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# DEFENSE NUCLEAR FACILITIES SAFETY BOARD

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October 17, 2005

The Honorable Samuel W. Bodman  
Secretary of Energy  
1000 Independence Avenue, SW  
Washington, DC 20585-1000

Dear Secretary Bodman:

A key function of the Defense Nuclear Facilities Safety Board (Board) is to review the design and construction of new Department of Energy (DOE) defense nuclear facilities and recommend such modifications as the Board considers necessary to ensure adequate protection of public health and safety. The Board has considered the treatment of high-level waste at the Hanford Site as a system, including the high-level waste tanks, new treatment facilities, and interfaces. As such, the Board believes that a conservatively designed Waste Treatment Plant (WTP) that will remain operable following any natural phenomenon hazard is essential to the treatment and disposal of this waste. The Board continues to review nuclear safety aspects of the design and construction of the WTP on this premise. The bases for our oversight reviews are DOE's orders, standards, and directives, supplemented by industry standards and the state of the practice. The Board believes it would be useful for you to have a benchmark understanding of the state of our nuclear safety reviews at WTP.

For the past several years, the Board has performed safety-related reviews of the WTP design and construction efforts. The Board has communicated to DOE a number of safety-related issues in the areas of seismic ground motion, structural engineering, chemical process safety, fire protection, waste feed delivery, electrical distribution, instrumentation and control, and ventilation for confinement and process systems. The Board believes DOE has responded to these issues, though not always in a timely manner, and has provided technically sound paths forward for their resolution. The following paragraphs summarize the primary remaining safety issues identified by the Board to date, as well as the status of DOE's efforts to address these issues.

These nuclear safety issues can be divided into four major areas:

- Seismic ground motion
- Structural engineering
- Chemical process safety
- Fire protection

**Seismic Ground Motion.** In letters to DOE dated July 30, 2002; January 21, 2003; July 29, 2004; and April 19, 2005, the Board identified numerous issues regarding the earthquake ground motion criteria specified by DOE for WTP. The approach used to develop these criteria is based on probability theory and provides a “design basis event estimate” for plant design. Furthermore, original WTP ground motion criteria assumed that the response of the site’s soil and rock characteristics would be similar to that in California (i.e., the California attenuation relationship). The geotechnical ground motion community considered that approach acceptable in the early 1990s. By 2002, however, more representative, site-specific attenuation relationship approaches had become available and were in use at other DOE sites, based in part on the use of measured on-site soil and rock properties.

Shortly after the Board began to exercise safety oversight of the WTP project in late 2001, the Board questioned the use of the California attenuation relationship, with the belief that it could result in an increase in the ground motion at the Hanford Site. The Board requested that DOE address this issue. In response, DOE chose to estimate site-specific attenuation while allowing its contractor for WTP, Bechtel National Incorporated (BNI), to continue with the plant design. In studying this issue, DOE found that the soil column below WTP was reduced relative to that originally assumed, which accounts for a significant increase in ground motion. DOE’s efforts eventually led to the development, in February 2005, of significantly more demanding interim ground motion criteria (interim criteria).

Although the Board believes that the interim criteria provide a reasonably conservative basis for continuing with the plant design, some important uncertainties remain. The only means of reducing these uncertainties is to measure soil and rock properties under the WTP site. These measurements would allow development of a site-specific attenuation relationship. DOE has decided to measure site-specific properties using a deep drilling program and estimates that effort will require up to 2 years before final ground motion design criteria can be determined.

BNI is in the process of updating the structural model for the building and preparing to reanalyze the High Level Waste and Pretreatment facilities using the interim criteria. This effort will determine the impact of the ground motion increase on the already constructed slabs and walls. Based on its understanding of the existing design margins in these two facilities, the Board does not believe significant reconstruction of existing slabs or walls will be necessary. However, the planned reanalysis is required to substantiate this belief.

BNI is also evaluating safety-related facility and chemical processes equipment to determine the impact of using the interim criteria. In contrast to potential impacts on the already constructed slabs and walls, the impact of the increased ground motion on equipment is not as well understood. The Board is aware that DOE is using a peer review team to assist in its review of BNI’s evaluation. The Board views the continuing involvement of these technical experts as a

crucial aspect of DOE's oversight and believes the review team will provide the expertise necessary for successful and economical resolution of any technical issues that remain.

The Board believes that:

- The interim criteria, developed by DOE, provide a reasonably conservative basis for validating the existing design and construction of the plant. However, some uncertainty exists in this interim criteria because of incomplete site characterization data.
- When evaluating existing structures and equipment, some retrofit may be necessary. DOE should conservatively design these fixes to minimize potential impact on the design should the final ground motion criteria exceed the interim estimate.
- DOE should continue to use conservative approaches in the ongoing design of safety-related structures and equipment.
- DOE should continue to use the best available technical resources, including expert peer review, to determine the impact of the more stringent WTP interim criteria on existing structures and equipment.

