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National Nuclear Security Administration

September 11, 2015

The Honorable Joyce L. Connery
Chairman
Defense Nuclear Facilities Safety Board
625 Indiana Avenue NW, Suite 700
Washington, DC 20004

Dear Madam Chair:

This letter responds to the Defense Nuclear Facilities Safety Board request from June 25, 2015, for a better understanding of the Uranium Processing Facility (UPF) confinement ventilation system (CVS) design and performance in a post-seismic condition. The National Nuclear Security Administration (NNSA) has prepared two enclosures for your consideration: 1) "*Technical Evaluation of the UPF Confinement Strategy,*" and 2) "*UPF Confinement Strategy Evaluation Approach.*"

The first enclosure provides an evaluation of the UPF confinement strategy. The UPF confinement strategy consists of a series of physical barriers that prevent or mitigate the unintended release of radioactive materials to the environment. These barriers, which include an active CVS, provide multiple layers of confinement that are designed to mitigate process upsets such as process-related spills, overpressures, fires, and other energetic events. The second enclosure provides a summary of the approach used in the technical evaluation, including identification of technical references used to prepare the report.

Based on an unmitigated analysis, the safety function of the confinement system does not warrant treatment as safety significant or safety class. Consequently, a level one natural phenomena hazard design category is required for the system and its components. Most physical structures that also provide physical barriers to release are being designed to perform a confinement function during and following natural phenomena hazard (NPH) events. Conservatively, such structures are being designed to NPH level two [e.g., seismic design category (SDC)-2]. These barriers provide additional assurance in the integrity of the overall confinement system. Consistent with its safety function, the active CVS is being designed to meet the SDC-1 target performance goal. Thus, the elements of the confinement system will all either meet or exceed the required design criteria, and will function in the confinement design basis event.

The technical evaluation was initiated to demonstrate very high assurance of confinement. However, we subsequently decided to use the active confinement ventilation system (ACVS) as part of the confinement strategy, making such a demonstration unnecessary. We include the evaluation because it demonstrated that passive barriers effectively prevent and mitigate the unintended release of radioactive materials even in the absence of the ACVS. With the ACVS, it is clear that post-seismic consequences would be a small fraction of a rem, consistent with Departmental expectations. The unmitigated analysis of the material at risk demonstrated that the categorization of the confinement ventilation system as SDC-1 is consistent with DOE STD 1189, *Integration of Safety into the Design Process*, and Central Technical Authority guidance.

If you have any questions or need additional information, please contact me, at (865) 576-9850.

Sincerely,

Geoffrey L. Beausoleil
Manager

Enclosures

cc w/enclosures:
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Enclosure 1: Technical Evaluation of the UPF Confinement Strategy
(If you need a copy, please contact Dale Govan at 202-586-1151, or dale.govan@hq.doe.gov)

Enclosure 2: UPF Confinement Strategy Evaluation Approach

The evaluation of the Uranium Processing Facility (UPF) confinement strategy was prepared in accordance with the May 12, 2015 technical determination by the National Nuclear Security Administration (NNSA) Central Technical Authority (CTA). The CTA determined that to meet the requirements of Department of Energy (DOE) Order (O) 420.1C, *Facility Safety*, the confinement system as a whole must be able to provide adequate confinement during and following a design basis seismic event. Design requirements for individual components of the overall confinement system (such as the ventilation system) depend on their post-seismic safety function. The technical evaluation is not a safety design basis document, but rather a qualitative determination that the overall UPF confinement strategy complies with DOE O 420.1C.

The UPF confinement system is a series of physical barriers that prevent or mitigate the unintended release of radioactive materials to the environment. These barriers, which include an active confinement ventilation system (CVS), provide multiple layers of confinement that mitigate process upsets such as process-related spills, overpressure of equipment, process-related fires, and other process-related energetic events. Most physical barriers are designed to perform a confinement function during and following natural phenomena hazard (NPH) events [e.g., seismic design category (SDC)-2] with exception that the CVS is designed to meet the SDC-1 target performance goal.
There are two considerations when evaluating the impact of an NPH event on a facility and the associated consequence: the direct consequence of the event itself and the consequence of secondary causes initiated by the NPH event. For the UPF complex, a seismic event will not directly result in a significant radiological release. Passive confinement structures are designed to SDC-2 and function to mitigate the direct effects of a seismic event. Furthermore, airborne release fractions from spills are very low and only result in minor migration of uranium outside the facility. Examples of these structures are:

