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DEFENSE NUCLEAR FACILITIES SAFETY BOARD

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99-0002961

December 7, 1999

Brigadier General Thomas F. Gioconda
Acting Assistant Secretary for Defense Programs
Department of Energy
1000 Independence Avenue, SW
Washington, DC 20585-0104

Dear General Gioconda:

The Secretary of Energy issued the Consolidated Record of Decision for the Tritium Supply Program on May 6, 1999. The Commercial Light Water Reactor—Tritium Extraction Facility alternative was chosen as the primary tritium supply program to support national stockpile management activities. The Tritium Extraction Facility (TEF) project is in its final design phase; construction is scheduled to start next year at the Savannah River Site.

The Defense Nuclear Facilities Safety Board (Board) and its staff have been reviewing the design of safety-related aspects of the TEF project. In the design of processes involving hazardous materials it is considered good safety practice to provide multiple layers of protection to prevent or mitigate the accidental release of hazardous material to the environment. Such practice is recommended by several Department of Energy (DOE) directives. The Savannah River Site (SRS) manuals and practices for incorporating safety measures are consistent with this defense-in-depth philosophy, as acknowledged in the Board's letter to DOE dated March 18, 1999. The preliminary design of TEF, however, does not yet appear to have fully implemented a hierarchy of safety controls consistent with the site's manuals of practice. Additional consideration of this matter is merited in developing the final TEF design.

Enclosed is a report prepared by the Board's staff for your information and consideration in the final design of TEF. The report includes examples of areas in which additional design features would enhance safety by improving the reliability of the controls and providing additional defense-in-depth without a significant impact on the cost and schedule for the project.

If you have any questions on this matter, please do not hesitate to call me.

Sincerely,

John T. Conway
Chairman

c: Mr. Mark B. Whitaker, Jr.

Enclosure

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DEFENSE NUCLEAR FACILITIES SAFETY BOARD

Staff Issue Report

November 17, 1999

MEMORANDUM FOR: G. W. Cunningham, Technical Director
J. K. Fortenberry, Deputy Technical Director

COPIES: Board Members

FROM: F. Bamdad

SUBJECT: Design Review for Tritium Extraction Facility

This report documents the results of several reviews of the preliminary design for the Tritium Extraction Facility (TEF), conducted by the staff of the Defense Nuclear Facilities Safety Board (Board). These reviews were conducted at the Savannah River Site (SRS) on May 17–20, 1999, and October 18–20, 1999, and during a televideo conference held on September 1, 1999. The Board also held a meeting at SRS on October 19, 1999, to review the status of the TEF design and discuss some of the civil and structural issues before the final design is complete.

Background. The Department of Energy (DOE) made a decision on May 6, 1999, to use the commercial light water reactor alternative as the primary tritium supply program. Tritium will be produced in a commercial reactor by irradiation of tritium-producing burnable absorber rods (TPBARs) containing lithium-6, which produce tritium when irradiated with neutrons. The lithium-6 rods replace the boron-10 burnable absorber rods used in commercial reactors to control reactivity. After being irradiated, the lithium-6 rods will be shipped to SRS, where tritium will be extracted from the rods in a new facility—the TEF. The product gas will subsequently be processed at the existing Replacement Tritium Facility (RTF) to support national stockpile management activities. The final design phase for TEF began in August 1999 and is proceeding in an expeditious manner to support the scheduled start of construction next year.

Discussion. The Board's staff has focused its reviews, applying the principles of Integrated Safety Management, on the identification of hazards, the adequacy of controls, and civil and structural issues that may impact the final design of the facility. In its reviews, the staff has attempted to ensure that the final design of TEF adequately protects the health and safety of the public and workers during normal operations, potential operational accidents, and external events. The detailed design is based on several key design assumptions, particularly functional classification of safety systems.

The facility design consists mainly of two concrete buildings, a corridor connecting the buildings to each other, and an encased underground pipeline system to transfer the product gas to RTF. The Remote Handling Building (RHB) is a canyon-like structure designed to receive, handle, and store the irradiated rods and extract tritium for transfer to the Tritium Processing Building (TPB). TPB contains gas processing systems such as flow-through beds, purge and glovebox strippers, and zeolite-bed recovery systems, as well as control rooms and equipment support rooms. The exterior concrete structures are designed to Performance Category 3 requirements to provide protection against design basis natural phenomena hazards (NPH). The essential components of the interior structure, such as gloveboxes, modules, and a double-walled piping system, which confine the gas during normal operations, are designed to NPH Performance Category 2 requirements. The following topics have been reviewed and discussed extensively with TEF project representatives from the DOE Savannah River Operations Office and Westinghouse Savannah River Company (WSRC).

