[DNFSB LETTERHEAD]

January 11, 1991

Mr. Victor Stello, Jr.
Deputy Assistant Secretary for Facilities
Office of Defense Programs
U.S. Department of Energy
Washington, DC 20585

Dear Mr. Stello:

Enclosed for your consideration and action, where appropriate, are (1) two tables comparing the restart requirements for seismic qualification of safety systems of the Savannah River reactors, and (2) a report by a staff member of the Board of a trip made to Savannah River during which the Supplementary Safety System (SSS) was reviewed.

As you are aware, the Board has been reviewing the seismic design aspects of the safety systems of the Savannah River reactors. This review has included a comparison of the restart requirements for seismic qualification of these systems. The information contained in several documents (i.e., DOE K Reactor Restart Strategy, Westinghouse Independent Safety Review (WISR) report, K Production Reactor Safety Analysis Report (SAR), and Westinghouse Seismic Engineering Procedure (SEP-10)) was used to perform this comparison.

The enclosed tables indicate that the SEP-10 Seismic Qualification Priority list is generally consistent with the DOE K Reactor Restart Strategy and the conclusions of the WISR. However, several inconsistencies are identified in the enclosed tables, where the SEP-10 Seismic Qualification Priority is in conflict with the DOE K Reactor Restart Strategy and in several cases with some of the other relevant documents. This review of the requirements for seismic qualification has led the Board to believe that there may be a lack of coordination among the various documents.

The enclosed trip report indicates that heavy reliance is being placed on the SSS to shut the reactor down following a seismic event, since the safety rods are not seismically qualified. The report also points out that a better understanding is needed of the hydraulic and nuclear factors influencing performance of the SSS, including the effects of control rod motion induced by the seismic event. The report suggests that particular attention is needed for a seismic event with maximum acceleration of less than 0.05g, say one with 0.04g. The report points out that under these conditions, it would be necessary to consider the impact on safety of the seismic effects of a 0.04g seismic event on the safety computer, safety and control rods, and the A.C. power to the process water pumps, since these systems may not be capable of reliably performing their safety function under these conditions.

In this connection, and in light of the importance of the SSS to the overall safety of the Savannah River reactors, we draw your attention to the importance of certain scale model tests of SSS performance that are to be made under conditions of decaying coolant flow. It is difficult to understand why these tests, which would be essential to better understanding of the effect of coolant flow on the time behavior of the distribution of ink, are currently scheduled after restart of the reactors.

The Board will continue its review of the requirements for seismic qualification of the Savannah River reactors, both for restart and afterwards, including the question of the inconsistencies referred to above.

Sincerely,

John T. Conway
Chairman

3 Enclosures

cc:
Dr. Donald F. Knuth
Deputy Assistant Secretary for Operations
Office of Defense Programs
U.S. Department of Energy
Washington, DC 20585

DEFENSE NUCLEAR FACILITIES SAFETY BOARD

December 20, 1990

MEMORANDUM FOR: Dr. Herbert J. C. Kouts
Member

FROM: Andrew G. Stadnik

SUBJECT: Report of a Trip to the Savannah River Site (SRS) Concerning Supplementary Safety System (SSS) Design Adequacy and Other Topics (File Reference - SSSRPT)

A trip to the Savannah River Site was made to review the design adequacy of the Supplementary Safety System (SSS) used in the production reactors, obtain details on the Process Water System pump suction valve actuator replacement effort, and discuss the use of Unusual Occurrence Reports (UORs) as a management tool. Several observations and comments developed by Dr. Paul C Rizzo (Rizzo Associates, Inc.) and myself are summarized as follows:

1. A heavy reliance is being placed on the SSS for shutting down the reactor during a seismic event. It is the only design basis earthquake (DBE) seismically qualified system for this purpose. Planned scale model testing to better determine the ink distribution and moderator flow characteristics is planned for sometime after restart. Considering the importance of the ink distribution and moderator flow modelling, DOE should provide the basis for scheduling these scaled tests after restart.

