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July 8, 2009

Mr. Jeffrey Makiel
Federal Project Director for NSTX Upgrades
Princeton Site Office
U.S. Route 1 North at Sayre Drive
P.O. Box 451
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References

(1) " Hazard Analysis Assessment for the National Spherical Torus Experiment (NSTX) Upgrade Project " J. Makiel to A. Cohen. May 20, 2009.
(2) DOE-STD-1027-02
(3) 10CFR830, subpart B

Dear Mr. Makiel,

Pursuant to your correspondence dated May 20, 2009 (Ref 1) please be advised that the NSTX Activity Certification Committee (ACC) has convened to address the following;

1. Review a Preliminary Hazard Analysis Report for the upgrades planned by the MIE Project;
2. NSTX is currently considered a "below hazard category 3" facility. Upon completion of the MIE project, will this designation change? When performing the assessment, other planned modifications by the NSTX Program outside the MIE project between now and CD-4 (2014) should be considered as well as any operational considerations involving experimental run time;
3. Evaluate the work scope for Questions 1 and 2 in aggregate, as well as individually, should work scope be severed at a later date within the Project.

In response to item 1, an NSTX Upgrades Project Preliminary Hazard Analysis document has been developed and reviewed by the ACC. The preliminary hazard analysis (which builds upon the NSTX Safety Analysis Document) shows that the two planned upgrades, individually and collectively, will have negligible impact at PPPL and the environment. The operation of NSTX, post the planned upgrades, continues to fall well within the established safety parameters and classification currently in place for NSTX machine operations at PPPL.

In response to item 2, the ACC analyzed the two upgrades, which include(s); enhanced capability to the center stack assembly (higher magnetic fields), and the inclusion of a second neutral beam injector (increased heating and current drive). Upon technical review, in accordance with DOE-STD-1027-02, and 10CFR830 subpart B, analysis shows that employing a conservative NSTX run schedule, and a single compartment model, where by all radioactive sources (including products of activation) at PPPL are appropriately weighted and summed, NSTX, post the planned upgrades, will continue to be classified as "below hazard category 3" facility.

At this time the ACC is not aware of any sub-system upgrade(s), outside of the MIE, which would impact the NSTX " below hazard category 3 facility" classification. As the ACC is an on-going review process any new sub-systems that could have future impact would be reviewed prior to implementation. At this time none are known.

In response to item 3, technical analysis of the planned upgrades, for the purpose of hazard classification, have been performed in the aggregate and individually. Any reduction in work scope associated with the upgrades would not result in a change to the " below hazard category 3" facility classification.

Supporting technical analysis and data for the above will be made part of the NSTX Upgrade Project CD-1 submittal package.

Please do not hesitate to contact me if there are any questions.

Sincerely,

Adam Cohen
Deputy Director
Princeton Plasma Physics Laboratory

Concurrence:

Charles Gentile
ACC Chair

Erik Perry
NSTX Upgrade Project Manager

NSTX Nuclear Facility Hazard Classification
-Presently and Post Upgrades-

NSTX ACC Presentation to the PPPL ES&H Executive Safety Board

L. Dietrich, C. Gentile, H. Kugel, J. Lacenere, J. Levine, G. Pitonak, A. vonHalle

August 4, 2009

Outline

- Regulatory Requirements
- Nuclear Facility Hazard Classification Criteria
- Results of Analysis
- External Evaluation
- Conclusions

Regulatory Requirements

- 10 CFR 830 subpart B, Safety Basis Requirements

  - Defines nuclear facility hazard classification categories (nuclear hazard categories 1,2, and 3).

  - If below hazard classification 3, then 10 CFR 830 subpart B does not apply.

- DOE-STD-1027, Hazard Categorization Standard

  - Sets requirements based on quantities of nuclear materials in site inventory.

  - Inventory quantities used to determine nuclear hazard classification in accordance with the requirements of 10 CFR 830 subpart B.

Nuclear Facility Hazard Classification Criteria

- Hazard Category 1 - Nuclear Facilities which can have potential for a significant off-site consequence (i.e. > 20 MW(t)).

- Hazard Category 2 - Nuclear Facilities which can have potential for significant on-site consequence and have inventories that meet the threshold values of DOE-STD-1027.

- Hazard Category 3 - Nuclear Facilities which can have potential for significant localized consequence and have inventories that meet the threshold values of DOE-STD-1027 (TFTR like devices).

