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Department of Energy

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DNF SAFETY BOARD

The Honorable John T. Conway
Chairman
Defense Nuclear Facilities Safety Board
625 Indiana Avenue, N.W.
Suite 700
Washington, D.C. 20004

Dear Mr. Chairman:

This is the final reply to your June 11, 1996, letter transmitting the report of the May 28, 1996, trip covering your staff's design and construction review of the Hanford Canister Storage Building. The trip report states continuing concerns over the development and implementation of design criteria for this high priority project.

The U.S. Department of Energy acknowledges these Defense Nuclear Facilities Safety Board (Board) concerns and agrees areas requiring improvement exist (e.g., expediting the implementation of design criteria). In this respect, The Department is committed to resolving these design issues before the authorization of the next phase of construction (scheduled for August, 1996). A technical review team will include a review of these issues during preparation of the Safety Analysis Report. Many of the documents and data supporting our decisions have already been forwarded to your staff for review.

Enclosed are the detailed responses to specific issues raised in the May trip report. We will continue to work with the Board and the Board staff to resolve these design and construction issues as soon as possible.

The Department appreciates this opportunity to strengthen this important Hanford project through the resolution of your staff's observations. If any other information would be helpful, please feel free to contact me.

Sincerely,

Richard J. Guimond

for Alvin L. Alm
Assistant Secretary for
Environmental Management

Enclosures

ENCLOSURE

RESPONSES TO DNFSB STAFF DISCUSSION/OBSERVATIONS ON CANISTER STORAGE BUILDING (CSB) DESIGN AND CONSTRUCTION

The following are responses to issues identified in the DNFSB Staff Memorandum from A. H. Hadjian to G. W. Cunningham, dated June 7, 1996, on "Structural Review of the Canister Storage Building at the Hanford Site." This DNFSB Staff Memorandum was enclosed with the June 11, 1996, letter from DNFSB Chairman John T. Conway to DOE Under Secretary Thomas P. Grumbly.

<u>Current Dispositions of Specific Board Staff Observations:</u>

Issue a.1 At this late date, while concrete is being placed at the CSB, the commitments are primarily written in the future tense.

Response: Review and analysis of the paper trail for design criteria is a DOE priority. Within the past month, much of this material has been forwarded to the DNFSB Staff. To facilitate its assimilation, a detailed meeting was held on July 8; future meetings are planned. The necessary criteria to permit start of the CSB vault construction (below grade structure) were documented and in place prior to authorizing start of construction and prior to pouring concrete. Bounding analysis indicated no risk in proceeding and no rework is anticipated. Design criteria have been incorporated in the design specification and in work statements to the Architect Engineer for the CSB in a timely fashion.

Issue a.2 While modifications to existing design criteria are incorporated in several documents, they have not been communicated to the CSB design agent for immediate implementation because of contractual constraints.

Response: The DOE is not satisfied with the past performance of timely implementation of design criteria. Communication to all project participants of design criteria and other important information is our intent and practice. The past delays in implementation were not due to any contractual constraint on communication of design criteria to the design agent, but was caused by, among other things, the need to assess the cost, schedule, and safety impacts prior to decisions on details of design criteria implementation.

Orderly implementation of the design criteria in a phased approach takes a number of steps. 1) RL approves or directs the Maintenance and Operation (M&O) contractor to implement the design criteria, 2) the M&O contractor reviews the criteria for cost, safety, and schedule impacts, makes decisions on the timing of the implementation, 3) the M&O contractor transmits the criteria to the design agent, 4) the design agent reviews the criteria and proposes design subcontract changes to implement the criteria, 5) the M&O contractor and the design agent begin negotiating design subcontract changes, 6) M&O considers all factors and may direct that the criteria not be implemented immediately while informing DOE, and 7) the M&O contractor and the design agent conclude negotiations and execute design subcontract changes. While these steps are necessary for orderly implementation of design criteria, DOE is taking an active role to ensure more timely implementation of design criteria in the future.

Issue a.3 The decision as to the extent to which the facility should be hardened for tornado/wind loads, missiles (tornado generated and small airplane crash), man-induced hazards and hydrogen deflagration/detonation is still pending, and could significantly alter decisions made regarding loads on the substructure and the deck.

