DEFENSE NUCLEAR FACILITIES SAFETY BOARD

May 19, 1994

MEMORANDUM FOR: G. W. Cunningham, Technical Director

COPIES: Board Members

FROM: J. T. Arcano, Jr.

SUBJECT: Review of Facilities and Unirradiated Fuel Storage at the Reactor Materials Area of the Savannah River Site, March - April 1994

1. **Purpose:** This memorandum describes the observations of Defense Nuclear Facilities Safety Board (DNFSB) staff during a review of facilities and unirradiated fuel storage at the Reactor Materials Area (M-Area) of the Savannah River Site (SRS). A walk-through of the M-Area facilities was conducted on March 31, 1994, followed by briefings from the Department of Energy Savannah River Operations Office (DOE-SR) and Westinghouse Savannah River Company (WSRC) and another walk-through between April 19-21, 1994. The review was conducted by DNFSB staff members J. Arcano, Jr., J. Blackman, A. DeLaPaz, P. Gubanc, and R. Schapira.

2. **Summary**

Safety issues stemming from a review of the planned storage of unirradiated fuel at K-Reactor prompted a DNFSB staff tour of Building 321-M on March 5, 1994. During this tour, numerous fuel rods and assemblies stored on hand-carts (dollies) were seen, while a large number of storage positions in a nearby borated concrete storage rack were vacant, raising concerns for the adequacy of criticality safety within M-Area. These concerns prompted additional building tours and subsequent reviews of M-Area safety analyses, the status of M-Area authorization basis documentation, and an Unreviewed Safety Question Determination (USQD) which had originally been found positive by WSRC (based upon their inability to verify the adequacy of existing structural analyses of Building 321-M) but was subsequently determined by DOE-SR to be negative. DOE-SR's determination was based on a broad interpretation of DOE Order 5480.21 and is an example of over reliance on probabilistic methods without considering the prudency of using deterministic principles involved with the development of defense-in-depth concepts. This issue is further elaborated in an April 29, 1994 letter from the DNFSB Chairman to The Honorable Charles B. Curtis, Under Secretary of the Department of Energy.

During the April 1994 DNFSB staff tour of Building 321-M, only one fuel rod was stored on a dolly (because it could not fit into the borated concrete rack). WSRC had

also issued a standing order limiting the amount of fuel storage on dollies and the number of dollies on which fuel is loaded. Issues of concern to DNFSB staff include the following:

a. The approval process for updated authorization basis documentation for M-Area has progressed very slowly and it is conceivable that if the pace is not hastened, the documentation might not be approved prior to completion of the de-inventory operations currently in progress.

b. An emergency response procedure to secure the building water supply within one hour after a natural disaster to assure criticality safety has not been fully demonstrated by WSRC.

c. Various radiological control discrepancies were noted in and around the Building 321-M Furnace Casting Room.

The enclosed Attachment contains an overview of M-Area facilities, and a more detailed description of Building 321-M.

3. Background

As a result of issues raised regarding the safety of the planned storage of unirradiated fuel at K-Reactor, a DNFSB staff member toured Building 321-M on March 5, 1994 and discovered numerous fuel rods and assemblies stored on hand-carts (dollies). Fuel had been removed from the uppermost row and outermost columns of the building's borated concrete fuel storage racks in response to a structural evaluation of the racks which questioned their integrity under tornado wind loads. No limit existed for the total number of fuel elements allowed in Building 321-M and there was no limit on the total number of fuel elements allowed out of the borated concrete racks or in-process in the building at any time.

DOE-EH Nuclear Safety Site Representatives had surveyed M-Area in October 1993 for conduct of operations issues, and in March 1994 for radiological controls issues. However, no criticality concerns had been noted.

Unirradiated fuel is currently being stored at the K-Reactor, the L-Reactor, and M-Area. DOE-SR intends to start transferring fuel from L-Reactor to the K-Reactor and M-Area facilities by May 1994.

4. Discussion:

a. Unirradiated Fuel Storage: At the time of the DNFSB staff tour of Building 321-M on March 31, 1994, only six fuel tubes were being stored outside of the borated concrete storage racks. WSRC had performed a USQD showing that natural phenomenon-induced criticality accidents in the racks were incredible (less than 10^{-6} occurrences per year), and had returned the previously removed fuel to the periphery of the borated concrete storage racks.

During the April, 1994 DNFSB staff review, only one fuel tube was being stored on a dolly. As a result of questions raised by DNFSB staff regarding the safety adequacy of fuel storage on dollies, WSRC issued a standing order for Building 321-M which limits fuel storage on dollies to four fuel tubes per dolly, and also limits the number of dollies on which fuel is loaded to ten. The number of tubes and dollies allowed has been determined based on operational considerations. The staff noted that the number of dollies upon which fuel can be stored is not adequately controlled since greater than ten carts currently have Nuclear Safety Emblem (NSE) tags which allow fuel to be placed on them.

