Department of Energy
National Nuclear Security Administration
Washington, DC 20585

JUN 14 2011

The Honorable Peter S. Winokur
Chairman
Defense Nuclear Facilities Safety Board
625 Indiana Avenue, NW, Suite 700
Washington, DC 20004

Dear Mr. Chairman:

On May 16, 2011, the Defense Nuclear Facilities Safety Board (DNFSB) issued a letter requesting a report and briefing regarding *Review of Safety Basis for Tritium Facility, Lawrence Livermore National Laboratory*. The DNFSB requested both a report response and briefing within 30 days of your letter providing a rationale for the current proposed control strategy and safety basis for the Tritium Facility. This letter and the enclosure transmit the Livermore Site Office (LSO) response; additionally, LSO briefed the DNFSB members on June 10.

LSO evaluated the revised Documented Safety Analysis (DSA) and Technical Safety Requirements (TSR) and is preparing a Safety Evaluation Report (SER) to document the basis for approval by the LSO Manager. The SER includes a number of Conditions of Approval (COAs) that LSO will direct LLNL to implement. In particular, the SER retains the tritium gloveboxes classification as safety-significant; provides a COA limit of 2% by volume for the total hydrogen species; and requires the fire suppression, detection and alarm systems to be maintained and operated in accordance with the National Fire Protection Association standards as part of the TSR fire protection program.

The COAs along with the control set identified in the DSA and TSR annual update, provide reasonable assurance that the facility can be operated safely and in a manner that adequately protects workers, the public, and the environment consistent with the requirements of 10 Code of Federal Regulations 830 and DOE-STD-3009 Safe Harbor Methodology. If you have any questions concerning this letter, please contact me at (202) 586-2179 or have your staff contact Sharon Steele at (202) 586-9554.

Sincerely,

Donald L. Cook
Deputy Administrator
for Defense Programs

Enclosure

cc: A. Williams, LSO
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Report to the Defense Nuclear Facilities Safety Board in Response to

Defense Nuclear Facilities Safety Board Letter Concerning the Review of the Safety Basis for the Tritium Facility at the Lawrence Livermore National Laboratory

Prepared by

Department of Energy
National Nuclear Security Administration
Livermore Site Office

June 2011

INTRODUCTION

This report responds to the Defense Nuclear Facilities Safety Board (DNFSB) letter (Reference 1) of May 16, 2011, regarding the safety basis and control strategy at the Building 331 (B331) Tritium Facility at the Lawrence Livermore National Laboratory (LLNL). The Tritium Facility is a Hazard Category 3 nuclear facility with a maximum allowed inventory of 30g of tritium in each of the two facility increments and an overall facility limit of 35g of tritium.

The DNFSB summarized in their letter that "The Board believes that the proposed strategy provides neither adequate credited safety controls for certain postulated fire scenarios involving tritium nor an appropriately credited confinement strategy." This conclusion is based on a Staff Issue Report included with the letter. The Staff Issue Report identified four additional observations, along with the concerns regarding the confinement strategy classification and Fire Suppression System (FSS). The DNFSB requested a report and briefing within 30 days of receipt of Reference 1 providing the rationale for the current proposed control strategy and safety basis for the Tritium Facility at LLNL. The briefing was provided to the DNFSB on June 10, 2011.

BACKGROUND

In late 2009, the National Nuclear Security Administration (NNSA)/Livermore Site Office (LSO) and the DNFSB identified a number of technical issues with the B331 Documented Safety Analyses (DSA) (References 2 and 3). LSO directed LLNL to resolve these issues through the annual update, while implementing a Justification for Continued Operations (JCO) in the interim to ensure the facility continued to operate safely while the issues were addressed. Particularly relevant to the subject of the DNFSB letter, LSO specifically directed LLNL to re-evaluate the unmitigated and mitigated consequences to the facility worker as a result of tritium and special tritium compound leaks, deflagrations, and fires, and derive the controls accordingly. The JCO as approved by LSO required LLNL to maintain operable tritium room monitors and Fire Detection and Alarm System (FDAS) for Radioactive Materials Area (RMA) operations (Reference 4).

The LSO review team has completed its review of the revised DSA and Technical Safety Requirements (TSR) (Reference 5) and is preparing a Safety Evaluation Report (SER) documenting the bases for approval by the LSO Manager. The SER includes a number of Conditions of Approval (COA). The review team has concluded that with the identified COAs, the control set identified in the DSA and TSR annual update provides reasonable assurance that the nuclear facility can be operated safely and in a manner that adequately protects workers, the public, and the environment consistent with the requirements of 10 Code of Federal Regulations (CFR) 830 and the Department of Energy (DOE) Standard (STD) 3009 safe harbor methodology.