- Radiological Facilities (PPPL) have nuclear inventories < Hazard Category 3. Are not subjected to 10 CFR 830 subpart B requirements for Safety Analysis Documentation. Are not subjected to potential Price Anderson Act violations associated with 10 CFR 830 subpart B non-compliance issues.

Results of Analysis

- Bounding Condition(s) : PPPL (viewed) and analyzed as a single compartment model. All site nuclear materials : nuclear sources, prompt activation, tritium, used (tabulated) in making determination of NSTX and site category. Currently NSTX (and PPPL) are categorized as a "Below Category 3 Nuclear Facility". Thus in our case 10 CFR 830 subpart B does not apply.

- Analysis of NSTX post upgrades, employing current site nuclear inventory values, show that NSTX, as well as PPPL, will remain a "below Category 3 Nuclear Facility". Assumes that NSTX will be limited to 4×10^{18} DD neutrons / year and the site inventory (non-NSTX radionuclide inventory will remain at the current levels). Post upgrade site will be ~ 0.35 below the threshold for cat. 3 nuclear facility. Full analysis in "Assessment of Applicability of 10 CFR 830 subpart B to NSTX Planned Upgrades" report dated July 7, 2009. J. Levine, J. Menard, et al.

- If site wide nuclear inventory changes (new machine, new sources) classification could change. In this case the site could be analyzed as a multiple compartment model, similar to what was done at PPPL during TFTR D-T operations.

External Evaluation (DOE HQ) For Current Conditions

- External review by DOE HQ (Carol L. Sohn) has recently evaluated the the current condition of the PPPL site for nuclear facility hazard classification, and has determined in a report dated July 8, 2009 that ;

  - * “PPPL has put into place a robust system to ensure that facilities remain below the DOE-STD-1027 threshold quantities”.

  - “PPPL is a below category 3 nuclear facility”.

* some DOE sites have moved into a category 3 nuclear facility classification without knowing it. PPPL site controls are in place to ensure that this not occur here.

Conclusion

- Technical analysis shows that with the inclusion of a second NB and new CS, NSTX (as well as PPPL) will continue to remain a “below Hazard Category 3” Facility. NSTX Safety Certificate post upgrades will limit D-D neutron production to $4x10^{18}$ n / year.
- 10 CFR 830 subpart B will not apply to the NSTX upgrades or to the current PPPL (radiological) configuration.
- The PPPL site will continue to be a “Radiological Facility” post the upgrades (assuming no new D-D or D-T devices or large sources are installed at the site).
- If new capability / assets are added to the site, re-evaluation of site conditions applicable to DOE-STD-1027 and 10 CFR 830 subpart B will need to be addressed.
- A documentation package evaluating this issue will filed in the PPPL Operations Center and available for the CD-1 review.

ASSESSMENT OF APPLICABILITY OF 10CFR830, SUBPART B TO NSTX WITH PLANNED UPGRADES

REFERENCES:

1. Letter, J. Makiel (DOE-PSO) to A. Cohen (PPPL), "Hazard Assessment for the National Spherical Torus Experiment (NSTX) Upgrade Project", 5/20/09.

2. Letter, J. Levine (PPPL) to J. Faul (DOE-PSO), "Assessment of PPPL Radionuclide Inventories for Applicability of 10CFR830, Subpart B", 3/9/09.

Reference 1 requested an assessment of the planned major item of equipment (MIE) project for upgrades to NSTX with respect to its current status as a Below Hazard Category 3 facility. These planned upgrades consist of the installation of a new center stack (CS), and installation of a second neutral beam injector (NBI). Reference 1 asked that this assessment be performed considering the two components of the MIE project in aggregate, as well as individually. In addition, any impacts from other planned NSTX modifications outside the MIE project (none are known that would impact this assessment), as well as operational considerations involving experimental run time should be considered.

In March 2009, an assessment of existing PPPL radionuclide inventories, including those associated with NSTX, was performed to determine the status of the Laboratory with respect to 10CFR830 Subpart B applicability (i.e., to identify any Category 3 nuclear facilities). In that assessment, which was documented in Reference 2, the nuclear facility hazard categorization methodology of DOE-STD-1027-92 ("Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23, Nuclear Safety Analysis Reports", Change Notice No. 1) was used. In particular, this methodology requires that facilities or facility segments where there are combinations of radioactive materials should be designated as Category 3 if the sum of the ratios of the quantity of each material to the Category 3 thresholds in Table A.1 of the Standard exceeds one (e.g., [inventory of isotope A/threshold of isotope A] + [inventory of isotope B/threshold of isotope B] + [inventory of isotope n/threshold of isotope n] >1). Facilities designated as Category 3 must comply with the applicable requirements of 10CFR830, Subpart B. The Reference 2 assessment determined that PPPL has no facilities that would be designated Category 3 (or higher) nuclear facilities.