During a May 12, 1994 tour of M-Area, the DNFSB staff was advised that nuclear safety emblems had been removed from all but the 10 dollies currently in use at Building 321-M. WSRC reiterated their position that the Safety Analysis Report (SAR) permits fuel storage on dollies and that administrative limits on fuel storage on dollies are not required; standing order limits are being implemented as a "best management practice." WSRC also stated that their standing order limits can be modified or removed at the facility manager's discretion without concurrence or approval by DOE-SR since fuel storage on dollies is permitted by the SAR.

WSRC presented preliminary results of natural phenomenon-initiated criticality events at Building 321-M related to storage of fuel tubes in both the borated concrete racks and on the tube dollies. In both cases, the accident sequences had probabilities of occurrence well below the threshold of credibility (10^{-6} per year). These accident analyses assume that a criticality accident would produce 5×10^{17} fissions as opposed to 1×10^{19} fissions, prescribed by Nuclear Regulatory Commission Regulatory Guide 3.34, *Assumptions Used for Evaluating the Potential Radiological Consequences of Accidental Nuclear Criticality in a Uranium Fuel Fabrication Plant*. WSRC personnel stated that justification for the lower number of fissions requires demonstrating that a criticality accident in Building 321-M would be self-limiting. DNFSB staff will review the accident analysis results when they are completed and approved by DOE-SR.

b. Safety Authorization Basis: The current DOE-approved authorization basis for M-Area include the 1987 Building 321-M SAR and the 1988 Operational Safety Requirements (OSR) for Building 321-M. A WSRC plan to generate an M-Area Justification for Continued Operation (JCO), in lieu of a revision to the SAR, was accepted by DOE-SR in December 1992. This cost-saving action to generate a JCO was considered a compensatory measure as part of an exemption request from DOE Order 5480.21, *Technical Safety Requirements*, and DOE Order 5480.23, *Nuclear Safety Analysis Reports*.

In July 1993, WSRC submitted the M-Area JCO to DOE-SR for review and approval after which a period of discussion and comment has ensued. Because a Basis for Interim Operation (BIO) is required by DOE Order 5480.23 to be submitted with the SAR upgrade plan and schedule, it became evident to DOE that the elements of a BIO are required in a JCO in order to approve the JCO and exemption requests for M-Area facilities. Therefore, in March 1994, DOE-SR tasked WSRC to compare the JCO against the draft DOE BIO guidance, draft DOE Standard *Guidance for Preparation of DOE 5480.22 (TSR) and DOE 5480.23 Implementation Plans*. WSRC plans to resolve the additional DOE-SR comments, complete the BIO comparison, and formally transmit this information to DOE-SR in May 1994.

According to DOE-SR, the path forward will be to task WSRC to prepare an addendum to the JCO which identifies areas which were highlighted by the JCO/BIO comparison as missing from the JCO. The most significant item missing from the JCO appears to be a Preliminary Hazards Analysis (PHA) for all M-Area facilities. DOE-SR intends to make the case to DOE headquarters that the JCO provides the substantive information required by a PHA and that the cost involved to create a PHA is not justified. Other areas required for a BIO which are lacking in the JCO include: discussion of the operational history and occurrences, and a discussion of compliance schedule agreements for Order compliance at M-Area facilities.

DOE-SR estimated that the JCO would be submitted by WSRC to DOE-SR in May 1994, and forwarded to DOE headquarters by June 1, 1994. DOE-DP headquarters line management estimates that their review of the JCO will take about two months.

Throughout the lengthy and iterative JCO review process, Building 321-M and other M-Area facilities have continued to operate, albeit in a de-inventory mode, for almost one year under a SAR and OSR which only address Building 321-M. It is anticipated that the current de-inventory campaign will complete near the end of calendar year 1994. However, if it is decided to also de-inventory the Mark 22 charges currently being stored in K Reactor facilities, de-inventory operations

could last up until the end of calendar year 1995. Thus, at the rate at which the JCO approval process is progressing, it is conceivable that DOE approval including headquarters will not be attained before de-inventory operations have completed. The DNFSB staff believes the DOE-SR JCO approval process needs improvement to make it more timely in establishing authorization basis documentation for the M-Area facilities.

c. USQ Status and Ten Compensatory Actions: When the original M-Area JCO was submitted to DOE-SR in July 1993, WSRC completed an Unreviewed Safety Question Determination (USQD) for the upgraded analysis. The USQD was determined by WSRC to be positive based upon WSRC's inability to verify the adequacy of existing structural analyses of Building 321-M following various natural phenomena events. This led to a revision of the probabilities for several natural phenomena-induced criticality events. Along with the positive USQD, WSRC identified ten interim actions to reduce the likelihood of such a criticality accident. These actions included: maximizing the use of the borated-concrete storage racks; relocating cans containing loose scrap metal to a storage room which afforded additional structural protection by the room's steel walls; issuance of an emergency procedure to secure the building water supply within one hour in response to certain natural disasters; and storing floor sweepings from de-inventory casting operations in sealed cans to reduce the potential for dispersion of the fissile material in flood water.