Response: The attached schedule shows the activities to be accomplished prior to the next phases of construction which will address project issues and Board concerns in this area. Copies of the current analyses have been provided in response to the Board's request. Tornado assessment, as shown in the attached schedule, is in progress. Other issues pertaining to the deck and associated equipment have been addressed in the June 1996 Safety Analysis Report submittal. The current deck and superstructure designs could be impacted by the additional loadings due to these hazards, but bounding calculations (letter, E. R. Jacobs, Fluor Daniel, Inc., to WHC, "CSB Structure Reanalysis for NRC/NPH," dated April 24, 1996) show that design of the substructure will not be impacted based on documented assessment from the design agent.

Issue a.4 There is still confusion regarding the design life of the CSB structures (75 years of "service life" is stated, versus the 40 years of design life). It should be recognized that any increase of life span would adversely impact probabilistically based loads, such as natural phenomena hazards (NPH). Thus, there is risk in delaying this decision.

Response: The DOE directed that the 40 year design life of the CSB be documented in the CSB Safety Analysis Report to clarify the issue. The design for natural phenomena hazards (NPH) is based on the 40 year design life.

Issue a.5 It is puzzling to note that maximum precipitation for flood is based on a return period judged to be 10,000 years and snow load only on 100 years. There is no technical analysis to substantiate the contention that the return period for the maximum precipitation is 10,000 years; and furthermore, the 100-year snow loading is inappropriate for critical structures.

Response: The precipitation (rain) criterion for CSB site runoff is the Probable Maximum Precipitation (PMP). There is no probability specifically assigned to the PMP. However, in the ASCE (1988) report *Evaluation Procedures for Hydrologic Safety of Dams*, the

PMP for selected locations west of the Rocky Mountains has annual probabilities ranging from 10^{-5} to $<10^{-14}$. The PMP annual probability for the site closest to the Hanford Site is 10^{-11}. These probabilities are consistent with ongoing studies in the southwestern United States (Personal communication, J. L Vogel, National Weather Service). In using the PMP for the design criterion, both NRC and DOE requirements are fulfilled because the PC-3 precipitation, with an annual exceedance probability of 10^{-4}, is less than the PMP.

The design ground snow load of 20 psf is based on the precedent of the NRC operating license for Washington Public Power Supply System's WNP 2. The DOE ground snow load is 15 psf. The DOE value is based on ASCE-7, which indicates a ground snow load for the Hanford Site of 15 psf. The use of ASCE-7 is arrived at by following DOE-STD-1020-94, which refers to DOE Order 6430.1A, which refers to ANSI A58.1, with ANSI A58.1 being replaced by ASCE-7.

Issue a.6 The final Geomatrix hazard study results have not yet been incorporated in design documents. Additionally, design documents need to be updated for tornado and snow loads.

Response: Revision 1 of the NPH document for the CSB (WHC-SD-SNF-DB-009) was issued on June 10, 1996. This document now incorporates the seismic hazard study results from *Probabilistic Seismic Hazard Analysis, DOE Hanford Site, Washington*, WHC-SD-W236A-TI-002, Rev 1 (Geomatrix, 1996). The NPH document provides input to the CSB Performance Specification and the CSB Safety Analysis Report. It should be noted that the spectral accelerations for Performance Category 3 at the 200 East site from the final Geomatrix hazard study essentially coincide with those given in the earlier revision of the NPH document. It is also noted that the horizontal and vertical design spectra for the CSB exceed the spectra given in the final Geomatrix hazard study, so these minor changes will not impact on-going design or analysis for the CSB.

Issue b.1 The modeling of the side soil and the soil beneath the basement of the substructure is not in accord with standard practice (e.g., ASCE 4 Standard and the SASSI Code). This will affect both the earth pressure loads on the exterior walls and the soil-structure interaction analysis results.