Adequacy of Designed Controls—WSRC has several manuals and procedures for the identification of hazards, the necessary controls, and the appropriate functional classification of these controls. Examples are the Conduct of Engineering and Technical Support Manual (known as E7) and the Functional Classification Methodology Manuals. The process prescribed in these manuals and procedures has been presented to the Board in the past; applied to some facilities, such as the Consolidated Tritium Facilities; and acknowledged by the Board as a reasonable application of the defense-in-depth concept. The Board's staff, however, observed in May 1999 that the WSRC approach was not implemented consistently at the TEF project for identification of the hierarchy of controls with appropriate functional classification. Several examples were identified where the preliminary design of TEF relied heavily on administrative controls and operator action as the primary line of defense to prevent or mitigate accidents. Although most of these administrative controls are backed by defense-in-depth systems for additional protection, some are the only layer of control identified to date. At the completion of the preliminary design phase of the TEF project, the Board's staff expected to find a more consistent emphasis on designing against the identified hazards instead of relying on operator action to prevent them.

This issue of applying the proper hierarchy of controls and defense-in-depth, as demonstrated for the Consolidated Tritium Facilities, has been discussed with project personnel, and some effort is being made to consider the suggestions of the Board's staff in the final design of TEF. The following are examples of proposed design features that, if implemented, would enhance safety by improving the reliability of the controls and providing additional defense-in-depth without a significant impact on the project cost and schedule:

- Potential operational accidents caused by moving the crane over an operating furnace are prevented by administrative controls. These scenarios could more effectively be avoided by a simple interlock on the crane motor when the furnace is operating. (During a meeting on October 18, 1999, project personnel stated that this suggestion of the Board's staff would be considered for implementation in the final design.)

- The Preliminary Safety Analysis Report (PSAR) assumes that one furnace operates at a time. The administrative control to support the PSAR assumption could be replaced with a designed interlock to avoid accidental operation of more than one furnace at a time.

- The design process hazards review identified a potential for exposure of workers to high levels of radiation if the shield doors should be inadvertently opened when cask or truck bay areas are occupied. Identification of radiation monitors and alarms to protect the workers was recommended. The control identified in the PSAR is limited to operator training and does not include implementation of any design features to protect workers.

- To compensate for the lack of a confinement system during a seismic event (as discussed below) and provide protection for workers, the project relies on operators being trained to evacuate the building immediately after the initiation of a seismic event has been sensed. An alarm system triggered by an earthquake monitor could be installed to ensure timely evacuation and prevent exposure of workers to hazardous materials.[1]

- The PSAR relies on administrative controls on the inventory of hazardous materials that is at risk for a small fire and the program for control of combustible materials to prevent such small fires from expanding to larger ones. Although the building's fire sprinkler system is designed for defense-in-depth, existing fire barriers could be seismically designed to compartmentalize the building and reduce the potential for a small fire to expand after an earthquake.

- Administrative controls are identified to protect the design parameters. For example, the design pressure of the product tanks is protected by an administrative control during normal operation, instead of a design feature such as a pressure control and alarm system with an appropriate functional classification.

Additionally, several systems, such as the ventilation system, are identified in the PSAR as necessary for worker protection. The design is proceeding with these systems categorized as non-safety-significant. The technical justification for their functional classification is not clear at this time. The attachment to this report lists several other observations made by the Board's staff that require further review of the TEF project.

Design Confinement Capabilities—DOE Order 420.1, *Facility Safety*, which establishes the design requirements for new defense nuclear facilities, requires confinement of hazardous material in a system that can withstand the effects of natural phenomena. For a specific nuclear facility, the Order allows the number and arrangement of the confinement system elements to be determined on a case-by-case basis and their adequacy to be demonstrated in the Safety Analysis Reports.

The confinement system identified in the PSAR for the TEF project consists of the gloveboxes, modules, and double-walled piping system. However, these systems are designed to Performance Category 2 requirements, and therefore do not provide confinement during a design basis seismic event. The PSAR shows the consequences of a seismic event to be small enough that this design approach may not result in a significant risk to the public and workers. A realistic dose calculation of the consequences to the public and workers shows these values to be

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[1] Installation of such a seismic detector and alarm system needs to be evaluated as a means of enhancing worker safety at other nuclear facilities.

of the order of a few rem. TEF project personnel believe such small consequences do not merit the significant additional cost of upgrading the confinement system to Performance Category 3 to meet the seismic requirements.[2]

There are, however, some passive design modifications that could be made to improve the reliability of the confinement system without significant impact on the project cost and schedule. For example, the seismic design of the anchorage and supports for the confinement system could be improved to reduce their vulnerability to an earthquake.

Design and Procurement Requirements—The structures, systems, and components (SSCs) identified in the PSAR are categorized as safety-significant, non-safety-significant defense-in-depth, production support, and general services. The flowdown of the design and procurement requirements from DOE and industry standards, through WSRC site manuals and practices, to the project systems and components is not clear at this time. The Board's staff will continue reviewing site manuals and procedures and the TEF project System Design Description documents to ensure that safety systems are designed to appropriate requirements, codes, and standards.