Several conclusions from the review are relevant to the issues raised in the DNFSB letter. The bases for approval as summarized in the SER are provided below to respond to the issues raised in Reference 1 regarding glovebox confinement strategy, B331 FSS, and glovebox deflagration event controls. Responses are also provided for the remaining additional issues from Reference 1 and include input from LLNL (Reference 6).

DEFENSE NUCLEAR FACILITIES SAFETY BOARD STAFF REPORT ISSUES

Confinement Strategy Classification

The B331 DSA Hazard Analysis (HA) provided a bounding analysis of a release of 30g tritium from a glovebox. Practically speaking, releases of the full 30g inventory of material from glovebox events is highly improbable due to the nature of the process, where material is distributed in various areas of the box, i.e., in process vessels, on beds, separated by valves inherent to the system design, etc. The majority of tritium glovebox leaks will result in low consequences to facility workers, which does not drive Safety-Significant (SS) designation for the gloveboxes. For the remaining leaks, LLNL proposed crediting the tritium room monitors, which trigger prompt worker exit from the room. LSO agrees that prompt worker exit from the rooms is the imperative for these leaks; however, it is LSO's position that the glovebox barrier is a major contributor to Defense-in-Depth (DID) that further reduces the likelihood of these higher consequence events by slowing the rate of releases from the glovebox. As such, LSO concluded from the review that the glovebox should be retained as a SS System, Structure or Component (SSC). Thus, based on a COA in the SER, LLNL shall retain the Tritium Processing Station (TPS) and Tritium Science Station (TSS) gloveboxes as SS SSCs. The tritium room monitors will additionally be SS SSCs for tritium leaks, with a safety function of identifying tritium in room air and alerting personnel of a release.

Additional layers of DID for tritium leaks include:

- Tritium monitors in the glovebox;
- Process piping and manifold;
- Process vessels; and
- Dedicated Box Air Tritium Scrubber (DBATS)/cleanup cart.

LSO has concluded that this control set provides reasonable assurance of adequate protection of workers, the public, and the environment from the identified hazards consistent with the requirements of 10 CFR 830 and the DOE-STD-3009 safe harbor methodology.

Fire Protection Strategy Classification

The revised analyses in the B331 DSA HA identified high consequences to facility workers for the majority of fire releases. As discussed above, at the time the issues with the DSA fire analyses were identified, a JCO was implemented to ensure the facility continued to operate safely while the issues were addressed. LSO's approval of the JCO included a compensatory measure that ensured the operability of the B331 FDAS to alert facility workers in the event of a fire.

The HA identifies numerous fire scenarios for tritium handling, tritium storage, and other activities. The majority of scenarios postulated releases of the full facility inventory of 30g. This is a conservative analysis due to the facility's concrete construction and combustible loading controls [a Specific Administrative Control (SAC) that limits combustible loading to seven pounds per square foot in increment rooms], which will limit RMA room fires to the room of origin per the Fire Hazard Analysis Maximum Possible Fire Loss calculation. The TPS and TSS gloveboxes are the only programmatic activities that could realistically approach 30g of tritium.

Focus is on protection of the facility worker from exposure to radiological release in the fire scenarios, not from the fire itself, which would be a standard industrial hazard. Given the potentially high radiological consequences to facility workers from fire scenarios, SS controls are necessary for worker protection. The combustible loading SAC is an initial condition for the fire scenarios that ensures combustible loading in the facility is maintained at levels consistent with assumptions for maximum fire severity in the RMA laboratories; this is a SS preventive control that reduces the frequency of significant fire events.

Tritium is stored in the Tritium Facility in various forms and quantities, with the majority stored as solid hydride. Within the Tritium Facility, several types of tritium storage vessels/devices and containers are used internal and external to gloveboxes:

- Tritium storage vessels [Uranium-bed vessels and titanium-bed vessels, commercial tritium getter, molecular (or mole) sieve bed vessels];
- Tritium gas storage vessels (Palladium bed vessels, product vessels, qualified pressure vessels);
- Tritium gas process vessels used for storage (Tritium process manifolds, Tritium skid manifolds);
- Tritium recovery devices (Army eyeballs, telephone dials); and
- Tritium liquid storage containers [water tight containers (e.g., carboys), vacuum pump casings].

