DOE Headquarters Office of Science

Review of Princeton Plasma Physics Laboratory

Nuclear Facility Hazard Categorization

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Report for Office of Science (SC) – Headquarters (HQ) Review of

Princeton Plasma Physics Laboratory (PPPL) Nuclear Facility Hazard Categorization

Executive Summary:

DOE-HQ Office of Science conducted an off-site review of implementation of DOE-STD-1027-92, *Hazard Categorization and Accident Analysis Techniques for compliance with DOE Order 5480.23, Nuclear Safety Analysis Reports*, "Change Notice 1, September 1997 (see Reference 1) at the PPPL during March and July 2009. The Senior Nuclear Safety Advisor was requested by the SC Deputy Director for Field Operations to verify implementation of DOE-STD-1027 for SC facilities as part of an extent of condition review.

Ten criteria from DOE-STD-1027 and 10CFR830, Subpart B (see Reference 2) were used. Based on an overall review of the findings and observations, the review team concluded that elements of DOE-STD-1027 have been implemented at PPPL. No Hazard Category 1, 2 or 3 nuclear facilities have been declared by PPPL. PPPL self-identified that the required paperwork to demonstrate conformance with ANSI 43.6 was missing for one source. PPPL worked aggressively to convert this source to a special form in July 2009.

The review identified one finding and one observation in accordance with the SCMS procedure, *Quality Assurance and Oversight* (see Reference 12). No Level 1 (**L1**) findings were identified. All ten review criteria were met. PPPL has initiated several actions that provide additional conservatism to ensure facilities remain below the hazard categorization thresholds of DOE-STD-1027. These actions in combination with the low quantities of radio-nuclides and evaluating the entire site's inventory have helped to ensure that PPPL facilities remain below the Hazard Category 3 threshold quantities as identified in DOE-STD-1027.

Report for Office of Science (SC) – Headquarters (HQ) Review of

PPPL Nuclear Facility Hazard Categorization

Background: During the past three years, the Office of Science (SC) has identified several sites that have not appropriately applied use of DOE-STD-1027-92, *Hazard Categorization and Accident Analysis Techniques for compliance with DOE Order 5480.23, Nuclear Safety Analysis Reports*, "Change Notice 1, September 1997, resulting in incorrect hazard categorization of nuclear facilities. 10CFR830, Subpart B, *Safety Basis Requirements*, states that "contractors shall categorize facilities consistent with DOE-STD-1027-92, *Hazard Categorization and Accident Analysis Techniques for compliance with DOE Order 5480.23, Nuclear Safety Analysis Reports*, Change Notice 1, September 1997". Based upon discussions with the SC Deputy Director for Field Operations, the Senior Nuclear Safety Advisor was requested to verify implementation of DOE-STD-1027 for SC facilities as part of an extent of condition review. A review plan (see Reference 3) was prepared utilizing ten criteria from DOE-STD-1027 and 10CFR830 Subpart B. This report documents the review of the PPPL for hazard categorization in conformance with DOE-STD-1027-92, Change Notice 1, September 1997. The review was conducted off-site during March and July 2009 by the Office of Science Senior Nuclear Safety Advisor (SNSA). The U.S. Department of Energy's Princeton Plasma Physics Laboratory (PPPL) is a collaborative national center for plasma and fusion science. Its primary mission is to develop the scientific understanding and the key innovations which will lead to an attractive fusion energy source. Associated missions include conducting world-class research along the broad frontier of plasma science and technology, and providing the highest quality of scientific education. PPPL is operated by Princeton University for the Department of Energy. While PPPL has a wide variety of radiological facility operations, there are no declared Hazard Category 1, 2 or 3 nuclear facilities.

The review utilized the SCMS procedure on *Quality Assurance and Oversight* for categorizing findings and practices. Findings were defined as an identified inadequacy with implementation of a requirement. Findings were categorized as levels 1, 2, or 3. This categorization was necessary to identify the degree of management formality and rigor required for the correction, tracking to closure, and trending of findings. Listed below is an explanation of each of the levels.

- **Level 1 Finding**
  These are issues of major significance that warrant a high level of attention on the part of line management. Typically these reflect a gap in addressing requirements or a systemic problem with implementing the requirements. If left uncorrected, this level of finding could negatively impact the adequacy of operations and/or accomplishment of the SC mission.