In December 1993, WSRC was informed that DOE-SR had determined that the USQD was not positive and that only three of the ten interim actions should be maintained. WSRC, however, had implemented most of the other interim actions and intends to keep them in place as good management practice. The DNFSB staff believes that additional actions are warranted with regard to the emergency procedure for securing the building water supply. Specifically, WSRC stated that the procedural steps to secure water to the building were demonstrated the week previous to the April DNFSB staff review and that all shifts would be trained in the procedure by April 22. However, the practicality of the M-Area-wide emergency response actions, particularly on back shift, has not been reviewed or demonstrated for M-Area by WSRC.

DOE-SR's rejection of the positive USQD was based on NE-70 guidance provided in a memorandum dated December 1992: "The term inadequate safety analysis as used throughout DOE 5480.21 should be interpreted to refer only to those situations in which the safety analysis supporting the current/interim authorization basis is found not to be bounding." DOE-SR has interpreted the "bounding" accidents to include all Building 321-M accident events which were analyzed, not limited to the subset of natural phenomena-induced criticality events. This interpretation may allow degradation of defense-in-depth without

any further action required to determine the potential impact resulting from the increased probability of building structural failure as a result of natural occurrences. This is an example of overreliance on probabilistic methods without considering the prudency of using deterministic principles involved with the development of defense-in-depth concepts. This issue is further elaborated in an April 29, 1994 letter from the DNFSB Chairman to The Honorable Charles B. Curtis, Under Secretary of the Department of Energy.

d. Radiological Controls: During DNFSB tours in and around the Building 321-M Furnace Casting Room (a High Contamination and Airborne Area), several radiological control discrepancies were noted including: donning instructions not posted; undressing instructions not posted where required; and lack of a buffer zone between the High Contamination/Airborne Area and the Radiologically Controlled Area where various items are routinely passed across the boundaries. WSRC has taken corrective actions to post donning and undressing procedures, and to establish a buffer zone just outside of the High Contamination/Airborne Area.

5. **Future Staff Action**: The DNFSB staff will:

a. Continue to monitor WSRC and DOE efforts to approve the JCO for M-Area.

b. Review Building 321-M safety analysis calculations for natural phenomenon-induced criticality events, once completed and approved.

c. Review the verification of emergency actions in response to natural disasters at Building 321-M.

d. Continue to monitor radiological control practices in the Building 321-M High Contamination Area.

Description of M-Area Facilities

The Reactor Materials Area (300 M-Area) is located adjacent to the Savannah River main administration buildings (700 Area). The primary mission of M-Area was to produce fuel and target assemblies for Savannah River production reactors. Currently, however, most M-Area facilities are in various stages of shutdown, de-inventory, and clean-up. M-Area facilities have been conducting de-inventory operations for almost one year with anticipation that they will be completed near the end of calendar year 1994. However, if it is decided to also de-inventory the Mark 22 charges currently being stored in K Reactor facilities, de-inventory operations could last up until the end of calendar year 1995. The primary de-inventory process is a casting operation which produces ingots from uranium-aluminum scrap and fuel tubes. The ingots are then shipped to the Oak Ridge Y-12 Plant for storage.

M-Area Facilities

Building 321-M, the Fuel Fabrication Facility, previously produced fuel tubes of enriched uranium-aluminum alloy with aluminum cladding. The fuel tubes were assembled into fuel assemblies and used as a fuel to produce ^{238}Pu, ^{239}Pu, ^{254}Cf, and tritium in SRS reactors. Currently, the primary activity in this building is casting chopped-up pieces of excess fuel tubes and pieces of U-Al alloy scrap into ingots to consolidate materials into a form more suitable for transport. Almost all fissile material in M-Area is located in Building 321-M.

The 311-M tank farm consists of two tanks: a nitric acid tank, and a Trichloroethylene (TCE) tank which is no longer used.

The 312-M tank farm tanks have been cleaned and physically disconnected from any process, and are no longer used.

Building 313-M, the slug fabrication process building, produced depleted uranium slugs clad with aluminum for producing plutonium in SRS reactors. However, this process has been discontinued and the facility is currently in cold standby.

Building 316-M, the mixed waste storage shed, contains minimal amounts of fissile material (1.1% enriched uranium) in sludge which resulted from processing Mark 15 fuel assemblies. The sludge is awaiting processing and future vitrification.