The NSTX experiment generates 2.5 MeV neutrons through the fusion of deuterium fuel, which results in activation of materials in nearby components including the torus vacuum vessel, center stack, support structure, and external poloidal field (PF) and toroidal field (TF) coils. Table 1, which is reproduced from Reference 2, provides the sum of the activities of each NSTX activation isotope (assuming approximately a year's worth of current NSTX generation of 1E17 neutrons), comparisons with the Category 3 thresholds, and summation of the radionuclide threshold ratios. As indicated in Table 1, the summation of NSTX radionuclide threshold ratios that determines nuclear facility status is dominated by three short-lived isotopes; Na-24, Mn-56, and Cu-64. These isotopes contribute 98.3% of the summation total, with Mn-56 alone representing 84.4% of the contribution. Thus, this assessment of the impacts of the MIE project on nuclear facility status focuses on these three principal radionuclides.

Table 2 lists the projected neutron production rates for the NSTX upgrades, along with the rates from current NSTX experiments. These rates are used to estimate the expected generation of the principal

isotopes mentioned above with the upgrades in place. For this assessment, the following simplifying assumptions were made to conservatively estimate the NSTX radionuclide inventories:

- NSTX runs for two weeks for the year.
- During the first run week (Monday through Friday), NSTX generates its total neutrons for the year (from Table 2) less the amount to be generated during the second week.
- NSTX does not operate over the following weekend.
- NSTX generates the maximum daily amount of neutrons in Table 2 for each of five (5) consecutive days during the second run week (Monday through Friday).
- No decay of the three principal isotopes takes place during the first or second run weeks[1].
- Normal decay of the three principal isotopes takes place during the interval between the end of the first run week and the beginning of the second run week (assumed to be 60 hours[2]).

The results of the assessment are shown in Table 3. The summation of radionuclide threshold ratios is shown for each NSTX upgrade possibility: second NBI only, new CS only, and new CS plus second NBI. Using the 98.3% contribution of the three principal isotopes to the summation total, as indicated above, the overall maximum summations of radionuclide threshold ratios would be:

A. 2^{nd} NBI Only – 0.0196

B. New CS Only – 0.1475

C. New CS + 2^{nd} NBI – 0.2950

All of these summations are <1.

The possibility that the production of daughter products from the decay of NSTX radionuclides could rise to the Category 3 thresholds has also been examined. As noted in Table 5 of Reference 2, most radionuclides generated by neutron activation (including the three principle ones) decay to stable isotopes. For those that don't, Mo-99 and Mo-101, the maximum inventories of the resultant decay products (Tc-99m and Tc-101) would be too small (1.8 Ci and 56 Ci, respectively, for the new CS + 2^{nd} NBI upgrade) relative to their Category 3 thresholds (1.70E+04 Ci and 1.62E+05 Ci, respectively) to change the conclusions regarding the summation of the radionuclide threshold ratios indicated above.

It should be noted that when the residual TFTR tritium and PPPL source inventories reported in Reference 2 are also considered, the maximum summation of radionuclide threshold ratios for PPPL after implementation of the NSTX upgrades would be ≤ 0.645, which is <1.

[1] This is a conservative assumption. 96% of Mn-56 generated during an operating day would, for example, be expected to decay away in the intervening 12 hours before operations resume the next day.

[2] For example, the interval between 7:00 PM Friday and 7:00 AM the following Monday is 60 hours.

ASSESSMENT OF APPLICABILITY OF 10CFR830, SUBPART B TO NSTX WITH PLANNED UPGRADES

Conclusion

Based on the classification criteria of DOE-STD-1027-92 and the above discussion, NSTX would continue to be designated a Below Hazard Category 3 facility after implementation of all, or any part, of the planned MIE project. The requirements of 10CFR830, Subpart B would not apply to the NSTX Upgrade Project.