- **Level 2 Finding**
  These are issues that represent a non-conformance and/or deviation with implementation of a requirement. Multiple issues at this level, when of a similar nature, may be rolled-up together into one or more Level 1 Findings.

- **Level 3 Finding**
  These are issues where it is recognized that improvements can be gained in process, performance or efficiency already established for meeting a requirement. This level of finding should also include minor deviations observed during oversight activities that have been promptly corrected on the spot and verified as completed. This level includes observations.

Good practices of benefit to other organizations, lessons learned or exemplary performance were also to be identified and documented as noteworthy practices (**NWP**).

The discussion that follows describes the evaluation of each of the ten review criteria identified in the review plan (see Reference 3).

Criterion Evaluation:

1. ***The SC site has categorized facilities consistent with DOE-STD-1027, Change Notice 1. (10CFR830.202)***

PPPL has three sources of radiological inventory as follows: 1) residual tritium inventory associated with the former operation of the Tokamak Fusion Test Reactor (TFTR); 2) radiation source inventory; and 3) neutron activation products due to operation of the National Spherical Torus Experiment (NSTX). Current inventories of all radiological materials (including excluded materials) are approximately 28.93 times the Hazard Category 3 threshold quantities. Two sources have been excluded from the inventory that meet either special form criteria or the sealed source criteria. PPPL self-identified a third source (1.92 times above the Hazard Category 3 threshold quantities) that did not have the required paperwork and converted it to a special form in July 2009. With the exclusion of the three sources, the inventory is 35% of the Hazard Category 3 threshold quantities for all facilities. PPPL has taken a conservative approach by applying the threshold quantities to the site rather than to a specific facility.

PPPL did not have a hazard categorization procedure or regulatory limits to ensure that future missions will remain below the Hazard Category 3 threshold quantities. On April 1, 2009, PPPL modified Section 10 of their ESH Manual. The Manual now adds an explicit requirement to the source acquisition policy to ensure new acquisitions do not exceed the DOE-STD-1027 thresholds.

This criterion was met.

2. ***The SC site has adequately categorized facilities either as Hazard Category 1, 2 or 3 depending only on the quantities of radioactive material in the facility given the threshold quantities in Table A.1 as well as the appropriate ground rules for evaluating the facility (DOE-STD-1027-92, Change Notice 1, Section 3.1).***

PPPL utilizes a series of spreadsheets to identify and track radio-nuclides. Residual tritium inventory from TFTR is summed in Table 1 of the PPPL self assessment. Table 6 of the PPPL self assessment tracks source inventory. The tritium and sealed source inventories are tracked in Table 2. Neutron activation products due to the operation of the National Spherical Torus Experiment (NSTX) were calculated in Table 7 of the self assessment. Table 4 sums all three inventories excluding the three sealed sources described in Criterion 1.

Some discrepancies were identified following a review of the PPPL inventories. DOE-STD-1027 references specific activities from LA-12981-MS and isotope half-life values from ICRP 30. DOE-STD-1027 also references in LA-12846-MS half-lives from the Table of Isotopes, Seventh edition, Lederer and Shirley, 1978. Either document could be used as a basis for half-life values. However, a review of Tables 3 and 7 indicated that half-life values were not consistent with either of these documents (e.g., Ni^{59} 7.5E04 years versus 8.0E04 years). **FIND-L2-01: Some half-life values in the various databases used at PPPL for inventory tracking are not fully consistent with DOE-STD-1027 or its references.** However, it is important to note that the differences are very small and would not result in a change in the current hazard categorization.

PPPL utilized the Hazard Category 3 threshold quantities from DOE-STD-1027 for their inventory database. However, the database does not include any of the Hazard Category 2 threshold quantities to address the potential for criticality. The U^{235} Hazard Category 2 threshold quantity in DOE-STD-1027 is more restrictive than the Hazard Category 3 threshold quantity because of the generic approach described in Footnote 1 of DOE-STD-1027, Table A.1. This item is addressed further in criterion 9.

This criterion was met.

3. ***The SC site has determined final hazard categorization based on an "unmitigated release" of available hazardous material. For the purposes of hazard categorization, "unmitigated" is meant to consider material quantity, form, location, dispersibility and interaction with available energy sources, but not to consider safety features (e.g., ventilation system, fire suppression, etc.) which will prevent or mitigate a release. (DOE-STD-1027-92, Change Notice 1, section 3.1.2)***

Per documentation from PPPL, the locations of the three excluded sources are not near any dispersible energy sources.

