UNITED STATES
NUCLEAR REGULATORY COMMISSION
ADVISORY COMMITTEE ON REACTOR SAFEGUARDS
WASHINGTON, DC 20555 - 0001

February 24, 2005

The Honorable Nils J. Diaz
Chairman
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555-0001

SUBJECT: REVIEW OF THE FINAL SAFETY EVALUATION REPORT FOR THE MIXED OXIDE FUEL FABRICATION FACILITY CONSTRUCTION AUTHORIZATION REQUEST

Dear Chairman Diaz:

During the 519th meeting of the Advisory Committee on Reactor Safeguards (ACRS), February 10-11, 2005, we met with representatives of the NRC staff and a representative of the Union of Concerned Scientists to discuss the Final Safety Evaluation Report for the Mixed Oxide (MOX) Fuel Fabrication Facility (MF^3) Construction Authorization Request submitted by Duke Cogema Stone & Webster (DCS) on February 28, 2001. Our review focused on safety issues and did not include questions of materials accountability and control or physical protection issues. We were joined in our reviews of this Final Safety Evaluation Report by members of the Advisory Committee on Nuclear Waste. This matter was also discussed with representatives of DCS and the NRC staff during the 504th and 507th meetings of the ACRS on July 9-11 and November 6-8, 2003, respectively, and at meetings held by the Reactor Fuels subcommittee on November 16, 2001, April 10, 2002, April 21, 2003, and December 15-16, 2004, as the Department of Energy's design requirements for the facility evolved. We also had the benefit of the documents referenced.

CONCLUSION AND RECOMMENDATION

The information from DCS on the safety of construction, maintenance, and operation of the Mixed Oxide Fuel Fabrication Facility at the Savannah River Site provides sufficient assurance to proceed with construction and an integrated safety analysis. The Final Safety Evaluation Report for the Mixed Oxide Fuel Fabrication Facility Construction Authorization Request should be issued.

BACKGROUND

The Mixed Oxide Fuel Fabrication Facility, MF^3, is to manufacture mixed oxide (plutonium dioxide - uranium dioxide) reactor fuel for use in the Catawba and McGuire commercial nuclear power reactors. The facility is being developed as part of the national strategy to dispose of excess weapons-grade plutonium (predominantly ^{239}Pu) by using this plutonium for power production. MF^3 will be located on the Department of Energy's Savannah River Site near Augusta, Georgia, and Aiken, South Carolina.

The MF^3 will receive slightly contaminated, weapons-grade plutonium dioxide and other feeds from a Department of Energy facility to be built on the Savannah River Site. At MF^3, this plutonium dioxide will be dissolved, purified by solvent extraction, precipitated, converted back to plutonium dioxide, and blended to yield a solid solution with uranium dioxide. The solid solution will be further blended with uranium dioxide and formed into reactor fuel pellets and eventually zirconium-clad fuel rods and assemblies. The facility design for these operations is patterned after a facility operated for many years in France to perform similar activities with reactor-grade plutonium dioxide. Contaminated wastes produced by MF^3 will be returned to the Department of Energy at the Savannah River Site.

Prior to construction of MF^3, the applicant, DCS, must obtain NRC approval (10 CFR Part 70.23(b)). The approval process for the facility involves two major steps. The applicant is now engaged in the first step which is to yield a construction permit. The applicant will later have to request a license to possess and utilize special nuclear materials. For this first step, the applicant is required to submit:

- a description of the facility site
- a description and safety assessment of the design bases of the principal structures, systems, and components of the facility
- a description of the provisions for protection against natural phenomena
- a description of the quality assurance program to be applied to the design, fabrication, construction, testing, and operation of the facility

The safety assessment of the design bases provides the rationale for the selection of functions or values and demonstrates that the design bases will provide reasonable assurance that the facility can withstand natural phenomena and the consequences of possible accidents.

A detailed quantitative analysis of the facility safety in an Integrated Safety Analysis (ISA) is not required in this first step of the approval process.

FACILITY LOCATION

MF^3 will be located on the well characterized Savannah River Site. Many other Department of Energy nuclear facilities are located on this site and perform functions similar to the functions of MF^3. Seismic hazards and other natural phenomena at the site have been extensively studied. The applicant has incorporated the current understanding into the MF^3 site characterization, and the Final Safety Evaluation Report provides a thorough, competent review of this material.