Product vessels and qualified pressure vessels used in tritium systems are designed and constructed using American Society of Mechanical Engineers codes and standards applicable to boiler and pressure vessels. Product vessels are filled to less than 1.2 atmospheres. This requirement is designated as a SAC to reduce the likelihood of failure if the vessels are exposed to a fire.

Items containing significant quantities of tritium are robust metal vessels, which can withstand significant increases in pressure prior to failing in a fire, or are stored inside the TPS or TSS gloveboxes. Metal hydride storage beds must be heated to temperatures on the order of 200-400°C for tens of minutes to offgas the absorbed tritium. LLNL concluded from its analyses that due to the magnitude of fire required for these releases, continued occupancy by facility personnel would not be supportable. In other words, facility personnel would be incapacitated by a fire of this size well before tritium would be released into the room. Due to the limited amounts of tritium in individual tritium recovery devices and legacy items, a large fire, again inconsistent with continued human occupancy, would be necessary to release significant quantities of tritium. Developing fires would be readily observable by facility personnel.

LLNL proposed crediting the tritium room monitors to mitigate consequences for a very limited subset of fires that would not be detected by the facility worker. For the remainder of the scenarios, LLNL concluded that personnel exit from the room with the fire is an inherent response to obvious physical danger and that response alone would mitigate worker consequences. The LSO review team agreed with this point, but did not concur with it as the sole protection for the worker. As noted above, multiple SACs covering combustible loading,

vessel pressure and allowable storage conditions were proposed by LLNL. The review team recommended further augmenting the proposed TSR controls.

Multiple options for additional controls were evaluated and discussed with LLNL including the FDAS and FSS, which are currently Equipment Important to Safety (EITS). Given the preference for engineered controls over Administrative Controls (AC), the LSO review team considered elevating the FDAS and/or FSS to SS SSCs. The FSS was concluded to not provide protection to the involved facility worker since the sprinkler heads in the room open between 155-175 °F; temperatures in this range in a facility room are incompatible with continued human occupancy. Data gathered by the LSO Fire Protection Engineer demonstrates that FSS are highly reliable; this is particularly the case in the situation of a facility operating under a nuclear facility maintenance program. The FSS currently meets and is maintained consistent with National Fire Protection Association (NFPA) requirements per existing DOE/NNSA requirements. The review team concluded elevation of the FSS to SS was not warranted. Taking into consideration that fires are limited to a single room and given that fires of the magnitude necessary to breach tritium pressure vessels or drive tritium off storage beds are readily detectable by facility personnel and incompatible with continued occupancy, LSO concluded that the FDAS was additionally not warranted as a SS SSC. For SS designation, DOE-STD-3009 does allow that considerations should be based on engineering judgment of possible effects and the potential added value of SS SSC designation.

LSO would like to additionally provide clarification regarding EITS at LLNL. Reference 1 states that "EITS is not a formally defined safety classification in the context of a safe harbor hazard analysis compliant with Title 10 Code of Federal Regulations (CFR) Part 830, Nuclear Safety Management." While not identified by name in 10 CFR 830.203, EITS is identified in DOE Guide 424.1-1B as integral to the seven questions specified to evaluate the four explicit criteria in 10 CFR 830.203(d). Implementation of the Unreviewed Safety Question (USQ) process codified in 10 CFR 830 requires defining EITS to include both credited safety SSCs (i.e., safety class and safety significant) and a select subset of non-credited SSCs. As described in DOE Guide 424.1-1B, EITS would be that equipment that performs an important DID function. LLNL DSAs call out which equipment should be treated as EITS, establishing a clear understanding with LSO as to the non-credited safety equipment that is of sufficient importance to the approval authority to warrant treatment as EITS in the USQ program. EITS are accordingly identified in all LLNL DSAs. LLNL has additionally identified more stringent quality assurance and procurement requirements for this select set of DID SSCs. Pursuant to the USQ process required by 10 CFR 830, identification as EITS precludes the Contractor from authorizing a change to non-credited EITS if that change can:

- Increase the probability of a malfunction to EITS;
- Increase the consequences of a malfunction of EITS; and
- Create the possibility of a malfunction of EITS of a different type.

The LSO review team concluded that development of training and drills to ensure the appropriate personnel response for the in-room facility worker is critical for protection of the worker in these scenarios; hence, the review team recommends these controls be elevated to a SAC per a COA. Further, while the FDAS and the FSS are not credited controls, it is important to maintain these

systems in accordance with their NFPA requirements. Therefore, the review team additionally recommended TSR Fire Protection Program key elements that ensure these systems continue to be operated and maintained in accordance with NFPA requirements.