This criterion was met.

4. ***As applicable, the SC site has appropriately utilized facility segmentation consistent with the groundrules of Attachment 1 of DOE-STD-1027. (DOE-STD-1027-92, Change Notice 1, Attachment 1, page A-1)***

PPPL did not consider segmentation of any radionuclide inventories at PPPL. Inventories were sufficiently below the Hazard Category 3 threshold for the site (minus excluded sources) so that segmentation was not an issue.

This criterion was met.

5. ***As applicable, exclusions of sealed sources used by the SC site are consistent with 49CFR173.469 or testing specified by ANSI N43.6 for hazard categorization. The facility has documentation that the source or prototypes of the source have been tested and passed the tests specified by DOT or ANSI. The facilities also have a source control policy that complies with DOE Notice 5400.9, "Sealed Source Control Policy" and the source control policy specified in Article 431 of the DOE Radiological Control Manual (DOE-STD-1027-92, Change Notice 1, Attachment 1, page A-1)***

As of July 2009, PPPL excluded three sealed sources from their inventory for determining hazard categorization. The first source (70 Ci Cs^{137}) has documentation to demonstrate meeting the special form requirements of 49CFR173.469. The second source (15.8Ci Pu^{238}-Be) also has documentation to meet the requirements of 49CFR173.469. A third source (~1Ci Pu^{239}) was placed into a Los Alamos National Laboratory (LANL) special form capsule to meet the requirements of 49CFR173.469 during July 2009.

PPPL has a Sealed Source Control and Accountability Program Manual which serves as their Sealed Source Control Policy. This document will be reviewed as part of the Princeton Site Office normal oversight responsibilities and was not evaluated in conjunction with this hazard categorization review.

No discrepancies were identified with the Sealed Source leak testing data.

This criterion was met.

6. ***As applicable, exclusions of commercially available products used by the SC site for hazard categorization are consistent with 10CFR30, Parts 30.11-30.19 and include timepieces, illumination devices, thermostats, electron tubes, microwave receiver tubes, etc. (DOE-STD-1027-92, Change Notice 1, Attachment 1, page A-2)***

PPPL does not exclude any commercially available products from their inventory.

This criterion was met.

7. ***As applicable, exclusions of material contained in DOT Type B shipping containers (with or without overpack) with current certificates of compliance used by the SC site for hazard categorization are consistent with Attachment 1. Materials stored are authorized by the certificate. (DOE-STD-1027-92, Change Notice 1, Attachment 1, page A-2)***

PPPL does not credit any DOT Type B shipping containers for excluding radiological materials.

This criterion was met.

8. ***As applicable, the SC site has appropriately categorized facilities that are involved with an inventory of hazardous materials that vary with time on the basis of their maximum inventory of hazardous materials. (DOE-STD-1027-92, Change Notice 1, Attachment 1, page A-2)***

PPPL has such low levels of radiological inventory that tracking of materials between the respective facilities is not necessary.

This criterion was met.

9. ***As applicable, the SC site has categorized facilities consistent with Attachment 1 related to the potential for criticality for the lower threshold values of three isotopes (Pu^{239}, U^{233} and U^{235}). (DOE-STD-1027-92, Change Notice 1, Attachment 1, page A-12)***

Per the master inventory listing, currently PPPL has Pu^{239} and U^{235} materials. No U^{233} is currently on-site. Excluding the three sources, the quantities of the two existing isotopes are very small. There is currently no potential for criticality based upon the results of inventory listing. However, the inventory listing does not account for criticality. In the event that the mission of PPPL would change and additional Pu^{239}, U^{233} or U^{235} would be introduced on site, the inventory does not currently contain features to ensure that there would be no potential for criticality. **FIND-L3-02: PPPL should consider amending the master inventory listing to ensure that fissile materials are summed and maintained below the potential for criticality values. This is an observation.**

This criterion was met.

10. ***Exemptions to 10CFR830, Subpart B are consistent with 10CFR820 Subpart E. (10CFR830, page 1816-1817 and 10CFR820.60)***

There are currently no Safety Assessment Documents under DOE O 420.2B (See Reference 4) at PPPL. PPPL does not exclude any radiological materials associated with accelerators (as allowed under the definition of non-reactor nuclear facility in 10CFR830, Subpart B) from their master inventory listing. PPPL has not utilized other exemptions or exclusions from 10CFR830, Subpart B.

This criterion was met.