- Building structures designed to SDC-2 prevent collapse and associated release of material;
- Process systems with uranium bearing solutions are predominately designed to SDC-2, Limit State D and contain solutions in the event of a design basis seismic event;
- Gloveboxes that have in-process radiological material have SDC-2, Limit State D foundations that prevent collapse of the glovebox. Although the glovebox walls are not designed to SDC-2, their robust design serves to limit material release to a fraction of the material present;
- Structures, Systems, and Components (SSCs) within the facility are designed to prevent adverse system interaction that could result in a radiological release;
- Radiological material staged for processing is restrained in SDC-2 designed racks or staging devices; and
- The majority of radiological material at risk is not susceptible to airborne releases from spills because it is either metal, in SDC-2 designed equipment, or in robust containers such as DOE Manual (M) 441.1-1, *Nuclear Material Packaging Manual*, compliant containers that are qualified for drops.

Therefore, an additional energy source is necessary to initiate a post-seismic release of material outside the facility. The most energetic source with the ability to comprehensively impact the facility material at risk (MAR) is a fire. Since a fire may be initiated by several means, a robust fire prevention and mitigation strategy is employed in the design of the facility. Key fire protection features included in the design that serve to prevent or mitigate significant releases from fires initiated by several means are:

- Separation of fire areas by fire barriers;
- An SDC-2 fire suppression system; and
- Physical separation or protection of radiological material from ignition/combustible sources

Of these three, only the physical separation/protection design features identified by the third bullet were considered in the technical evaluation.

Given that a seismic event by itself will not create significant pathways for radiological release, the technical evaluation concentrates on secondary scenarios that result in exposure of radiological material to a fire. The amount of material exposed is estimated based on physically realistic, conservative assumptions. Factors considered in the conservative estimation of the amount of material exposed are as follows.

- The starting point for MAR estimations was the MAR used in the unmitigated dose consequence calculations for building-wide fires obtained from RP-EF-801768-A057, Revision 0, *Conceptual Safety Design Report for the Uranium Processing Facility*, Y-12 National Security Complex, March 2015 (CSDR). Based upon this MAR, the unmitigated dose consequences for UPF complex-wide fires evaluated in the CSDR did not exceed thresholds requiring safety-significant or safety class controls.
- MAR involved in each unmitigated, building-wide fire was reviewed to determine the location of the material (e.g., MAR located in-process or staged in over-packed containers on racks or in arrays). Two sources were used to assign the MAR by location.
  - RP-EF-801768-A042, Revision 0, *Preliminary Evaluation of Radiological and Toxicological Exposure for the Uranium Processing Facility*, Y-12 National Security Complex, September 2014.
  - RP-OP-801768-A005, Revision 0, *Hazardous Materials Estimates for UPF Alternatives*, Consolidated Nuclear Security L.L.C., Oak Ridge, TN, July 2014.
- The MAR used in the unmitigated analysis was reduced by eliminating quantities confined within over-packed containers located on SDC-2 qualified staging racks or in arrays. Staging racks provide Nuclear Criticality Safety (NCS) controls (e.g., spacing of containers) and, along with arrays, have been identified as Items of Interest (IOIs). IOIs are engineered controls for the protection of radiological materials subject to damage by fire. NCS IOIs are evaluated by Fire Protection Engineering (FPE) to determine the potential for fire damage and to identify control sets that could function to protect the IOI from the thermal effects of a fire (e.g., radiant heat shields, thermal barriers, etc.). The FPE IOI evaluation considered a multitude of fire sources. The fire sources included specific process hazards (e.g., hydraulic systems) as well as sources that are common to most processing areas (e.g., cable trays, ordinary combustibles, etc.). For common fire sources, the design protects the IOI (e.g., IOI located beyond exposure distance from fires involving cable trays and ordinary combustible waste receptacles). It should be noted that the control sets identified for protection of the IOIs do not credit fire resistance of the over-packed containers. The FPE IOI evaluations are documented in the following reports.
  - RP-EZ-801768-A034, Revision A, *Evaluation of Fire Exposure to IOIs UPF SAB/CMREC HLPR and Calcination and Leaching Areas*, Consolidated Nuclear Security, Y-12 National Security Complex, April 2015.
  - RP-EZ-801768-A035, Revision A, *Evaluation of Fire Exposure to IOIs MPB East/Casting Areas*, Consolidated Nuclear Security, Y-12 National Security Complex, April 2015.
  - RP-EZ-801768-A036, Revision A, *Evaluation of Fire Exposure to IOIs MPB West Areas*, Consolidated Nuclear Security, Y-12 National Security Complex, April 2015.
- In addition to the IOI evaluations described above, consideration was also given to seismically-induced fires identified in the current Preliminary Fire Hazards Analysis (PFHA), FH-EF-801768-A001 (FH-EF-801768-A001, Rev. 3) and the draft PFHA (FH-EF-801768-A002, Rev. A) that is being prepared for the current UPF complex design. For instance, the draft PFHA does not identify any

seismically-induced fires in the Casting process area. Therefore, the Casting process area MAR was eliminated from consequence calculations.