Prepared By: Jerry D. Levine, Head, Environment, Safety & Health

Jerry Levine

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Table 2 Projected Neutron Production Rates for NSTX Upgrades

NSTX capability	Increase in neutrons per shot relative to present NSTX	MAX neutrons per shot	MAX neutrons per day	Estimated total neutrons per year	MAX neutron rate [1/s]	Shots per day	Current [MA]	Toroidal field [T]	NBI power [MW]	Pulse length [s]
Present NSTX	1.0	4.0E+14	1.3E+16	8.0E+16	4.0E+14	32	1.2	0.5	6	1
2nd NBI only	2.5	1.0E+15	3.2E+16	2.0E+17	1.0E+15	32	1.2	0.5	8	1
New CS only	25.0	1.0E+16	2.4E+17	2.0E+18	2.0E+15	24	2	1	5	5
New CS + 2nd NBI	50.0	2.0E+16	4.8E+17	4.0E+18	4.0E+15	24	2	1	10	5

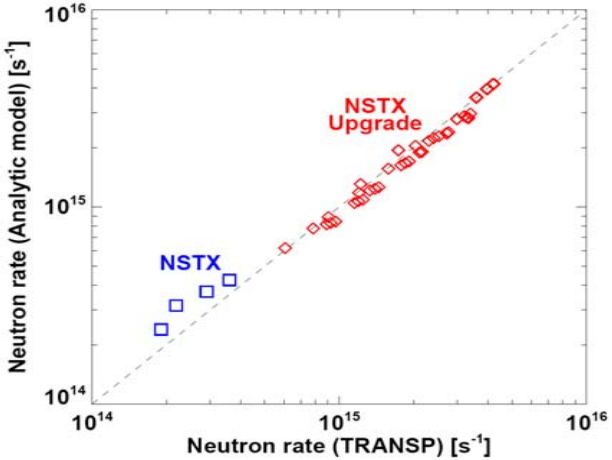

Table 1 Assessment of Maximum NSTX Activation Products (After 1E17 DD Neutrons)

Isotope	Half-Life	Bq/gm [1]	Ci/lb	Maximum Total Ci [2]	Cat 3 Threshold (Ci)	Max Ci/Cat 3 [3]
H-3	1.23E+01 Yr	1.98E-06	2.42E-14	**3.15E-09**	**1.60E+04**	**1.97E-13**
C-14	5.73E+03 Yr	5.54E-05	6.78E-13	**8.82E-08**	**4.20E+02**	**2.10E-10**
Na-24	1.50E+01 Hr	7.40E+01	9.06E-07	**1.18E-01**	**3.00E+02**	**3.93E-04**
Si-31	2.62E+00 Hr	1.71E+02	2.09E-06	**2.72E-01**	**3.20E+05**	**8.50E-07**
P-32	1.43E+01 Dy	1.28E-01	1.57E-09	**2.04E-04**	**1.20E+01**	**1.70E-05**
P-33	2.53E+01 Dy	3.97E-04	4.86E-12	**6.31E-07**	**9.40E+01**	**6.71E-09**
S-35	8.72E+01 Dy	9.54E-04	1.17E-11	**1.52E-06**	**7.80E+01**	**1.95E-08**
Cl-36	3.01E+05 Yr	2.25E-08	2.76E-16	**3.59E-11**	**3.40E+02**	**1.06E-13**
Ar-39	2.69E+02 Yr	1.04E-05	1.27E-13	**1.65E-08**	**4.00E+04**	**4.13E-13**
K-42	1.24E+01 Hr	1.31E+01	1.61E-07	**2.09E-02**	**4.60E+03**	**4.54E-06**
K-43	2.23E+01 Hr	1.94E-03	2.38E-11	**3.09E-06**	**1.16E+03**	**2.66E-09**
Ca-45	1.63E+02 Dy	3.58E-02	4.39E-10	**5.70E-05**	**1.10E+03**	**5.18E-08**
Ca-47	4.54E+00 Dy	2.24E-03	2.75E-11	**3.57E-06**	**7.00E+02**	**5.10E-09**
Sc-47	3.43E+00 Dy	2.36E-01	2.90E-09	**3.76E-04**	**5.80E+03**	**6.48E-08**
Cr-51	2.77E+01 Dy	3.10E+01	3.80E-07	**4.94E-02**	**2.20E+04**	**2.25E-06**
Mn-54	3.12E+02 Dy	2.52E-01	3.09E-09	**4.01E-04**	**8.80E+02**	**4.56E-07**
Mn-56	2.58E+00 Hr	1.81E+04	2.22E-04	**2.89E+01**	**2.80E+03**	**1.03E-02**
Fe-55	2.68E+00 Yr	5.45E-01	6.68E-09	**8.68E-04**	**5.40E+03**	**1.61E-07**
Fe-59	4.46E+01 Dy	4.86E-01	5.96E-09	**7.74E-04**	**6.00E+02**	**1.29E-06**
Co-58	7.08E+01 Dy	5.78E+00	7.08E-08	**9.21E-03**	**9.00E+02**	**1.02E-05**
Co-58m	9.10E+00 Hr	1.07E+03	1.31E-05	**1.70E+00**	**6.20E+06**	**2.74E-07**
Co-60	5.27E+00 Yr	4.80E-01	5.88E-09	**7.64E-04**	**2.80E+02**	**2.73E-06**
Co-60m	1.05E+01 Mn	9.88E+04	1.21E-03	**1.57E+02**	**5.80E+07**	**2.71E-06**
Co-61	1.65E+00 Hr	7.86E-01	9.63E-09	**1.25E-03**	**8.00E+04**	**1.56E-08**
Ni-59	8.00E+04 Yr	1.55E-04	1.90E-12	**2.47E-07**	**1.18E+04**	**2.09E-11**
Ni-63	1.00E+02 Yr	5.02E-02	6.15E-10	**8.00E-05**	**5.40E+03**	**1.48E-08**
Ni-65	2.52E+00 Hr	2.84E+02	3.48E-06	**4.52E-01**	**9.00E+03**	**5.02E-05**
Cu-64	1.27E+01 Hr	1.27E+05	1.55E-03	**2.02E+02**	**1.54E+05**	**1.31E-03**