2. DOE should provide documentation of the nuclear physics codes and core physics analyses used to establish the expected reactivity behavior upon actuation of the SSS. This should include the basis for (1) the reality of any positive slopes in the calculated reactivity curves, and (2) if it is necessary to pursue any design modifications to eliminate positive slopes in the expected reactivity transient. This area was not a specific topic for review during this trip.

3. Given the seismic trigger levels for the SSS and other seismic sensors, the DOE should be asked to comment on the consequences of a seismic event of less than 0.05g, such as 0.04g. This should consider the impact of not being able to rely on the safety computer, safety and control rod system, and pump power supplies, since these systems may not be seismically evaluated and acceptable to these levels.

4. A better understanding with DOE appears to be needed so that the DNFSB is kept up-to-date, in a timely manner, with changes to the Westinghouse Reactor Operations Management Plan (ROMP).

5. The WSRC implementing document "Site Item Reportability and Issue Management" (SIRIM), for DOE Order 5000.3A (UORs) needs to be reviewed after it is formally

issued. Also, a follow up review should be conducted to determine whether the implementation of DOE Order 5000.3A by DOE-SRS and WSRC has been effective.

BACKGROUND:

On November 16, 1990, Dr. Paul C Rizzo (Rizzo Associates, Inc.) and I met with DOE and WSRC personnel to discuss the design adequacy of the SSS, obtain background information on the process water system pump suction valve actuator replacement, and discuss the use of UOR's as a management tool at SRS. This meeting was initiated based on your discussions with Mr. Ira Spears (GAO) documented in your Memo to File of October 29, 1990, and questions raised during a Board meeting on October 25, 1990.

DISCUSSION:

1. A copy of our original agenda with the DNFSB's questions and the actual WSRC agenda are provided in Attachment 1. The list of the attendees is provided in Attachment 2. The main DOE contact was Mr. Charles Brooks. The main WSRC contacts were Mr. Carl Hirst and Mr. Fred Beranek. WSRC presented information on all the questions raised by our original agenda.

   The handouts received from WSRC are listed in Attachment 3. A copy of these items including the drawings has been provided to our library. The following paragraphs briefly discuss the answers to our agenda questions, identify the additional items DOE/WSRC will be providing on the agenda topics, and document the observations/comments developed by Dr. Rizzo and myself on the topics reviewed.

2. SSS Design Adequacy

   A. Presentation of Information

   (1) Extent of SSS Seismic Qualification (part of our agenda item A.2) - WSRC identified that the SSS is essentially using Seismic qualification Utilities Group (SQUG) methodology and conventional methods. The SSS includes one automatic initiation method (seismic triggers) and one manual initiation method (pull ring). The automatic safety computer, the nuclear console switch, and the external fission counter switch initiation methods for the SSS are not seismically qualified. Some portions of the SSS are not seismically qualified because they are viewed as fail safe - if they fail during a seismic event their failure will turn on the SSS. This included some electrical cables and pressure transducer lines. The drawings that have been provided identify the extent of seismic qualification, but do not designate the method used (i.e., analysis, walkdown, or like component test data).

   The normal core instrumentation (temperature, pressure, and flux instruments) used to determine the SSS effectiveness could also be considered "part of" the SSS during its operation, since these would be used to monitor reactor conditions and determine the effectiveness of the SSS. It was identified by WSRC that the flux monitors are not seismically qualified. WSRC identified that this issue was addressed under "WISR-19," and the close-out documentation of this issue identifies that this situation is acceptable.

The extent of seismic event indication was reviewed. If a seismic event occurs, three separate indicators are activated, as follows:

- An alarm is sounded in the control room at 0.002g (horz). Thisvalue was confirmed by WSRC during the meeting. This alarm alerts the control room operator that a seismic event is occurring or has just occurred.

