Department of Energy
Savannah River Operations Office
P.O. Box A
Aiken, South Carolina 29802

JUL 21 1998

The Honorable John T. Conway
Chairman
Defense Nuclear Facilities Safety Board
625 Indiana Avenue, NW, Suite 700
Washington, DC 20004

Dear Mr. Chairman:

SUBJECT: Margin of Seismic Safety for Postulated Seismic Events

Over the past few years our staffs have worked closely together on a number of seismic-related issues concerning Department of Energy (DOE) facilities. Most recently, discussions and meetings have focused on the degree of seismic safety conservatism in new facilities at Savannah River Site (SRS) and in particular, over the past several months, regarding the Actinide Packaging and Storage Facility (APSF).

The purpose of this letter is to describe (1) the SRS approach for establishment of seismic safety margin for new SRS facility designs, (2) the SRS plan for demonstrating the APSF seismic safety margins, and (3) the current status of issue resolution on SRS seismic ground motion development.

Enclosure 1 describes our approach to increase seismic safety margins above those required in current DOE standards for new SRS facility designs (including new moderate and high hazard facilities yet to be designed or constructed). We believe this approach is consistent with the philosophy of the Defense Nuclear Facilities Safety Board (DNFSB) and will provide assurance that substantial additional seismic safety margins are present in the capacity of new facilities at SRS. Enclosure 1 also describes how the current APSF design is comparable in seismic safety margin to that which will be achieved for new SRS facilities by this approach.

Enclosure 2 describes our specific plan for evaluating the present APSF design to demonstrate the extent of existing seismic margin relative to the design basis codes and standards. This plan is the product of extensive technical discussions between SRS and DNFSB staff to reach a mutually agreed upon method to demonstrate that appropriate additional seismic safety margins are included in the design of the APSF. While the existing APSF design basis analyses have demonstrated the design exceeds current DOE and national consensus codes and standards requirements, the specific approach to achieving these margins described in Enclosure 1 was not developed in time for the APSF design. Therefore, the verification study described in Enclosure 2 will provide further understanding of the additional seismic safety margins present in the existing design prior

design prior to construction. We have learned several lessons through the course of completing the APSF design and have already incorporated them in the design process for other new facilities.

Enclosure 3 reflects the current status of issue resolution on the SRS seismic ground motion development. The practices used for determining the current SRS seismic design basis motions reflect the current state-of-the-art and SRS has received favorable peer review on this approach. In addition to providing the basis for this approach to the DNFSB staff and consultants, DOE and Westinghouse Savannah River Company (WSRC) staff have had several meetings on this subject with DNFSB staff to respond to questions and provided additional information over the past eight months.

We share the objective of including an appropriate level of conservatism in the seismic design of new facilities. It is important that we now reach closure on the sufficiency of approaches to these issues in order to support Departmental efforts regarding consolidation of certain plutonium inventories and the Department's effort to meet commitment dates made in response to the DNFSB Recommendation 94-1. Prompt closure can help assure we meet our safety objectives up-front and thus minimize redesign and/or construction modifications and schedule delays. We propose to have our site technical experts brief the DNFSB on the enclosed approaches regarding site seismic design and ground motion when the additional APSF seismic verification study is completed by the end of August 1998.

We will contact your staff to set up a convenient time for the briefing. In the interim, questions you or your staff may have may be directed to me or Brent Gutierrez of my staff at (803) 725-3919.

Sincerely,

Greg Rudy
Manager

VC-98-0112

3 Enclosures:
1. SRS Seismic Design Approach
2. APSF Seismic Margin Study
3. SRS Approach on Ground Motion Closure

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ENCLOSURE 1
Savannah River Site Seismic Design Approach

It has been suggested in recent discussions between Savannah River Site (SRS) and Defense Nuclear Facilities Safety Board (DNFSB) representatives, that it might be prudent to incorporate a higher level of seismic safety in new Department of Energy (DOE) facilities at SRS than currently required by DOE and site Standards. The reasons presented were: 1) The DNFSB has not yet concurred with the SRS seismic design spectrum, 2) seismic criteria and analysis methodology has changed over the years, often resulting in higher loads, and 3) additional costs to increase margin of seismic safety during new construction are substantially less than costs to modify the facility later and might be justified from a cost-benefit analysis.