As-76	1.10E+00 Dy	2.35E+00	2.88E-08	**3.74E-03**	**2.60E+03**	**1.44E-06**
Zr-93	1.50E+06 Yr	1.10E-09	1.35E-17	**1.75E-12**	**6.20E+01**	**2.82E-14**
Zr-95	6.40E+01 Dy	3.80E-03	4.66E-11	**6.06E-06**	**7.00E+02**	**8.66E-09**
Nb-93m	1.36E+01 Yr	5.95E-02	7.29E-10	**9.47E-05**	**2.00E+03**	**4.74E-08**
Nb-94	2.00E+04 Yr	2.47E-04	3.03E-12	**3.93E-07**	**2.00E+02**	**1.97E-09**
Mo-93	3.50E+03 Yr	6.60E-05	8.08E-13	**1.05E-07**	**2.00E+03**	**5.25E-11**
Mo-99	2.75E+00 Dy	6.00E+01	7.35E-07	**9.55E-02**	**3.40E+03**	**2.81E-05**
Mo-101	1.46E+01 Mn	3.94E+03	4.83E-05	**6.28E+00**	**9.00E+04**	**6.98E-05**
Ag-108m	1.30E+02 Yr	4.23E-04	5.18E-12	**6.73E-07**	**2.00E+02**	**3.37E-09**
Ag-110m	2.50E+02 Dy	5.10E-01	6.24E-09	**8.11E-04**	**2.60E+02**	**3.12E-06**
Pb-205	1.51E+07 Yr	4.27E-14	5.22E-22	**6.79E-17**	**2.40E+03**	**2.83E-20**
Pb-209	3.28E+00 Hr	7.13E-03	8.73E-11	**1.14E-05**	**6.20E+05**	**1.84E-11**
Bi-210	5.01E+00 Dy	4.93E-05	6.04E-13	**7.85E-08**	**3.20E+02**	**2.45E-10**
Bi-210m	3.00E+06 Yr	4.31E-13	5.28E-21	**6.87E-16**	**7.20E+00**	**9.54E-17**

Summation of Radionuclide Threshold Ratios **1.22E-02**

NOTES

1 Specific activity 0 seconds after generation of 1.00 E17 DD neutrons at the rate of 2.00 E14 neutrons per second for 500 seconds.

2 Maximum total Ci for each isotope is obtained by multiplying the T=0 specific activity in Ci/lb by the total combined weight of the NSTX structure, which includes the vacuum vessel, center stack, support struture, and external PF and TF coils. This total combined weight is 130,000 lbs (from the NSTX Status Report darted 2/10/95).

3 Sum of Max Ci/Cat 3 ratios for Na-24, Mn-56 and Cu-64 is 1.20E-02, representing 98.3% of the total NSTX Summation of Radionuclide Threshold Ratios.