Building 320-M was where the alloy fabrication process was conducted for target tubes and control rods (lithium-aluminum alloy cores with aluminum cladding). Fabrication operations have been discontinued and all lithium target tubes have been removed from the facility.

Building 322-M is the Reactor Materials Quality metallurgical and physical testing laboratory

where both fissile and non-fissile materials are metallurgically examined. The building vault was being used to store fissile material in the form of 10 cans of floor sweepings, 3 cans of grinding sludge, and a uranium- aluminum standard. This material is awaiting shipment to Building 321-M for final disposition.

Buildings 330-M and 331-M are warehouses where depleted uranium cores and slugs are stored. Building 331-M is currently storing one box containing several target pieces which contain 1.1% enriched uranium.

Building 340-M, a liquid waste handling facility, is in operation to support Building 322-M and contains residual contamination.

The Liquid Effluent Treatment Facility (LETE) is an industrial waste-water treatment system consisting of three close-coupled treatment facilities: the Dilute Effluent Treatment Facility (DETF), the Chemical Transfer Facility (CTF), and the Interim Treatment/Storage Facility (IT/SF). The DETF treats spent process solutions and low-contamination process effluents from M-Area. CTF operations were discontinued in early 1992, except for the slurry system, which transports filtercake from the DETF to the IT/SF tanks. The IT/SF stores slurried waste awaiting chemical stabilization and solidification for permanent disposal.

Fuel Fabrication Facility (Building 321-M)

Building 321-M, the Fuel Fabrication Facility, is located within one half mile of the SRS main administration buildings (700 Area). This facility has historically manufactured aluminum clad fuel assemblies for the Savannah River Site production reactors.
During the manufacturing process, enriched uranium metal was alloyed with aluminum in concentrations required for reactor irradiation. The alloy was cast into hollow cylindrical ingots from which pre-extrusion billet cores were machined. These cores, encased in aluminum, were then extruded into logs, which were machined into sections, encased in aluminum, and coextruded into tubes. Each tube was then sized, cut to length, and straightened.

Today, the primary mission of Building 321-M is to de-inventory existing scrap and fuel tubes by casting them into ingots suitable for offsite shipment.

Building 321-M was constructed to be a "high resistance" facility, designed to withstand straight winds up to 150 mph, a Fujita Intensity F-3 Tornado (median wind speed of 180 mph), or a Modified Mercalli Intensity VII earthquake (horizontal ground acceleration of 0.1G). Although Building 321-M is of "high resistance" construction, the building is not seismically qualified nor has it been seismically evaluated. Following are descriptions of key areas currently being used in the building:

Assembly Area: During de-inventory operations, existing fuel assemblies are being disassembled in this area. Also within this area, fuel elements are stored in a borated concrete storage rack; in-process fuel is stored on hand carts (dollies) in this area.

The borated concrete storage rack consists of stacks of concrete slabs. Each individual slab is 8 inches high x 6 feet wide x 13.5 feet deep and has 9 polyvinyl chloride-lined storage holes with 5-inch inside diameters. The racks, capable of storing 1764 fuel tubes and assemblies, are maintained subcritical by at least 0.50 wt.% boron in the concrete. The behavior of the tube storage racks during tornadoes or earthquakes has not been fully evaluated.

Tube cleaning room: Some of the extruded U-Al logs and fuel and target tubes are cleaned in tanks in the tube cleaning room. Seven tanks (a degreaser tank, three cold rinse tanks, a caustic [NaOH] tank, a nitric acid tank, and a hot rinse tank) are available for cleaning.

Machining Area: For de-inventory operations, some logs are cut with the log saw, and fuel tubes are cut into sections to facilitate the casting of defueling ingots.

Casting Area: The casting area produces defueling ingots from U-Al scrap and excess fuel tubes.

Enriched Uranium Storage Vault: The enriched uranium storage vault is constructed of reinforced concrete with walls and roof twelve inches thick. It was constructed as a "maximum resistance" area to withstand a Fujita Intensity Five (F-5) tornado (290 mph) or a Modified Mercalli VIII earthquake (0.2 G) with little or no damage. All fissile material has been removed from the vault.

Safety Systems within Building 321-M include:

- 8 Nuclear Incident Monitor (NIM) systems, designed to activate evacuation alarm bells in the event of a nuclear incident.

- A ventilation system with HEPA filters. Structural analysis of the ventilation system is not available, but estimated to be capable of withstanding a Fujita Intensity 3 tornado or a Modified Mercalli VII earthquake.

- Two fire protection systems. The process computer room and the pit under the extrusion press are equipped with automatic total flooding Halon-type fire suppression equipment. Halon-type manual fire extinguishers (40 total) are used for fire suppression in all other facility locations. The use of water in regulated areas is prohibited to reduce the hazards and risks of a nuclear criticality incident.