SRS has developed site-specific Performance Category (PC)-3 and PC-4 seismic design ground motion spectra following the guidance in DOE Standard 1023. These spectra are used to develop structural loads for building design following the criteria contained in DOE Standard 1020. By following this process, the structural design will achieve natural phenomena hazard (NPH) performance goals with exceedance probabilities less than 10^{-4} and 10^{-5} per year for PC-3 and PC-4 facilities, respectively. Reducing the NPH performance goal exceedance probability requires increasing the seismic margin of the facility. This can be achieved by increasing the seismic demand, increasing seismic capacity or a combination of the two, which results in an increase in the margin of seismic safety.

In support of our shared objective to be appropriately conservative in the design of new nuclear facilities, DOE-SR agrees that it is prudent to increase the margin of seismic safety of new facilities (structures or segments of structures) to achieve a performance goal of less than 10^{-4} exceedance probability for PC-3 facilities and less than 10^{-5} for PC-4 facilities. Most DOE reactor and non-reactor nuclear facilities are robust structures designed for radiation protection and security so that a reasonable increase in seismic demand or capacity will not significantly change the facility design. However, some minimal increase in reinforcing steel quantities would be expected.

An effective approach to enhance seismic safety margin by increasing the seismic capacity of the structure (or segments of the structure) is to prescribe seismic ductile detailing requirements beyond those required in the DOE Standard 1020 for SRS. The application of ductile detailing requirements of the Uniform Building Code (UBC) for facilities in Seismic Zones 3 and 4, or of American Concrete Institute 318 for regions of high seismic risk, provides a positive means to assure that building structures can resist a seismic ground motion beyond that specified in the current DOE Standards. Depending upon the type of construction, this equates to a scale factor on the seismic loading of up to 1.5. Lower scale factors would apply for shear walls with low aspect ratios. Scale factors of 1.5 apply to frame construction and shear walls with medium to high aspect ratios.

With this in mind, DOE-SR will ensure that a revision is made to the SRS Engineering Standard 01060, Structural Design Criteria, that will increase the capability of new PC-3 and PC-4 facilities (structures or segments of structures) above that required in current DOE standards. Specifically, SRS Engineering Standard 01060 will be modified such that ductile detailing

requirements of UBC for Seismic Zone 3 shall apply for new construction resulting in an increase in the inelastic energy absorbing capacity of the structures. In addition, a load factor of 1.2 shall be included with the seismic load component in the applicable load combinations for the evaluation of structural elements. The use of the DOE Standard 1020 inelastic energy absorption factors (F_μ) for members resisting lateral loads to take account of the increased ductility will be allowed. The standard will remain unchanged for application to existing structures.

The affected facilities are those new facilities neither designed nor constructed (i.e., the Accelerator Production of Tritium (APT), the Tritium Extraction Facility (TEF), and future facilities) with a performance category of 3 or 4. The proposed revision to the site standard will not apply to the Actinide Packaging and Storage Facility (APSF). The APSF design and analysis has incorporated conservatism above that specified in DOE standards for a PC-3 facility. The APSF design has also been thoroughly and independently reviewed by the WSRC Structural Mechanics Section, using both independent verification analyses and direct inspection of the subcontractor's calculations, thus providing SRS assurance in the credibility and conservatism of the structural design to withstand the postulated seismic loading. Conservatism in the APSF design and seismic analysis that is beyond DOE standard requirements are summarized as follows:

1. The buildings are robust shear wall structures that have redundant load paths for lateral loads.
2. Reinforcing steel for floors, roofs, beams and walls is continuous top and bottom throughout the full length of the members and in general is sized for the maximum moment within that length.
3. Reinforcing steel is being detailed to develop its full tensile capacity in both faces providing for ductile behavior.
4. The detailing in the slabs, beams and columns follow the detailing requirements from American Concrete Institute International 349 Appendix C, Section C.4 – "Requirements to Assure Ductility".
5. Floor and roof beams use closed ties for stirrups. Floor and roof beams are not part of the primary lateral load resisting system.
6. The interim seismic design spectrum used as a basis for the APSF seismic loads envelops the current site design spectrum at all frequencies. Over the range of the fundamental frequencies of the PC-3 structures, the interim seismic design spectrum exceeds the site design spectrum by 11 to 40%.
7. The lateral seismic loads in the Material Access Area (MAA) and Auxiliary building were developed using the interim site spectrum input at the basemat elevation, thus discounting lower loading from deconvolution and embedment. The vertical spectrum is the larger of the interim site spectrum or the spectrum from the APSF Soil-Structure Interaction analysis.
8. Twenty-percent margin was added to the weight of the 15 to 17 feet of fill over the MAA and Truck Bay, a load that controls seismic design of those elements. This adds at least

375 psf to the Dead Weight (DW) and at least 525 psf to the load combination consisting of DW + Live Load + Seismic.

9. The ultimate flexural (Limit Load) capacity of the beams, slabs and basemats is at least 20% greater than the calculated capacity due to moment redistribution not accounted for in the design analysis.
10. The lateral dynamic soil pressure was taken as the larger of the enveloping load profile from the soil-structure interaction analysis or the American Society of Civil Engineers 4-86, Seismic Analyses of Safety-Related Nuclear Structures profile.
11. Lateral in-structure response spectra for Structures, Systems and Components design are conservatively taken as twice the interim site spectrum.
12. In several cases enveloping of conservatively developed loads are used when applying the separate unenveloped loads would be appropriately conservative.

The conservatism listed above is consistent with our approach and commitment to add seismic design margin for new facilities (i.e., it provides for a comparable level of conservatism as the above commitment for new facilities not yet designed). While the existing APSF design basis analyses have demonstrated the design exceeds current DOE and national consensus codes and standards requirements, the specific approach to achieving these margins was not prescribed during the development of the APSF design. Therefore, the margin study described in Enclosure 2 will provide further understanding of the additional seismic safety margins present in the existing APSF design prior to construction.

ENCLOSURE 2
Actinide Packaging and Storage Facility (APSF) Seismic Verification Study

The approach described in Enclosure 1 of this letter for new facilities at SRS that are not yet designed will provide a more clearly defined and quantifiable additional seismic safety margin in future SRS building structures. Future SRS projects will incorporate the approach through reference to the site design criteria in SRS Engineering Standards, thereby assuring such margins in the structural design. However, this approach was developed subsequent to the present APSF design and therefore, was not available at the start of design.

As a result of technical discussions between SRS and DNFSB staff regarding the structural capability of the APSF design, SRS and the Staff have agreed that a limited seismic verification study of the APSF would be useful in demonstrating the conservatism of the present APSF structural design. This seismic verification analysis will provide a better understanding of the level of conservatism in the design as well as the conservatism in the in-structure response spectra. Dr. Charles Keilers of the DNFSB staff summarized the results of the joint discussions, which he transmitted to SRS along with a recommended verification spectrum to be used in the study. SRS has reviewed the summary and the Verification Spectrum for use in conducting this limited seismic margin study and has proceeded with the implementation of the study. The Verification Spectrum will be used as input to evaluate locations in the buildings that have margins approaching the limits of the applicable codes and standards and to generate floor response spectra.

The outline of the limited margin study and the SRS plan for conducting this study for the APSF are given below.

1. *The attached spectrum be used to check or challenge the APSF design and generate floor response spectra.*

   The discussions between the DNFSB staff and SRS personnel on Thursday, June 11, 1998, indicated that the focus on using a verification spectrum was primarily for determining the conservatism in the APSF design, particularly with respect to in-structure vertical response spectra. Subsequent comments from the DNFSB suggest that for completeness, the spectra in the horizontal direction also be evaluated. The Verification Spectrum is the starting point to establish the extent to which seismic margin exists relative to the applicable codes and standards.