There are many layers of DID that provide protection in the event of a room fire. These include:

- Combustible loading limits (SAC);
- Tritium pressure vessel control (SAC);
- Hydrogen species inventory controls (SAC);
- Corridor storage prohibition (SAC);
- Formally defined in room worker fire response, including egress (SAC to be mandated per COA);
- Tritium room monitors (SS SSC);
- Fire detection and alarm system (EITS/TSR Fire Protection Program);
- Fire suppression system (EITS/TSR Fire Protection Program);
- Tritium gas storage vessels (EITS);
- Building structure (EITS);
- Fire Protection Program (Programmatic AC);
- Emergency Preparedness Program (Programmatic AC); and
- On-site Fire Department.

LSO has concluded that this control set provides reasonable assurance of adequate protection of workers, the public, and the environment from the identified hazards consistent with the requirements of 10 CFR 830 and the DOE-STD-3009 safe harbor methodology.

Additional Observations

Natural Gas

Natural gas is supplied to B331 via pipelines entering the two mechanical rooms. The pipelines have manual and seismically-activated shutoff valves outside the facility. The natural gas pipelines end in the mechanical rooms and no natural gas is piped into Increment 1 or 2 RMA laboratories. The walls surrounding the mechanical rooms are six-inch-thick seismic performance category 2 (PC-2) concrete walls that impede propagation of fire into the RMA. The mechanical room has multiple doors that do not lead to RMA laboratory rooms that would blow out to relieve pressure. They also have large vents that will relieve pressure. The explosion itself will not immediately affect tritium in other rooms. The potential for tritium release in other rooms would be driven by the progression of a subsequent fire. Given the robust fire-resistant building construction, and the obvious indications of this event, workers in the facility would be evacuated well before a fire initiating in the mechanical room could spread into adjacent rooms and release tritium; hence, the identification of low consequences to workers from this event. Based on the results of the analyses, no additional SS controls are necessary to protect workers from this hazard. Consistent with the treatment of the natural gas seismic shutoff valves in the other LLNL nuclear facilities, the B331 natural gas seismic gas shutoff valves have been identified to be EITS per the LSO SER.

Emergency Preparedness Hazard Assessment (EPHA)/DSA Dispersion Calculation Input Parameters

The B331 DSA and the LLNL EPHA do use different input parameters and assumptions for the HotSpot modeling code dispersion analysis calculations. There is a valid technical basis for some of the differences, such as selection of different terrain types since the EPHA analyses extend well beyond the site boundary into rural terrain (Standard) while the DSA analyses calculate consequences to on-site co-located workers and the maximally exposed offsite individual (typically at the site boundary) using the terrain type more appropriate for the more urban setting (City).

With respect to the subject safety basis, LSO concurs with the assumptions and dispersion parameters utilized for the B331 DSA consequence modeling.

Glovebox Deflagration

The hydrogen species control is credited in the HA to support prevention of the deflagration event. This safety-significant control (SAC) ensures that in the event of a significant leak from the process piping, manifold, or vessels into the glovebox, the mixture at equilibrium in the glovebox atmosphere will remain below hydrogen's lower flammable limit (LFL), taken conservatively to be 4% by volume, thereby significantly reducing the likelihood of a fire or deflagration in the glovebox. LSO has concluded that further limiting the total hydrogen species in the glovebox volume to 2% is sufficient to protect against deflagration, including a partial volume deflagration. This SER COA adds a safety margin to LLNL's proposed 4% total hydrogen species SAC. The hydrogen species control has been revised from the previously approved annual update to be more restrictive. The existing control limits the amount of hydrogen species in a single vessel in a tritium glovebox to an amount that will prevent reaching 4% hydrogen in the glovebox if the entire contents of one vessel were released. The revised control proposed by the annual update limits the hydrogen species in the entire glovebox to less than 4%. Based on the SER COA, the hydrogen species will be limited to 2% by volume.

As discussed for glovebox leaks, a release of the full volume of hydrogen species in the glovebox is highly improbable due to the nature of the process, where material is distributed in various areas of the box, i.e., in process vessels, on beds, separated by valves inherent to the system design, etc. Additional protection is provided by the glovebox tritium monitors, which alarm upon detection of tritium in the glovebox atmosphere. This indication allows facility workers to take actions to remove the tritium from the glovebox atmosphere using DBATS or the cleanup cart. At a high-level alarm, the tritium glovebox monitors automatically initiate the DBATS. Detection of tritium by the tritium glovebox monitors also secures the bed heaters. The glovebox tritium monitors provide added DID protection against a deflagration involving tritium in the glovebox. LSO considered the monitors sufficiently important to elevate to EITS during the review process. Each of these contributes to protection of the facility worker from deflagration during glovebox operations.