Table 3 Assessment of Maximum NSTX Activation Products for Upgrade Scenar

A. 2nd NBI Only (2E17 Neutrons/yr; 4E16 Neutrons 1st week, 1.6E17 Neutrons 2nd week)

Isotope	Half-Life	Cat 3 Threshold (Ci)	Maximum Total Ci after 1st Week [1]	Max Ci/Cat 3 after 1st Week	Residual Ci @ Start of 2nd Week [2]	Maximum Total Ci after 2nd Week + Residual [3]	Max Ci/Cat 3 after 2nd Week
Na-24	1.50E+01 Hr	**3.00E+02**	**4.72E-02**	**1.57E-04**	**2.95E-03**	**1.92E-01**	**6.40E-04**
Mn-56	2.58E+00 Hr	**2.80E+03**	**1.16E+01**	**4.14E-03**	**1.16E-06**	**4.62E+01**	**1.65E-02**
Cu-64	1.27E+01 Hr	**1.54E+05**	**8.08E+01**	**5.25E-04**	**3.05E+00**	**3.26E+02**	**2.12E-03**
Summation of Radionuclide Threshold Ratios				**4.82E-03**			**1.93E-02**

Table 3 Assessment of Maximum NSTX Activation Products for Upgrade Scenar

B. New CS Only (2E18 Neutrons/yr; 8E17 Neutrons 1st week, 1.2E18 Neutrons 2nd week)

Isotope	Half-Life	Cat 3 Threshold (Ci)	Maximum Total Ci after 1st Week [1]	Max Ci/Cat 3 after 1st Week	Residual Ci @ Start of 2nd Week [2]	Maximum Total Ci after 2nd Week + Residual [3]	Max Ci/Cat 3 after 2nd Week
Na-24	1.50E+01 Hr	**3.00E+02**	**9.44E-01**	**3.15E-03**	**5.90E-02**	**1.48E+00**	**4.93E-03**
Mn-56	2.58E+00 Hr	**2.80E+03**	**2.31E+02**	**8.25E-02**	**2.31E-05**	**3.47E+02**	**1.24E-01**
Cu-64	1.27E+01 Hr	**1.54E+05**	**1.62E+03**	**1.05E-02**	**6.12E+01**	**2.49E+03**	**1.62E-02**
Summation of Radionuclide Threshold Ratios				**9.62E-02**			**1.45E-01**

Table 3 Assessment of Maximum NSTX Activation Products for Upgrade Scenar

C. New CS + 2nd NBI (4E18 Neutrons/yr; 1.6E18 Neutrons 1st week, 2.4E18 Neutrons 2nd

Isotope	Half-Life	Cat 3 Threshold (Ci)	Maximum Total Ci after 1st Week [1]	Max Ci/Cat 3 after 1st Week	Residual Ci @ Start of 2nd Week [2]	Maximum Total Ci after 2nd Week + Residual [3]	Max Ci/Cat 3 after 2nd Week
Na-24	1.50E+01 Hr	**3.00E+02**	**1.89E+00**	**6.30E-03**	**1.18E-01**	**2.95E+00**	**9.83E-03**
Mn-56	2.58E+00 Hr	**2.80E+03**	**4.62E+02**	**1.65E-01**	**4.61E-05**	**6.94E+02**	**2.48E-01**
Cu-64	1.27E+01 Hr	**1.54E+05**	**3.23E+03**	**2.10E-02**	**1.22E+02**	**4.97E+03**	**3.23E-02**
Summation of Radionuclide Threshold Ratios				**1.92E-01**			**2.90E-01**

NOTES

1 Calculated by multiplying Maximum Total Ci in Table 1 for each isotope by ratio of 1st week neutrons generated to 1E17.
2 Calculated from product of maximum total Ci after 1st Week and exp (-Lambda*T), where T=60 hours,
and Lambda= ln2/half-life to account for isotope decay over the weekend between the two run weeks.
3 Calculated by multiplying Maximum Total Ci in Table 1 for each isotope by ratio of 2nd week neutrons generated to 1E17
then adding residual Ci at start of 2nd week.

National Spherical Torus Experiment

NSTX UPGRADE PROJECT

PRELIMINARY HAZARDS ANALYSIS

Revision 0

July 8, 2009

Prepared By: Jerry D. Levine, Head, Environment, Safety & Health

Jerry Levine

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NSTX Upgrade Project Preliminary Hazard Analysis