Civil and Structural Design Requirements—The final design of structures is based on WSRC Engineering Standard 01060, *Structural Design Criteria*, Revision 4. This revision incorporates several conservative enhancements to ensure the targeted performance of SSCs, particularly for Performance Category 3. Specifically, requirements for seismic ductile detailing, which significantly enhance the reliability of structures subjected to earthquake loads and which are stipulated in building codes only for regions of high seismic activity, have been incorporated. A multiplication factor of 1.2 is applied to seismic loads on structures and to estimates of dynamic settlement that will be imposed on structures at their most vulnerable configurations. The TEF site has been characterized extensively through an adequate number of bore holes, seismic soundings, and laboratory tests of soil samples. For the design of systems and components, a multiplication factor of 1.2 is also incorporated at the floor spectra level.

The Board's staff believes that the seismic design of this facility is being adequately performed by competent and experienced teams of designers equipped with state-of-the-art analytical capabilities.

The design spectrum being used for the design of the exterior structures is based on site characteristics and regional seismicity. This spectrum and its technical bases along with actions to increase seismic safety margin have been transmitted to the Board[3] and are currently under review by the Board's staff to determine their adequacy for TEF and other defense nuclear facility projects at SRS, in general.

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[2] While the TEF project approach to designing a confinement system may not result in severe radiological consequences, the Board's staff believes it should not be considered a standard practice for the design of new nuclear facilities.

[3] Letters from G. Rudy, Manager, DOE Savannah River Operations Office, to J. T. Conway, Chairman, Defense Nuclear Facilities Safety Board, dated October 29, 1999, and November 12, 1999.

Attachment

Staff Observations on TEF Design Adequacy

1. Water Spray on Electrical Equipment by Fire Suppression System

The fire suppression system in the Remote Handling Area includes water sprinklers. Any spurious activation of fire sprinklers could potentially disable the crane power supply, control systems, or instrumentation. Special precautions may also be needed to protect electrical equipment and the process computers in the control room from water damage due to operation of the fire sprinklers. Other areas that include water sprinklers should also be evaluated for any potential impact on electrical and electronic components.

2. Tritium Air Monitoring Systems

Room air tritium monitors and alarms are classified as safety-significant systems. Loss of the monitoring system requires operator evacuation. The monitors rely on a blower that continuously draws air through a filter, a rotameter, and a Kanne ionization chamber. Because the blowers are powered from a different supply than the monitors, it may be possible to lose the blowers without losing the monitors. It was not clear to the staff that loss of the blowers would be immediately noticed through an alarm or other means and that operators would take appropriate action. This potential vulnerability (undetected loss of monitoring capability) may be corrected by powering the blowers from the same uniterruptible power supply that powers the monitors.

3. Cables in High Radiation Areas

It appears that several power, control, and instrumentation cables will be routed through high-radiation areas. Typically, commercial nuclear power plants use class 1E cables qualified to IEEE-383 and -1202 that can withstand high radiation exposures. The cables at TEF may be exposed to even higher levels of radiation than those encountered in nuclear power plants, and could experience embrittlement of insulation and jacket materials. The result could be failure of the cables. Specific conservative design criteria may be necessary to design, procure, and install these cables. Additionally, the TEF project needs to consider implementation of a cable condition monitoring program, similar to that of the Defense Waste Processing Facility, to monitor the cable degradation using Electrical Characteristics and Diagnostics or an equivalent system.

4. Surface Contamination of TPBARs

Table 1 of the Hazard Assessment Document, S-HAD-00011, Rev. 3, details the radiological inventory of TPBARs. The contribution from radioisotopes found in the light water reactor coolant (e.g. cesium 134 and 137, very common isotopes in a reactor coolant) is not identified. The TEF project needs to consider the potential contribution from the reactor coolant contaminants in the radioactive inventory source term used in the hazards assessments. Particular attention needs to be paid to those isotopes that may become volatile (e.g., in the furnace) and transported or collected on filters or cool surfaces.

5. Habitability of Control Areas

There are two aspects of the habitability of control areas. The first concerns upset conditions within the TEF itself, and the second concerns upsets at other H-area facilities. The latter concern does not appear to have been thoroughly considered in the proposed design of the TEF control areas.

6. Inadvertent Mixing of Fuel Rods with TPBARs

The TEF hazard analysis assumes that fuel rods are not inadvertently mixed with TPBARs following removal from the reactor and subsequent processing at TEF. Such inadvertent mixing would significantly increase the radiation source term and resultant consequence at TEF. A positive design feature or other means could be incorporated to preclude this condition.

7. Safety Instrumentation and Control Design

The design of the safety-significant control systems appears to be based on applicable chemical and process industry standards. By adhering closely to these standards, designers may avoid many of the problems encountered at other DOE facilities in the past. Such issues as maintaining independence of control equipment from safety shutdown equipment should be stressed during the design. Applicability of ISA Standard S84.01, *Application of Safety Instrumented Systems for the Process Industries*, should be considered.