LSO requested and has received an informal interpretation from the NFPA regarding applicability of NFPA 69 to the B331 glovebox operations, i.e., an operation where the flammable gas is within piping inside a glovebox (not a flammable mixture), but could be released in accident scenarios into the glovebox to create a flammable mixture. The NFPA

response indicated that "NFPA 69 is typically intended to protect enclosures where under normal operational conditions, the enclosure contains flammable concentrations of flammable gases...rather than where this may only occur under emergency situations or accident scenarios." The response also stated that "Flammable layering is not directly considered by this standard."

LSO acknowledges that there is some limited potential in the event of a leak for stratification of hydrogen species in the box when the glovebox is operated in an isolated mode. However, hydrogen diffuses very rapidly in air. This precludes local pooling of hydrogen at the site of a leak. Leaking hydrogen is buoyant and would rise in a quiescent glovebox; however, this is counteracted by hydrogen's diffusivity and any turbulence in the box. Faster leaks would result in more turbulent currents in the glovebox, while slow leaks allow more time for diffusion as the leak continues. The buoyancy of hydrogen creates the potential for a volume of hydrogen at the top of the glovebox in the shape of a shallow slab that has a concentration greater than 4%. The 4% LFL for hydrogen limits flame propagation in the upward direction which significantly limits the amount of hydrogen oxidized. Higher concentrations in the range of 9% are required for propagation in any direction. Any concentrated volume in the box would have to be in the range of 9% to achieve combustion of a significant amount of hydrogen. Therefore, LSO concludes that the 2% total hydrogen species SAC required by the SER will provide adequate margin to ensure safe operation of the gloveboxes.

Tritium Room Monitor Uninterruptible Power Supply (UPS)

Loss of normal power to the facility would be immediately obvious to workers. A loss of normal power would affect the entire facility and be immediately noticeable to facility staff. Localized or equipment-specific power failures can result from the lack of supply power or circuit disconnection (e.g., tripped circuit breaker or physically disconnected circuitry). Under normal conditions a failure of the UPS alone would not be noticed by the worker and does not render the SS tritium room monitor inoperable. A failure of UPS can render the tritium monitor inoperable only if accompanied by a coincident loss of normal power. A loss of normal power event would result in work stoppage. Tritium monitor operability is checked prior to opening the RMA. The functionality of tritium monitors would be confirmed after a loss of normal power event. Operability of the tritium room monitors will be protected by Limiting Conditions for Operation. Implementation of tritium room monitors as a SS SSC will require the development of Surveillance Requirement Procedures and a System Design Description, which will define interfaces including those related to the UPS.

CONCLUSION

LSO has concluded that the control set for the B331 Tritium Facility as described in the sections above provides reasonable assurance that the nuclear facility can be operated safely and in a manner that adequately protects workers, the public, and the environment from the identified hazards consistent with the requirements of 10 CFR 830 and the DOE-STD-3009 safe harbor methodology.

REFERENCES

1. Letter (P. Winokur/T. D'Agostino), *Review of Safety Basis for Tritium Facility, Lawrence Livermore National Laboratory*, dated May 16, 2011

2. COR-NSI-12/6/2009-218049 (A. Williams/B. Goodwin), *Scope for the Tritium Facility Documented Safety Analyses and Technical Safety Requirements Annual Update*, dated December 22, 2009

3. Letter (J. Mansfield/T. D'Agostino), *Review of the Tritium Process Station at Lawrence Livermore National Laboratory*, dated January 27, 2010

4. COR-NSI-3/5/2010-238826 (A. Williams/B. Goodwin), *Approval of Justification for Continued Operations for Building 331 Tritium Facility (TS:100023)*, dated March 17, 2010

5. NMTP10-101 (R. Rocha/A. Williams), *Transmittal of the 2010 Update of the Documented Safety Analysis and Technical Safety Requirements for the Tritium Facility – Building 331*, dated December 10, 2010

6. NMTP11-040 (R. Rocha/A. Williams), *Response to Defense Nuclear Facilities Board Letter Concerning Tritium Facility Safety Basis Review*, dated May 27, 2011