Hazard	**Barrier**
Radiation:	_ 2nd NBI Only: Estimate maximum of 0.0097 Ci/yr of tritium produced (based on 2.0E17 DD neutrons/yr projected generation rate). If released, dose at nearest business would be <3E-5 mrem/yr. 40CFR61 Subpart H limit is 10 mrem/yr, and EPA approval to construct is required at 0.1 mrem/yr. New CS Only: Estimate maximum of 0.0969 Ci/yr of tritium produced (based on 2.0E18 DD neutrons/yr projected generation rate). If released, dose at nearest business would be <3E-4 mrem/yr. 40CFR61 Subpart H limit is 10 mrem/yr, and EPA approval to construct is required at 0.1 mrem/yr. New CS + 2nd NBI: Estimate maximum of 0.1938 Ci/yr of tritium produced (based on 4.0E18 DD neutrons/yr projected generation rate). If released, dose at nearest business would be ~5E-4 mrem/yr. 40CFR61 Subpart H limit is 10 mrem/yr, and EPA approval to construct is required at 0.1 mrem/yr. _ Personnel occupancy of the NTC and other areas deemed necessary by Health Physics will be excluded during plasma operation and neutral beam conditioning. _ Maximum offsite dose from operations will be (scaled based on NSTX SAD Table 3): 3E-4 mrem/yr for 2nd NBI Only; 3E-3 mrem/yr for New CS Only; and 6E-3 mrem/yr for New CS + 2nd NBI (limit is 10 mrem/yr). Maximum worker dose will be ≤1000 mrem/yr (limit is 5000 mrem/yr).
Electrical	_ In order to ensure the protection of personnel from electrical hazards, the selection of electrical equipment and the design and construction of electrical distribution systems complies with national codes and standards wherever possible. Access to hazardous areas is controlled by the NSTX Safety System. _ To prevent electrical hazards from being transmitted outside the NSTX Test Cell (NTC) boundary all instrumentation is isolated via optical and/or magnetic (magnetic transformer) means prior to exiting the NTC boundary. _ Electrical work practices conform with the requirements of ES&HD 5008, Section 2 (“Electrical Safety”).
Fire	_ The NTC fire detection system consists of ionization smoke detectors and rate of rise heat detectors located at the ceiling and aspirated smoke detection (VESDA) under the platforms. _ The NTC fire suppression is a pre-action type automatic water sprinkler system similarly located.

Hazard	**Barrier**
Earthquake	_ The NTC along with the rest of the D-Site experimental complex structures, has been determined to have adequate capacity to remain functional under the overall loads due to an earthquake with a horizontal ground acceleration of 0.13g. _ The NSTX platform has been designed for 0.09g, the seismic requirements of the NSTX torus structure. Equipment associated with the NSTX Upgrades will designed and built consistent with these requirements.
Vacuum Windows	_ Personnel injury due to flying debris from failed windows, or from an individual being drawn to, or into, the opening is addressed via window design features and/or installation of protective covers, See ES&HD 5008, Section 9, Chapter 14.
Magnetic Fields	_ Personnel are prevented from entering the NTC during plasma operations by an access control system. _ During a hot access (access while coils are energized but plasma formation is prevented), the magnetic field strength that personnel are exposed to shall not exceed the threshold limit value, B_{TLV}, for routine occupational exposure. See DOE Standard STD-6003-96.
RF Fields	_ RF systems have been designed with leakage levels that comply with IEEE Standard C95.1-1991 (outside the test cell) and are routinely checked for leakage. In addition, RF transmission into the NTC is prevented whenever personnel have access to the NTC.
Mechanical	_ During a hot access into the NTC, personnel are required to stay in a protective enclosure to protect against magnetically propelled projectiles or possible arc splatter that may attend an electrical bus failure. _ Gas cylinders are stored/installed in accordance with PPPL safety procedures (ES&HD 5008, Section 9, Chapter 2) to prevent breaking the cylinder heads, which could propel the cylinders due to a rapid release of gas.
Hot Fluids	_ The Low Temperature Bakeout Heating/Cooling System, which is run with water at temperatures up to 150°C, was hydrostatically tested to at least 1.5 times its operating pressure prior to operations. The High Temperature Bakeout Heating/Cooling System, which uses pressurized helium at temperatures up to 420°C, was pneumatically tested to 1.3 times its operating pressure prior to operations. _ Precautions are taken to prevent personnel contact with hot surfaces, including restricting access to areas where hot pipe or components are present, posting of warning signs, and personnel training.