**Structural Engineering.** To address safety issues raised by the Board, BNI is currently revising the structural design bases, as well as the structural models, for the High Level Waste and Pretreatment facilities. These revisions address issues related to the mesh density used in the structural models, application of thermal loads, and unique aspects of the High Level Waste building design. The Board has also asked DOE to identify how loads are distributed throughout the structural members for each facility so the local and global behavior of the structural components during seismic loading can be understood. Based on information provided by DOE and BNI, the Board expects that its review of the design bases, acceptance criteria, and model revisions should be reasonably straightforward since only a few issues remain unresolved. In addition, once reanalyses of the facilities have been completed, the design basis documentation and the summary structural reports, which provide load distributions in the High Level Waste and Pretreatment facilities, can be revised.

**Chemical Process Safety.** Three issues related to chemical process safety need to be addressed: hydrogen generation rate estimates, hydrogen in pipes and ancillary vessels, and pulse jet mixing of non-Newtonian fluids.

*Hydrogen Generation Rate*—In its letter of November 4, 2002, the Board informed DOE of its concerns regarding the hydrogen generation rate estimates being used to design WTP hydrogen mitigation systems. These concerns were based on BNI's use of the generation rate for the Hanford Tank Farms as the WTP design basis. The Board suggested that the markedly different processing and accident conditions in WTP were not accurately reflected in that

generation rate. DOE undertook studies to address this issue and revised its design basis generation rate equation to reflect the WTP process more accurately. The new generation rate equation appears to represent a conservative means of predicting hydrogen generation for WTP.

DOE has also revised the design basis for the waste feed to be consistent with an updated forecast of waste feed characteristics. Preliminary calculations indicate that the actual amount of hydrogen generated in WTP processes will be significantly lower than previous estimates. This, however, does not eliminate the hydrogen hazard from WTP. BNI is in the process of revising its final estimate of the quantity of hydrogen that will be generated during WTP operations and will incorporate this information into the design and safety bases. The approach being undertaken by BNI appears reasonable to the Board.

*Hydrogen in Pipes and Ancillary Vessels*—The Board believes that BNI has correctly identified hydrogen hazards associated with pipes and ancillary vessels. The Board's preliminary review indicates that BNI has developed some engineering solutions that will successfully prevent hydrogen-related accident scenarios. The exception appears to be BNI's desire to accept the risk associated with hydrogen deflagrations and detonations when a component failure would not adversely impact the public, collocated and facility workers, or other safety-class and safety-significant systems. If this is BNI's strategy, the Board expects that DOE will demonstrate that the likelihood of these accidents is extremely remote and that the public and collocated and facility workers will be protected. Additionally, the design needs to meet all applicable codes and standards and minimize the potential impact on WTP safety-related systems and site risk reduction objectives (e.g., timely treatment of tank waste).

The Board recognizes that DOE has just begun its review of BNI's strategy for dealing with these hydrogen-related issues and has not approved the final hydrogen mitigation design criteria or the final design. The Board believes DOE must not rush its evaluations of BNI's proposals and must demand a full understanding of the potential impacts of this design approach. DOE also needs to consider the entire spectrum of risk associated with these types of accidents (e.g., safety and mission risk) before approving a design with any inherent weaknesses. The Board believes this will be a difficult undertaking.

*Pulse Jet Mixing of non-Newtonian Fluids*—In its letter of March 24, 2004, the Board identified issues associated with the research and development test data being used to design the equipment for mixing non-Newtonian high-level waste. Although BNI has not completed the final mixing design, the research completed by BNI's research organization and Pacific Northwest National Laboratory indicates that BNI has developed a sufficient understanding of the requirements for mixing non-Newtonian fluids. The Board is aware of a number of design approaches, such as not requiring redundancy in certain cases, that will require careful DOE review before final designs can be approved. However, the Board believes BNI can develop a design that meets existing safety requirements upon completion of remaining research activities and ongoing engineering work.

**Fire Protection.** In its letter of July 21, 2004, the Board identified issues related to BNI's proposal to minimize the protection of structural steel against potential fires at WTP. After that letter was issued, BNI changed its approach, and it is currently preparing the technical basis for meeting applicable code requirements related to fireproofing structural steel. It is the Board's understanding that BNI now wishes to provide fire protection for selected structural steel members based on their role in supporting the structure during and after a fire, instead of protecting every member. This strategy is acceptable if it can reasonably be shown that unprotected structural members with reduced material properties due to a fire would not be relied upon to support the building. BNI is in the process of preparing the appropriate structural design criteria and implementing this strategy across the project. If this strategy is to be effective, the Board believes DOE must understand precisely how loads are distributed throughout each facility and account for degradation of the steel's material properties as the result of a fire. The Board notes that developing a well-defined load path in the High Level Waste facility is difficult.

**Conclusion.** The Board believes that the issues discussed above can be resolved on a timely basis and do not preclude continuing with the design and construction of the High Level Waste or Pretreatment facility. With the exception of the issue of hydrogen in pipes and ancillary vessels, DOE has committed to appropriate paths forward for addressing these issues. At the same time, however, it is important that DOE provide in-depth oversight of WTP to ensure that these issues are adequately resolved. DOE should continue to obtain and use expert peer review groups to supplement and extend its technical capabilities as required during the design, construction, startup, and operation process.

The Board will continue its reviews of the design and construction of this important project. Please contact me if you have any questions on the matters raised above.

Sincerely,



A. J. Eggenberger  
Chairman

c: The Honorable James A. Rispoli  
Mr. Roy J. Schepens  
Mr. Charles E. Anderson  
Mr. Mark B. Whitaker, Jr.