Summary of Findings: This review identified no Level 1 findings, one Level 2 finding and one Level 3 finding. Listed below is each of the findings:

Level 1 Findings:
None

Level 2 Findings:
FIND-L2-01: Some half-life values in the various databases used at PPPL for inventory tracking are not fully consistent with DOE-STD-1027 or its references.

Level 3 Findings:
FIND-L3-03: PPPL should consider amending the master database listing to ensure that fissile

materials are summed and maintained below the potential for criticality values. This is an observation.

Noteworthy Practices:
No noteworthy practices were identified.

Conclusion:
PPPL currently has no declared any Hazard Category 1, 2 or 3 nuclear facilities. PPPL self-identified inadequate paperwork for one sealed source and took steps to have it encapsulated to meet the special form criteria for exclusion from inventory. Small discrepancies exist between the half-life values used in the PPPL databases and those referenced in DOE-STD-1027 but these would not result in a change to hazard categorization. Generally, PPPL has put into place a robust system to ensure that facilities remain below the DOE-STD-1027 threshold quantities. All ten criteria were met.

Documents reviewed:
- J. Levine, Assessment of PPPL Radionuclide Inventories for Applicability of 10CFR830, Subpart B, March 6, 2009
- Table 1, Residual TFTR Tritium Inventory, no date
- Table 2 – Cumulative PPPL Residual TFTR Tritium and Source Inventory, January 2009
- Table 3 – Assessment of Maximum NSTX Activation products (After 1E17 DD Neutrons), no date
- Table 4 – Assessment of PPPL Total radionuclide Inventory (Residual TFTR Tritium + NSTX Activation + Sources), no date
- Table 5 Analysis for Decay products, no date
- Table 6, PPPL Source Inventory, January 2009
- Table 7 – Specific Radioactivity Due to Neutron Activation of NSTX Components, no date
- IAEA Certificate of Competent Authority Special Form Radioactive Materials Certificate Number USA/0043/S-96, Revision 11, May 4, 2007 (Pu^{238}-Be source)
- Martinez, Abeyta, Leonard, Tompkins and Leonard, Development and Certification of a Special Form Capsule (Model II) for Sealed Sources to facilitate Transportation and Storage as Special Form Material, no date (Pu^{239}-Be source paperwork)
- Excluded Cs^{137} source paperwork, October 1, 1990
- E-mail from L. Dietrich to C. Sohn, PPPL Nuclear Facility Assessment, March 10, 2009
- E-mail from L. Dietrich to C. Sohn, Questions regarding PPPL Nuclear Facility Assessment, April 1, 2009
- E-mail from L. Dietrich to C. Sohn, Questions regarding PPPL Nuclear Facility Assessment, April 2, 2009
- E-mail from L. Dietrich to C. Sohn, Questions regarding PPPL Nuclear Facility Assessment, April 3, 2009
- Source Control Policy -- From PPPL ES&H Manual Section 10, "Radiation Safety"
- PPPL Site Map, version May 3, 2007

Interviews conducted:
- Princeton Site Office ES&H Manager

Observations completed:
- None

References:

1. DOE-STD-1027-92, Change Notice 1, *Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23, Nuclear Safety Analysis Reports*, September 1997.

2. 10CFR830, Subpart B, *Safety Basis Requirements*, January 10, 2001

3. *DOE Headquarters Office of Science Review Plan Review of SC Facilities Nuclear Facility Hazard Categorization*, January 12, 2009

4. DOE O 420.2B, *Safety of Accelerator Facilities*, July 23, 2004.

5. LA-12981-MS UC-940, *Table of DOE-STD-1027-92 Hazard Category 3 Threshold Quantities for the ICRP-30 List of 757 Radionuclides, LANL Fact Sheet*, Revised October 16, 2002.

6. ICRP-30, Volumes I-IV, International Commission on Radiological Protection, *Limits on Intakes of Radionuclides by Workers.*

7. DOE Order 414.1C, *Quality Assurance*, July 7, 2005

8. ANSI/HPS N43.6-1997, *Sealed Radioactive Sources*, Health Physics Society, November 1997

9. 49CFR173.469, *Tests for special form Class 7 (radioactive) materials*, January 2007

10. 49CFR173.476, *Approval of Special form Class 7 materials*, January 2007

11. 49CFR173.403, *Definitions*, January 2007

12. Office of Science Management System, Procedure 1, *Managing Issues Identified in Oversight Activities*, March 2008