An important feature of the Savannah River Site is its isolation from what is ordinarily considered the public. However, the boundary for MF^3 is designated to be coincident with the controlled area boundary of the facility, not with the boundary of the Savannah River Site. The workforce at the Savannah River Site, but not associated with MF^3 is, therefore, considered part of the public, and thus there is no longer a large separation between the public and nuclear facilities on the Savannah River Site. The applicable regulations (10 CFR 70.22(i)) require emergency plans only if the maximum dose to a member of the public is expected to exceed 1-rem. The applicant expects to demonstrate that the 1-rem exposure limit will not be exceeded as a result of an accident at MF^3 and does not intend to prepare an emergency plan that requires offsite response capability and preplanning for actions to protect members of the public. Alternatively, the applicant will establish an evacuation plan for the facility and a protocol with the Department of Energy to integrate this plan with current emergency response plans at the Savannah River Site. The applicant concludes that no special controls or principal structures, systems, and components are required to protect workers at MF^3 beyond those that have been identified for control of radioactive and chemical material releases. The staff accepts this conclusion at this stage of the approval process and will examine the details of the protocol in the second stage of the approval process.

We agree with the staff that examination of the details of the emergency response plans can be deferred to the second stage. We do identify some areas of concern that should be addressed at that time. The distance from a point of release of radioactive or hazardous chemical material from MF^3 in the event of an accident to a point outside the boundary of the MF^3 controlled area is small. Should there be an accident at MF^3, it is imperative that emergency actions to protect all personnel be undertaken quickly and effectively. A Memorandum of Understanding with the Department of Energy at Savannah River is necessary but not sufficient to assure this prompt response will occur. The applicant should also develop an emergency response plan for the protection of workers. The plan should include pre-planning of emergency actions, the development of emergency procedures, training of personnel, clearly defined management responsibilities, and clearly defined lines of communication.

SAFETY ASSESSMENT

The technological bases for the MF^3 are well known. We concur with the staff's conclusions that:

- The design bases of the principal structures, systems, and components of MF^3 provide reasonable assurance of protection against natural phenomena and operational accidents.
- DCS has adequately addressed baseline design criteria.
- The proposed facility design is based on defense-in-depth practices.

Though there is some potential for the release of hazardous chemicals, the dominant hazard posed by the facility is the dispersal of plutonium or other radioactive elements. The facility is designed with nested zones so that leakage is always inward. Minor releases of radioactive materials are filtered through double High Efficiency Particulate Absorbers (HEPA filters). The principal mechanisms for substantial dispersal of radioactive materials are criticality events, explosions, and fires. The applicant has addressed the issues of criticality safety in about 80 criticality control units following well-established standards including the requirements of 10 CFR Part 70 and the ANSI/ANS-8 standard. The staff has done an exhaustive review of the applicant's submission and has done independent analysis of specific technical items. We concur with the staff's conclusion that the applicant has established an adequate organization to deal with a nuclear criticality safety program, has developed appropriate design features for the facility, and has the means to assure nuclear criticality safety.

Fire hazards at the facility are significant. There are several thousand kilograms of hydrocarbons (nominally kerosene) which are used as solvents in the solvent extraction processes. Hydrogen is used for stoichiometry control in the mixed oxide fuel fabrication. Reactive materials such as hydroxylamine nitrate are used in the process chemistry. Notably, the processes could produce inadvertently the explosive “red oil” in its acid recovery and evaporation processes.

Red oil, which is not really an oil and may not be red, is a poorly understood hydrolysis product that has caused damage at plutonium purification facilities operated by the Department of Energy and by others in the world. MF^3 can produce red oil in both the “open” and “closed” geometries used at the facility. There is insufficient knowledge to allow red oil and its reactions to be modeled theoretically to determine conditions that avoid explosive reactions. The applicant is undertaking a research program to assess the kinetics of red oil formation and reaction, but significant results are unlikely to be available before design decisions must be made. Therefore, the applicant must rely on the empirical experience with red oil formation and combustion. For the open geometries, DCS has adopted safety standards developed by the Department of Energy. Similar standards are not available for the closed systems. The applicant claims that sufficiently large vents and provision for quenching can be used to control temperatures below 125 °C, which will prevent runaway reactions. The applicant’s technical bases for these conclusions are not clear to us. By the second stage in the approval process, the staff needs to develop adequate confidence that the applicant’s control strategy for closed systems can indeed prevent runaway reactions under reasonably conceivable transient conditions.