Hazard	**Barrier**
Gases/Cryogenics /Lithium	_ The content of the largest gas cylinder (311 cubic ft.) constitutes less than 0.1% of the volume of the NTC (approximately 354,000 cubic ft.). Thus, oxygen concentrations in the NTC would remain at safe levels for personnel even if a gas cylinder's entire contents were released to the room. _ Since SF_6 is heavier than air and can displace oxygen, leakage of the gas could be hazardous to personnel occupying an enclosed area below the leak point. Personnel protection is provided by strategic location of SF_6 detection in the NTC to provide local evacuation alarms. _ Trimethylboron (TMB) used in the boronization process is toxic (7ppm TLV, based upon the TLV of the reaction product B_2O_3) and pyrophoric in air. Protective measures include low TMB inventory (≤50 g), prior leak checking of components that will be TMB pressurized above 1 atm, use of portable leak detectors, limiting NTC access during boronization to only TMB trained personnel, interlocks that halt TMB injection on loss of plasma discharge or glow discharge current, and nitrogen purging of the stack vent line during TMB injection. _ Cryogenic system subsections which may be isolated by valves or other means are provided with pressure relief devices. Appropriate personal protective equipment is used by personnel engaged in handling cryogenic fluids. Pressure relief devices have been installed to preclude rupture of sections of the system by excessive internal pressure. All piping has been designed for maximum operating pressure and tested in accordance with applicable ANSI codes. Only materials suitable for cryogenic service are used if in contact with cryogenic fluids or subject to cryogenic temperatures. - Lithium hazards include fire or explosion hazards due to the high reactivity of lithium, and health hazards due to the corrosive and toxic nature of the stable end products of lithium reactions. Safety precautions include avoiding contact with sources of moisture, conducting fabrication and transport of pellet material under an argon atmosphere, receipt and disposal of lithium material in sealed containers, presence of special (LITH-X) fire extinguishers during lithium loading activities and transport to the NTC, venting & cleaning of the vacuum vessel prior to allowing worker entry after lithium experiments, and performing work activities according to approved procedures and using proper PPE.

In general, proper system design, construction and the presence of features that mitigate the effect of failures (e.g. redundancy, energy isolating barriers, etc.) will ensure the safety of

personnel. Personnel will be excluded from areas such as the NSTX Test Cell (NTC), the NSTX bus tunnel in the Test Cell Basement and other relevant areas when hazards exist, by the use of hardwired interlocks, procedures, signage, indicator lights and training.

Department of Energy
Princeton Site Office
P.O. Box 102
Princeton, New Jersey 08542

May 20, 2009

RECEIVED MAY 21 2009

A. Cohen, PPPL

SUBJECT: HAZARD ANALYSIS ASSESSMENT FOR THE NATIONAL SPHERICAL TORUS EXPERIMENT (NSTX) UPGRADE PROJECT

Major upgrades are being planned for the National Spherical Torus Experiment (NSTX) to explore new physics regimes and to enhance the understanding of toroidal confinement physics. A major item of equipment (MIE) project was approved last February which has authorized PPPL to proceed to critical decision 1 (CD-1): develop an alternative analysis and cost range.

The NSTX Upgrade Project has two discrete work packages:

1. Upgrade the center stack assembly as to provide a higher magnetic field;
2. Install a second neutral beam injector (NBI) to increase heating and current drive.

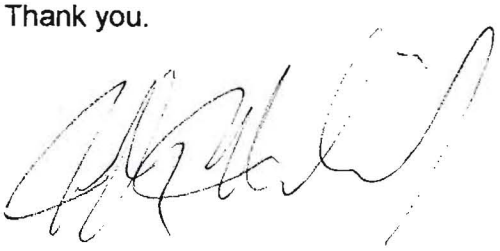
Although both workscope items above are planned as one MIE project, the NSTX Upgrade Project's planning structure is being implemented as to allow the work packages to be severed from each other in the event of future budget constraints.

I am requesting your support, as the chair of the PPPL ES&H Executive Board, to appropriately charge the NSTX Activity Certification Committee (ACC) to respond to the following:

1. Review a Preliminary Hazard Analysis Report for the upgrades planned by the MIE Project;
2. NSTX is currently considered a 'below hazard category 3' facility. Upon completion of the MIE project, will this designation change? When performing the assessment, other planned modifications by the NSTX Program outside the MIE project between now and CD-4 (2014) should be considered as well as any operational considerations involving experimental run time;
3. Evaluate the workscope packages for Questions 1 and 2 in aggregate, as well as individually, should workscope be severed at later date within the Project.

I request that the above tasks be completed by July 31, 2009 and all findings, analyses, and reports be posted on the NSTX website in support of the CD-1 review this fall. If you need further information, please feel free to contact me at extension x3721.

Thank you.



Jeffrey Makiel
Federal Project Director for NSTX Upgrades
Princeton Site Office

cc: E. Perry, PPPL
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DOE Headquarters Office of Science

Review of Princeton Plasma Physics Laboratory

Nuclear Facility Hazard Categorization

Carol L. Sohn, Senior Nuclear Safety Advisor

July 16, 2009

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