   SRS will use the DNFSB Verification Spectrum to generate in-structure horizontal and vertical response spectra at the roof elevation of the Auxiliary Building and the roof elevation of the MAA building. The use of this spectrum will require that statistically independent time histories be developed with spectra compatible to the Verification Spectrum. These time histories will be applied to the elevations of the basemat of the structures.

2. *The study can be limited to those portions of the design that are expected to be challenged by the spectra, based on engineering judgment. However, the rationalization for this should be presented.*

   The significant portions of the facility with respect to structural design are the MAA roof and basemat, particularly because these are controlled by out-of-plane shear, which is not a ductile failure mechanism. The roof and basemat design (as well as the static lateral soil pressure on walls) included an overestimate of the weight of soil overburden. Adjusting the overburden weight should compensate for the increased seismic loading for the roof and basemat.

   In the Auxiliary Building the vertical in-structure response spectra at the roof elevation exceed twice the free field spectra due to amplification from the roof slab. This will be addressed in the verification study

3. *The resulting floor response spectra would be compared to those calculated during design. Also, demand-to-capacity ratios would be determined for limiting locations, considering code capacities.*

   The SRS will use existing SSI models to generate horizontal and vertical spectra for the MAA and the Auxiliary Building at selected locations. Demand to capacity (d/c) will be calculated at locations selected based on high demand to capacity ratios from the design basis analysis. These locations are chosen because; 1) they represent non-ductile failure mechanisms and, 2) the d/c ratios in the design basis analysis at the selected locations range from 0.75 to 0.90.

4. *Where code capacity is exceeded using the verification spectrum, the design would be evaluated for conservative assumptions or for other features (listed in Enclosure 1) to determine if it is acceptable or modifications are required.*

   In the event that the verification analysis identifies margins in the structure less than allowed by code these would be further evaluated to quantify the margin to failure to determine if further action is necessary.

Implementation

SRS will implement this limited verification analyses that develops in-structure response spectra in the Auxiliary Building and the MAA. Upon completion of this verification study it is proposed that the DNFSB Staff review the results to gain an understanding of margin to code for building loads using the Verification Spectrum.

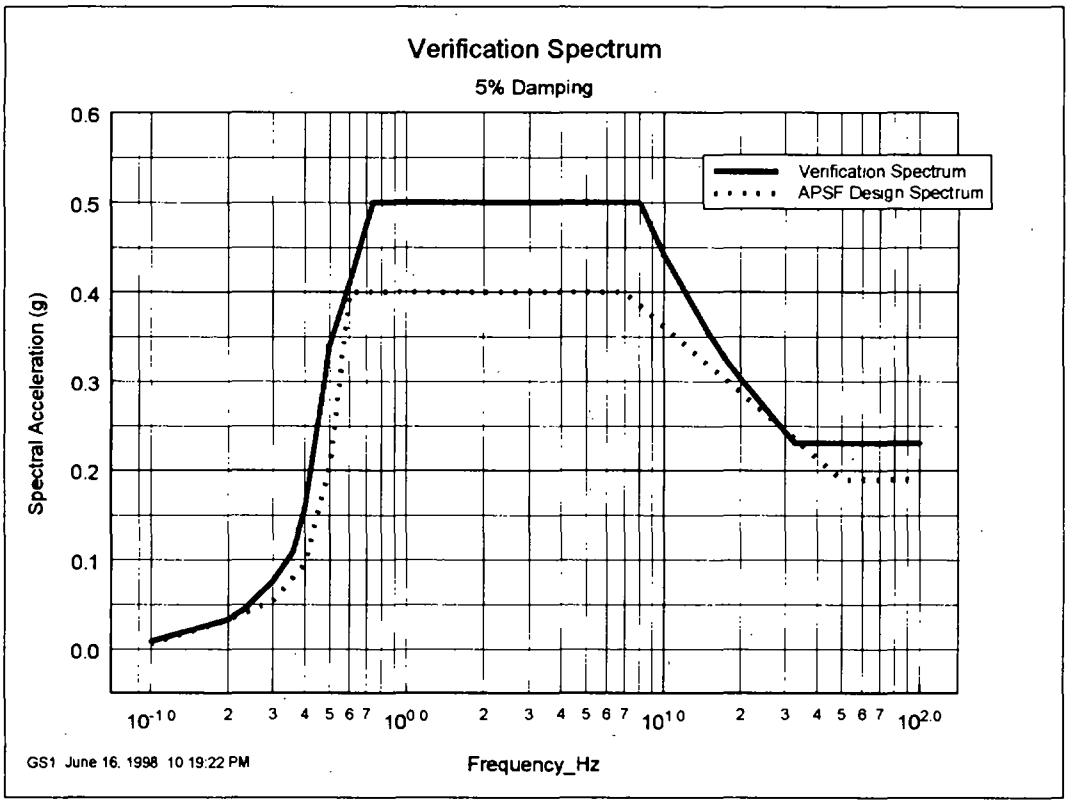
Attachment: APSF Seismic Verification Study Spectrum