Response: The CSB design and analysis have their roots in the HWVP Project where the foundation was actually constructed. During this previous time, a SHAKE and FLUSH series of analyses were performed for both the Vitrification and CSB facilities. These analyses showed that soil structure interaction worked to reduce structural motions from those of the free field prescribed at the ground surface. Also, the FLUSH analyses provided dynamic soil pressures which could be used in design. Though the configuration of the CSB has changed somewhat from that of the analyzed CSB, it was observed that the changes would only reduce the structural response. The results of the original analyses were reviewed and approved by Professor John Lysmer, a renowned authority on structural analysis. Founded on these analyses and results, a one step SAP90 analysis was selected for the CSB. In order to get soil pressures in a one step analysis, a series of soil brick elements were placed surrounding the building model and the boundaries of the soil elements were constrained to move from the bottom to the top with the free field at the various levels. It was judged that using the de-convoluted (from surface) motions at the base of the structure for a fixed base analysis would be conservative. Looking at non-linear SHAKE and FLUSH analyses, equivalent elastic soil properties were obtained which were used in the SAP90 analysis. Also, these equivalent properties were used in SHAKE to obtain the de-convoluted motions for use as input at the base of the vault structure. The analysis results were determined to be conservative because the surface free field response spectra from the final analysis model bounded the free field design response spectra which was the originally required surface motion. The soil pressures at the walls from the soil elements were seen to be essentially the same as those provided by the original FLUSH analysis. It is on this basis that the design model is deemed reasonable, the analysis results are appropriate, and the design is conservative.

Issue b.2 The seismic excitation of this significantly embedded substructure is achieved in a fashion that is new and needs to be verified. The computer code used for this analysis does not have direct capabilities to account for soil-structure interaction. There are state-of-the-art codes that would have provided more defensible results.

Response: The computer program (SAP90) in itself is not normally used to account for soil structure interaction. However, forcing the boundaries of the soil elements, constructed with appropriate properties as described above, to conform with the free field motion for the surface and below, provided soil pressure which are seen to be consistent with previous FLUSH analysis values. Because the FLUSH analysis values do not provide for out-of-plane (of the model) wall flexibility, they should be conservative as compared to a model (SASSI) which would account for this effect.

Issue b.3 Information on the acceleration time-histories used in the dynamic analysis was scant. Important ground motion characteristics, such as long period motions, adequate peak ground velocity and displacement, may be lacking in these records.

Response: ABB Impell Corporation was a subcontractor to Fluor Daniel on the HWVP Project. They provided the artificial earthquake time history which was used in the design of the CSB and is used in the SNF CSB Project. Robert P. Kennedy was a consultant to ABB Impell on this task, had direct involvement in development of the time history, and co-authored the task report. The report indicates that a single synthetic time history was created which simulated the Design Basis Earthquake. The resulting time history is shown to meet NRC acceptance criteria for a single design time history.

All important ground motion characteristics were included in the developed time history. Further information may be found in the report "Seismic Acceleration Time Histories in Support of Fluor Daniel, Inc." by M.W. Salmon, S.A. Short, S. Lu and Robert P. Kennedy.

Issue b.4 Since only one vault will be used for the K-Basin fuel and only one set of ventilation stacks will be constructed, a design based on three fully loaded vaults and three sets of ventilation stacks may not bound the worst design conditions for all structural load carrying elements. It is standard practice to use checkerboard loading patterns to capture the maximum forces in walls and slabs.

Response: The seismic analysis considered all three vaults to be filled with MCO's and all three intake structures and exhaust stacks to be in place. In addition to all the actual above grade eccentricities (e.g. MHM, Operating Shelter, Receiving Crane), the model included a 5% accidental eccentricity. A dominant feature of this below-grade vault is the participation of the soil mass in the wall flexure and in-plane shears. Since the stored Spent Nuclear Fuel (SNF) intake structures and exhaust stacks account for less than 1% of the total seismic model mass (soil, structure and stored fuel) and approximately 32% of the vault structure and stored fuel system, it was judged that the effective eccentricity was small and that the governing configuration for seismic analysis would be the condition in which all three vaults are full and all three intake and exhaust structures in place.

The design of the base mat and below grade walls is dominated by the ACI load combination 1.4D + 1.4T, where T signifies operating self straining thermal loads. The high temperature condition governs the exterior face reinforcing and the low temperature condition governs the interior face reinforcing. The extreme high temperature condition only occurs when the vault is completely full and the extreme low temperature condition occurs only when the vault is completely empty. Any thermal skip loading of the vault, e.g. one or two vaults full, relaxes the self straining thermal stresses in the vault structure and reduces thermal demand. Based on this reasoning, it was judged that the governing condition for the design of the base mat and below grade walls was either all the vaults full with high temperature inlet air or all vaults empty with low temperature inlet air. Therefore, the design of the base mat and below grade walls are bound by the two extreme conditions and, in our opinion, generally are not governed by a checkerboard loading pattern because of the dominance of thermal loads. Recent checks substantiate that while some stress values are higher, the design is not impacted.