- A seismometer at the -40 ft. elevation set at 0.02g (horz.) triggers the Reactor Shutdown System (safety rods). The RSS is not seismically qualified to the DBE.

- Seismic triggers at the -40 ft. elevation set at 0.05g (horz) and 0.033g (vert.) activate the SSS. This system is required to be seismically qualified to the DBE prior to startup.

During the discussion of this topic, WSRC agreed to provide (1) a detailed listing identifying all system components and the method of seismic qualification used for each component, (2) a copy of the report documenting the pull ring mechanism seismic adequacy, and (3) a copy of the WISR-19 closeout package identifying the acceptability of not seismically qualifying the flux monitors.

(2) PRA Influence on SSS Importance (Part of our agenda item A.2) - WSRC identified that the PRA results showed that the effects of the DBE on the SSS and its subsequent performance with respect to core melt frequency was very low. WSRC did not present any specific data on this matter.

WSRC agreed to provide documentation on the above.

(3) Defense in Depth (Part of our agenda item A-3) - WSRC identified that the SSS is the only seismically qualified shutdown system. WSRC indicated that the redundancy of the SSS provides defense in depth, and that this was consistent with NRC requirements for older commercial plants. One key area concerning defense in depth of the SSS was clarified in that the SSS consists of two completely redundant systems capable of shutting down the reactor. The seismic triggers for each system are located very close together in the -40 foot level. Their proximity could be a concern from the standpoint of common mode failure due to some external event. However, WSRC indicated that any failure of the seismic triggers from local spray damage or fire would result in actuation of the SSS.

The means to determine that the reactor is shutdown during a seismic event relies on reactor temperature and pressure indications which are seismically qualified. (Flux monitors are not seismically qualified to the DBE and thus would not be considered available after the occurrence of a DBE event to monitor the core.) Thus, the key issue is whether there is adequate distribution of poison that results in a shutdown reactor.

WSRC identified the flow modelling and analyses, which are based on experimental data from full scale models and actual plant test data, indicate that the poison will distribute and effectively shutdown the reactor given several performance assumptions. These assumptions include:

- worst case vent leakage
- worst case pressure decay
- one SSS side operating
- worst case actuation and delay times
- most limiting power, inlet temperature, and axial power shape
- minimum flow coastdown
- most positive reactivity coefficient
- no credit for larger ink volumes and concentrations available from the latest system upgrades.

WSRC identified that the flow modelling has been done on a two dimensional basis, and the results of the modelling correlate with existing test data. The 2D flow analysis results are considered adequate by WSRC in determining the poison distribution during the SSS actuation transient. The tools used to calculate the reactivity versus time curves for the SSS are summarized in figure 1 which is a chart from the WSRC presentations. WSRC indicated that the C reactor test data, as well as the 1959 CMX test model results, correlate well with the flow model. This, coupled with the GLASS and 3D GRIMHX analyses, indicate the reactor would be shutdown. Figure 2 shows the calculated SSS reactivity curve based on the tools used and the assumptions identified above.

The steep drop from about 25 to 32 seconds represents about 25 percent the SSS sparger ink returning to the core. At 35 seconds the pump Suction injection ink enters the core and WSRC has assumed that only a 1 percent k credit is taken for all ink in the system through the rest of the event. Additional figures, from the SAR Chapter 15, Section 3, were presented showing the margins to the thermal limits (flow instability) for the loss of AC pump power transient. This transient was identified as less limiting than the double ended guillotine break loss of coolant accident (DEGBLOCA).

During these discussions, WSRC also presented information on the control rod system (safety rods and shim control rods). This control rod system is a very complex elector-mechanical structure extending over 100 feet above the head of the reactor tank. This system has not been seismically evaluated for the DBE.

Also, there is currently no documentation evaluating this system to any level seismic event. Analyses are in progress to determine how much outward rod motion might occur during certain seismic events and what the impact of this would be. There is the possibility that the rods could be pulled out by the DBE and cause a reactivity excursion. Also, the DBE could cause the latching mechanism to release the rods which may drop into the core by gravity. At this time, it was premature to discuss this issue.