A similar situation arises in connection with the applicant’s plans for dealing with autocatalytic decomposition of hydroxylamine nitrate, though there is a much better understanding of the detailed kinetics of the pertinent reactions. In cases without nitrogen oxides, the applicant proposes to control temperature and concentrations. The detailed bases for the limits and the staff verification of the associated margins need to be better elucidated. In cases with nitrogen oxides, the applicant has proposed limitations on the concentrations. A large exhaust path is provided to prevent overpressurization. The staff has accepted these design provisions as “Reasonably and Generally Accepted Good Engineering Practices.” A more quantitative evaluation of the engineering margins should be provided in the second stage of the approval process.

Fires in moderation-controlled spaces of plutonium facilities have long been a major concern at reactor fuel fabrication facilities. The use of water to suppress fires may initiate a criticality event. Operating experience has shown that fires suppressed by alternative agents (sometimes called “clean agents”), but not cooled, can reignite when air is readmitted. In the second stage of the approval process for MF^3, the applicant should demonstrate that in moderation-controlled spaces with limited amounts of combustible materials, post-fire cooling by conduction and thermal radiation is sufficient to prevent re-ignition. For moderation-controlled spaces with large amounts of combustible materials, the applicant should demonstrate that post-fire cooling can be achieved under adverse conditions. Manually-controlled systems using limited water quantities sprayed from installed nozzles should be considered during the ISA phase.

WASTE HANDLING

MF^3 will return waste to the Department of Energy. The facility to receive this waste at the Savannah River site has not been designed, nor have the waste acceptance criteria been established. This raises the possibility that additional unit operations will have to be added to MF^3. Perhaps of more importance, the possibility of unplanned interruptions in waste receipt by the Department of Energy needs to be considered in the integrated safety analysis of the MF^3 design. It will be necessary to conduct operations at MF^3 in a way that assures there is always sufficient waste storage capacity to bring the facility to a safe configuration in the event that waste receipt is interrupted. A protracted hiatus in waste receipt would raise issues of waste aging within MF^3. Experience has shown chemical evolutions brought on by evaporation, radiolysis, and other chemical processes can lead to the formation of hazardous chemicals or conditions in wastes awaiting transport to the Department of Energy. Measures to mitigate any hazards posed by aging wastes need to be addressed in the safety analyses for the final stage of the authorization process for MF^3 for timeframes of short, intermediate, and long duration.

In conclusion, the NRC staff has prepared a wide-ranging, technically competent Final Safety Evaluation Report on the construction authorization request for MF^3. This Final Safety Evaluation Report should be issued.

Sincerely,

/RA/

Graham B. Wallis
Chairman

REFERENCES

1. Draft Final Safety Evaluation Report on the Construction Authorization Request for the Mixed Oxide Fuel Fabrication Facility at the Savannah River Site, South Carolina, December 2004 (as revised February 2, 2005).
2. Draft Safety Evaluation Report on the Construction Authorization Request for the Mixed Oxide Fuel Fabrication Facility at the Savannah River Site, South Carolina, Revision 1, April 2003.
3. U.S. Nuclear Regulatory Commission, Document control Desk, from Peter Hastings, Duke Cogema Stone & Webster, Subject: Mixed Oxide Fuel Fabrication Facility Construction Authorization Request Revised, Duke Cogema Stone & Webster, October 31, 2002.
4. U.S. Nuclear Regulatory Commission, Document Control Desk, from Peter Hastings, Duke Cogema Stone & Webster, Subject: Mixed Oxide Fuel Fabrication Facility Construction Authorization Request, Duke Cogema Stone & Webster, February 28, 2001.

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5. Letter to Mr. Peter Hastings, Duke Cogema Stone & Webster, from Andrew Persinko, NRC Subject: June 2003 Monthly Open Item Status Report, July 8, 2003.
6. DOE-STD-1022-94, Natural Phenomena Hazards Characterization Criteria, U.S. Department of Energy, Washington, DC, 1995.
7. Draft Environmental Impact Statement , U.S. Nuclear Regulatory Commission, February 28, 2003.
8. U.S. Nuclear Regulatory Commission, Document Control Desk, from Peter Hastings, Duke Cogema Stone & Webster, Subject: Update to Mixed Oxide Fuel Fabrication Facility Environmental Report Revisions 1 & 2, December 10, 2002.