Issue b.5 The modeling of the total structure does not follow accepted and reasonable design practice in that the deck, superstructure, ventilation stacks, and the MCO handling machine have not been adequately incorporated in the final analysis of the substructure.

The inadequacy is a result of the indecision regarding the hardening of the superstructure for external loads.

Response: Though design of a building substructure prior to calculating top-down wind or tornado loads on the superstructure is not typical, the flow of the project and urgency of schedule required actions which relied on innovative engineering. Judgements confirmed by "quick look calculations" indicated that as severe as tornado loading with missiles may be, the forces transmitted to the below grade structure are well below the forces transmitted by seismic. It was concluded that below grade design controlling values of soil pressures, member stresses, displacements or other parameters were not affected by tornado wind loads. The MCO handling machine has been included in the seismic calculation which affects the seismic response of the substructure (vault). An evaluation of the deck and related structures such as the stacks and inlets for tornado wind and missile impacts as well as 5% dead load increases required by ANSI 57.9 is in progress and those designs will be modified as appropriate to accommodate those loads prior to release of permanent construction. Superstructure design modifications are known to be required and are planned prior to release of that portion of the design for construction.

Issue c.1 Older versions of standards are being referenced and possibly used, such as UCRL-15910 in lieu of 1020-94, and ASCE 7-88, which was updated in 1993 and again in 1995. For example, the latest revision of ASCE 7-95 reflects improved design against wind effects.

Response: UCRL 15910 was used as the basis for design of the HWVP, and the analysis was performed to those criteria with some enhancements to envelop more current standards. The analysis was recently evaluated for compliance to 5480.28 and accompanying standards, and was assessed as conforming.

The CSB design requirements were obtained from ASCE 7-93. The DOE Standard 1020 was revised in January 1996 to incorporate ASCE 7-95, after establishing the CSB design. With respect to the straight wind criterion, the CSB criterion is 80 mph, not 70 mph as per ASCE 7-93, in fastest mile. The ASCE 7-95 criterion is an 85 mph 3-second gust which is comparable to 70 mph fastest mile [refer to NUREG-CR4492 "Methodology for Estimating Extreme Winds for Probabilistic Risk Assessments," Appendix B, 1986] and considerably less the 80 mph fastest mile. The CSB design for wind is conservative.

Issue c.2 The independent review by the design agent is performed in house. By itself, this may not be an issue; however, the review does not seem to have been probing nor in sufficient detail to raise any significant issues.

Response: The Fluor peer review follows a quality approach in which "probing" questions are considered through a checklist. Documentation of the peer review is not required in a report form, but rather in a calculation/check list format. The peer review was considered both insightful and thorough. The reviewer is independent of the CSB Project, and has significant technical experience and credentials in this area, as required by Fluor procedures.

The peer reviewer is a senior member of Fluor's Civil/Structure Engineering staff and a Principal Technical Specialist with more than 23 years of experience. He has a Bachelors and Masters degree in Civil/Structural Engineering. He is a Company recognized expert in computerized seismic analysis and structural/seismic design. He has in depth experience with DOE NPH design/analysis requirements and procedures, as well as actual design and analysis experience on many prior DOE projects. He is very familiar with and was involved on the design and analysis work for the HWVP Project. Also, Peer Review oversight was provided by a Senior Technical Director/Corporate Fellow who is nationally recognized for his background in structural/seismic engineering and dynamic analysis. The detailed design effort including SSI was overseen by our Civil/Structural Department Manager who also is nationally recognized for his work in earthquake engineering and structural dynamics.

Issue c.3 The Nuclear Regulatory Commission (NRC) equivalency evaluation continues to be confusing. Even though seismic is the only significant load considered in the design to date, an exception is taken to the requirements of Appendix A of 10CFR100 for the determination of the seismic load on the facility. Therefore, an implication of NRC equivalency may be misleading. The Board's technical staff does not plan to assess NRC equivalency of this facility design.

Response: Since the Board's technical staff does not plan to assess NRC equivalency of this facility design, the DOE is postponing discussion of this issue.

Issues c.4 The Safety Evaluation Report issued by the Department of Energy - Richland Operations Office (March 1996) for construction of the CSB substructure contained a number of items that were resolved for restart of construction; however, additional actions by the CSB Project are still outstanding.