The overall WSRC conclusions from the analyses are that:

- Redundancy provides adequate defense in depth

- Significant margin exists to thermal limits (flow instability)

- The modified SSS (with pump suction injection) provides adequate shutdown conditions during full AC flow, coast down and DC flow.

As a result of these discussions, WSRC agreed to provide the 1959 CMX full scale model test results, and the prechargeback test reports on the operation of the SSS using D2O to identify conservatisms in the assumptions and the correlation of the flow modelling tool (i.e. "MODFLOW") with test data.

(4) Planned testing (Part of our agenda item A.3) - During start-up, pre-operational tests wll be conducted to verify the SSS is properly lined up and all components are functional. This will mainly be electrical-type testing. The main "proof" test will be initiation of the SSS from a 20 percent power level monitoring temperatures, pressures and flux levels during the transient. The details of this test are being firmed up and should be available within a few months for the Board to review prior to start-up.

WSRC is discussing with DOE, several analyses and test programs for the longer term that may be pursued to reduce the uncertainties and provide either greater margins for unforeseen problems or allow for a possible increase in operating power levels. It was noted that this is being pursued in several areas besides the SSS performance results. This longer term effort for the SSS includes complex 3-D flow modelling, further development of the existing modelling tool, and scaled tests to further investigate 3-D tank flow patterns and ink distribution.

B. DNFSB Staff and Outside Expert Observations/Comments

(1) The degree of ink distribution over time is a critical issue. The most limiting point during the loss of pump power transient (which would likely be assumed to occur in conjunction with a seismic event) occurs during the first 5-10 seconds when the poison will not necessarily be very well mixed, and the decaying power and flow result in conditions that come closest to the thermal limits. However, the margin to

the thermal limits appears to be larger than that for the DEGB-LOCA. A great deal of the predictive analysis used to estimate reactivity (and temperature as well) is based on limited knowledge of the moderator flow pattern and ink dispersion characteristics. WSRC stated the flow model has been correlated with test data but no specific comparisons were presented. These are to be provided subsequent to the meeting. Also, a test program is planned with scaled tests as well as a test at 20 percent power. The scale model testing to better determine the ink distribution and moderator flow characteristics is planned for sometime after restart. Because of the importance of the ink distribution and moderator flow patterns, DOE should provide the basis for scheduling the scaled tests after restart.

(2) Local reactivity determinations with time are necessary to understand whether the core power decay is consistent with the assumptions being made. There does not appear to be an adequate assessment of the potential for achieving criticalities given the likely flow distributions and resulting geometries. This would include the effects of control rod motion during the DBE. A further understanding of the nuclear physics codes is necessary to obtain (1) a better understanding of the core physics aspect of the calculations and (2) a better understanding of the initial 10 seconds of reactivity and core power behavior including the expected effects of the control rod system. This aspect was not the focus of this meeting and is worth a subsequent session.

(3) Given the trigger levels mentioned in paragraph 2.A(1) above, the DOE should be asked to comment on the consequences of a seismic event of less than 0.05g, such as 0.04g. This should consider the impact of not being able to rely on the safety computer, safety and control rod system, and pump power supplies, since these systems may not be seismically evaluated and acceptable to these levels.

(4) The SSS can be activated by five different means as follows:

- The control room operator can manually activate the SSS with the pull ring in the control room. The pull ring activation system is seismically qualified by SQUG methods. The validity of a SQUG approach for this mechanism needs to be documented since there is no experience in the industry with such a system.

- The SSS is automatically activated by the seismic triggers (0.05g). This activation system is seismically qualified to the DBE.

- The SSS can be automatically activated by the safety computers; however, these are not seismically qualified to the DBE.

- The SSS can be activated two other ways - manually by the control room operator with a switch on the control room console or by a switch at the external fission counter on a control room panel neither mechanism is seismically qualified to the DBE.