ENCLOSURE 2 ATTACHMENT

APSF Seismic Verification Study Spectrum

Frequency (Hz)	Spectral Acceleration (g)	APSF Design Spectrum (g)
0.1	0.0085	0.006
0.2	0.034	0.033
0.23	0.0449	N/A
0.3	0.0764	0.054
0.358	0.109	N/A
0.4	0.157	0.096
0.5	0.341	0.202
0.6	0.409	0.4
0.7	0.477	0.4
0.74	0.5	N/A
0.8	0.5	0.4
0.9	0.5	0.4
1	0.5	0.4
2	0.5	0.4
3	0.5	0.4
4	0.5	0.4
5	0.5	0.4
6	0.5	0.4
7	0.5	0.4
8	0.5003	0.386
9	0.469	0.373
10	0.442	0.362
15	0.354	N/A
18	0.321	N/A
20	0.303	0.288
30	0.243	0.245
33	0.230	N/A
40	0.230	0.214
50	0.230	0.19
100	0.230	0.19

ENCLOSURE 2 ATTACHMENT



ENCLOSURE 3

Savannah River Site Approach on Ground Motion Closure

The practices used for determining the current SRS seismic design basis motions are current state-of-the-art. They have received extensive independent peer review and are considered consistent with established United States Nuclear Regulatory Commission safety performance goals. In March of 1997, the Site completed the development of the new SRS design basis spectra WSRC-TR-97-0085, Rev. 0 in accordance with DOE Standard 1023. This report has been previously provided to the DNFSB.

The report and the methodology used in the development of the new design basis spectra have been discussed with DNFSB representatives on several occasions. Based on these meetings, nine action items that require further clarification were mutually agreed upon. While there may be other issues developing, it is important that we reach closure on these issues by the end of this fiscal year so that potential impacts on the design of new facilities, such as APT and TEF, may be precluded.

The action items were identified during a meeting with the DNFSB on October 23, 1997. Information on all of these items was provided to the DNFSB staff on April 8, 1998, with the exception of item 6 on soil structure interaction methodology. A follow-up meeting was held on May 5, 1998, to discuss the responses to action items 1-9. Based on this discussion, two of the items were closed. Supplemental clarifications were requested on the remaining items, exclusive of item 6, which were provided prior to July 14, 1998.

It is expected that the development of the soil-structure interaction approach of item 6, which is underway will be completed by the end of this fiscal year. This item is separate from the other items and its resolution has no direct bearing on the justification or acceptance of the site design basis spectra, rather it relates to the use of the spectra for the evaluation of building structures. Successful response to the remaining open design items should provide resolution for acceptance by the DNFSB of the site design basis spectra.