannah River Site DOE, and the Headquarters Defense Programs (DP) Tritium Project Office (TPO) and all issues identified by the review teams that were prerequisite to preliminary design were resolved prior to the authorization letter for start of preliminary design.

We believe that "Schedule Contingency" as expressed by one of the three review teams is not a major issue due to the project risk reduction program and the fact that the current schedule is based on a 40 hour work week and the 2005 date for tritium production fixed by the President's stockpile memorandum.

RECOMMENDATION:

"We recommend that the Secretary of Energy establish guidelines for formally responding to and reaching closure within a reasonable time frame on comments made during future independent design reviews of the Tritium Extraction Facility project."

Appendix III
Comments From the Department of Energy

CONCUR:

The basis for the recommendation presented in the report appears to suggest that a consistent system for comment closeout be used. The Tritium Extraction Facility project has, and the DP TPO is instituting, action tracking systems in which all such action items will be included with due dates and responsibility assignments for tracking and disposition.

Thank you for the opportunity to provide comments on the draft report. If you require additional assistance or have questions about the comments, please refer them to Stephen Sohinki of my staff at (202) 586-0838.


Victor H. Reis
Assistant Secretary
for Defense Programs

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