Response: Outstanding items necessary to continue construction were completed in a timely fashion to support ongoing construction. The attached schedule shows the status of all items and planned resolution of the five currently open items. The five open items are NRC Equivalency (Items V-2, D-1, D-2, O-2 and O-3), Natural Phenomena Hazards (Items V-1, D-1, S-2, S-3 and O-4), Additional Calculations for Inadvertent Criticality (Item O-5), MCO Drop Analysis affecting substructure (Item T-1 and safety documentation) and Rebar Couplers (Item V-3). None of these items will impact the on-going vault construction or constitute any significant risk to that activity.

Response to Issue Under Summary:

Issue: The phased approach to safety analysis, design, and construction has resulted in an unnecessary risk (retrofits and/or delays) that would have been avoided if preliminary designs of the deck, superstructure, ventilation stacks, and the Multi-Canister Overpacks (MCOs) handling machine for all required loads were adequately incorporated in the final analysis of the substructure.

We agree that the phased approach, to safety analysis, design, and construction poses additional risks for possible retrofits since enabling assumptions need to be made in cases where data has not been fully developed. This is a recognized risk on a fast track project. Efforts have been taken on this project to manage this risk. Every effort is made to assure the enabling assumptions used are conservative and bounding. It must be recognized that there could be situations where enabling assumptions are found not to be bounding when data is fully developed. This could entail a retrofit under this situation. However, a phased approach, as demonstrated on the vault, has been successfully employed and no retrofits have occurred or are planned on this project to date.

REFERENCES

Design Criteria:

WHC-SD-SNF-DB-003, Spent Nuclear Fuel Project Path Forward, Additional NRC Requirements, Rev. 1, December 1995

WHC-SD-SNF-DB-004, Spent Nuclear Fuel Project Seismic Design Criteria, Nuclear Regulatory Commission Equivalency Evaluation Report, Rev. 1, December 1995

WHC-SD-SNF-DB-009, Spent Nuclear Fuel Project Path Forward, Natural Phenomena Hazards for the CSB, Rev. 1 released June 10, 1996

WHC-SD-W236-TI-002, Probabilistic Seismic Hazards Analysis, DOE Hanford Site, Washington, Rev. 1, February 1996, Geomatrix Consultants

Design Specification:

- WHC S-0425, Spent Nuclear Fuel Project, Canister Storage Building (CSB) Performance Specification, Rev. 1, dated March 25, 1996

- DSI, J. D. Phillips, WHC, to E. R. Jacobs, Fluor Daniel, Inc., dated March 28, 1996

Direction from WHC to A/E

- NRC Equivalency

  Letter, J. D. Phillips, WHC, to E. R. Jacobs, Fluor Daniel, Inc., Number 9650252, dated January 17, 1996

  Letter, G. D. Bazinet, WHC, to E. R. Jacobs, Fluor Daniel, Inc., Number 9651879, dated April 24, 1996

- Natural Phenomena Hazards (NPH)

  Letter, J. D. Phillips, WHC, to E. R. Jacobs, Fluor Daniel, Inc., Number 9650369, dated January 24, 1996

  Letter, G. D. Bazinet, WHC, to E. R. Jacobs, Fluor Daniel, Inc., Number 9652531, dated June 5, 1996

A/E Implementation of Requirements:

Letter, E. R. Jacobs, Fluor Daniel, Inc., to J. R. Zullo, WHC, Number FRF-2755/9600312, dated January 31, 1996

Letter, E. R. Jacobs, Fluor Daniel, Inc., to WHC, "Compliance Review ANSI 57.9," dated February 21, 1996

Engineering Deviation Notice 012, CSB Natural Phenomena Design Loads, dated February 22, 1996

Engineering Deviation Notice 008, CSB NRC Equivalency Implementation, dated March 4, 1996

WHC Change Request W-379-015, "Supplemental Vault Analysis," dated April 11, 1996

Letter, E. R. Jacobs, Fluor Daniel, Inc., to WHC, "CSB Structure Reanalysis for NRC/NPH," dated April 24, 1996

Letter, E. R. Jacobs, Fluor Daniel, Inc., to WHC, "ANSI 57.9 Review," dated May 15, 1996

Engineering Deviation Notice 042, NPH-Tornado Criteria Design Evaluation, dated June 6, 1996

Engineering Deviation Notice 043, Flood Criteria Evaluation, dated June 5, 1996

Change Request W-379-033, Incorporating EDNs 042 and 043

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NPH TORNADO DESIGN EVALUATION SCHEDULE