(5) It was also discussed at the meeting that while the system is being "inked," a small leak in the reactor tank will activate the Moderator Recovery System (MRS). This system "picks" up inked moderator and sends it back to the 2000 gallon MRS tank However, the 2000 gallons of moderator already in the tank is not inked before it flows into the reactor tank. This may result in the possibility of a local increase in reactivity. WSRC responded that they had considered this possibility, but had dismissed it on a cost/benefit basis. They also argued that 2000 gallons of un-inked moderator would have little impact on the 50,000 gallons of inked moderator already in the reactor. However, DOE may wish to reconsider the possibility of providing additional ink to the reactor tank when the MRS is activated in conjunction with the SSS.

3. Pump Actuator Discussion (Our agenda item B.1)

A. Presentation of Information - To address the Board's specific question of what is involved in the actuator replacement, WSRC provided a discussion of what is entailed in the process water system pump suction valve actuator replacement effort. A brief discussion was also provided on the cost-benefit rationale concerning why the K reactor efforts were deferred until post restart. The document provided is identified in Attachment 3. This document shows the old (SMA) and new (SB) actuator designs, and summarizes the cost benefit rationale to defer the item to post restart.

The SB or new design has a torque override capability that the existing 35 year old actuators (Seas) do not. This extra electrical control capability requires an extra wire. Extra wires are available for some of the valves, however, the wires themselves are 35 years old. This would require running new wires between the valve actuators and the control room and power supplies (runs of about 600 feet each). Thus, the scope of the actuator replacement effort included not only replacing the actuator mechanisms, but also running several hundred feet of new wiring in the event the existing wiring was inadequate.

WSRC identified that MOVATS testing has been performed, some deficiencies corrected, revised switch (limit and torque) settings established, and operational procedures implemented to ensure the wave could be closed when called upon. It was also noted that valve closure is not accounted for in the design basis analyses and thus is not considered required for safety. Therefore, given the performance testing and procedural changes made, and the rationale that the valves are not required for safety considerations, WSRC revised the status of this ROMP item (IM-008) which should be reflected in the latest ROMP and RSIP updates.

B. DNFSB Staff Observations/Comments

The DNFSB should be kept more aware of ROMP and RSIP updates and changes such as this. (Even in a prior meeting at SRS, DOE-SRSPO (McCoy) wvas surprised to hear of this item being delayed from pre- to post- restart.) The DNFSB is on distribution for revisions of the two major issue management documents for Restart (ROMP) and Long term (RSIP) operations, but intermediate information, prior to the official revisions to these large documents, should be provided by some means, in a timely manner.

4. UOR's as a Management Tool (Our agenda item B.2)

A. Presentation of Information - Both DOE and WSRC presented information on how they are using UORs to evaluate trends and identify symptoms on a plant, facility and site-wide basis. The items received are listed in Attachment 3. Also, WSRC and DOE indicated they review off-site UORs for applicability. There appears to be extensive use of computer databases to compile the UOR data and evaluate it. This appears to be a response to implementing DOE Order 5000.3A.

The material received from DOE included a listing of their database and examples of the types of evaluations they can perform. Both DOE and WSRC indicated that the information should end up being disseminated to the cognizant system and component engineers.

B. DNFSB Staff Observations and Comments

(1) Both the DOE and WSRC systems are just being implemented, and how well they are working could not be assessed at this time. It is intended that the databases will be available on-line when an incident occurs to allow the affected people to look for related UORs. The WSRC implementation document ("SIRIM") is still in a draft form, and should probably be reviewed after DOE has approved it.

(2) Some time will have to be allowed for the WSRC and DOE "systems" to be implemented before determining whether this system and the implementation of 5000.3A is effective, and whether the right people are aware and make use of the data. This item should be included in a subsequent review after about 6 months.

Figure 1, Figure 2 not shown here (will be sent to you upon request)