- The MAR used in the unmitigated analysis was also reduced to account for inventory limits related to security requirements. Portions of the UPF complex that are not fully-qualified Material Access Areas (MAAs) are subject to inventory restrictions based upon the security attractiveness level of the UPF-specific material forms. For certain forms of uranium, the difference between the MAR conservatively used in the unmitigated analysis and the inventory allowed by security requirements is considerable. Inventory restrictions based on material attractiveness will be administratively controlled via the Nuclear Material Control and Accountability (NMC&A) program.
- A significant portion of the MAR confined within tanks and interconnecting piping has been subtracted from the MAR used in the unmitigated analysis. Tanks and interconnecting piping will be predominately qualified to SDC-2, with the exception of a limited number of glass components (e.g., phase separators). Interconnecting piping not required to be qualified to SDC-2 will be constructed and installed in accordance with the robust requirements of the American Society of Mechanical Engineers (ASME) B31.3 piping code.
- Finally, the conservative MAR used in the unmitigated analysis was further reduced based upon controls on the inventory of uranium chips and UNH crystals. These inventory controls will be evaluated for implementation as Specific Administrative Controls (SACs) in accordance with DOE Standard 1186 (DOE-STD-1186).

The MAR reduction factors discussed above are indicative of the significant degree of conservatism that is associated with the MAR values in the CSDR. For the technical evaluation, the reduced MAR resulting from application of the factors described above was conservatively evaluated for exposure to a significant fire source. Reduced, form-based material inventories, comparable to those in the technical evaluation, will be established in the upcoming UPF Preliminary Safety Design Report (PSDR). Doing so complies with the DOE-STD-1189 provisions for minimizing hazardous material inventory and reducing the degree of conservatism based on evolving design information and is also consistent with the UPF Safety Design Strategy (SDS) intent of "in-process" staging. It should be noted that the MAR has been reduced by approximately 60 percent as a result of transitioning from the single building concept for enriched uranium operations to a multi-building campus approach that replaces 9212 operations only.

The NPH Design Category (NDC) for an SSC is not predetermined. Rather, the NDC determination for each SSC is determined using the approach outlined in DOE-STD-1189, Table A-1. Following unmitigated analysis, typically a mitigated analysis is performed for consequences exceeding co-located and public protection criteria. When performing mitigated analysis, a succession of barriers (both safety features and features providing Defense-in-Depth) are individually applied until the dose consequence has been sufficiently mitigated. To determine the NDC applicable to each individual SSC, DOE STD 1189, Table A-1, is used. Although the CSDR unmitigated analysis did not identify consequences exceeding co-located and public protection criteria, a mitigated analysis for the UPF confinement system was performed as part of the technical evaluation.

When the prevention and mitigation provided by the physical barriers other than CVS is combined with actual security- and process-based MAR values, the calculated dose reduction to the co-located worker and public is significant. Both the UPF Main Process Building (MPB) and Salvage and Accountability (SAB) mitigated radiological dose values are less than 0.5-rem to the off-site receptor and less than 5-rem to the co-located worker. In addition, other factors have been identified that, although not credited as part of the technical evaluation, are expected to further reduce receptor doses (e.g., actual release pathways). Therefore, the technical evaluation of the UPF confinement strategy demonstrates that, without taking any credit for utility of the active CVS, the other physical barriers that comprise the UPF confinement strategy prevent the release through confinement of the radiological materials, except for a small fraction of the radiological material at risk. Since the fraction of material that is still at risk for release following a seismic event results in a conservatively determined consequence of less than 5-rem to the co-located worker, the derived design basis for the active CVS is SDC-1. The technical evaluation was initiated to demonstrate very high assurance of confinement. However, we subsequently decided to use the active confinement ventilation system (ACVS) as part of the confinement strategy, making such a demonstration unnecessary. We include the evaluation because it demonstrated that passive barriers effectively prevent and mitigate the unintended release of radioactive materials even in the absence of the ACVS. With the ACVS, it is clear that post-seismic consequences would be a small fraction of a rem, consistent with Departmental expectations. The unmitigated analysis of the material at risk demonstrated that the categorization of the confinement ventilation system as SDC-1 is consistent with DOE STD 1189, Integration of Safety into the Design Process, and Central Technical Authority guidance.