Brookhaven National Laboratory/ Photon Sciences Directorate

Subject:	NSLS-II USI #5 – NSLS-II Linac Commissioning Corrective Actions to Unanticipated Operating Conditions						
Number:	LT-ESH-USI-005	**Version:**	1	**Effective:**	31May2012		**Pages** 1 - 7
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*Approval signatures on file with master copy.

VERSION	DESCRIPTION OF ANY CHANGES	DATE	PREPARER	APPROVED BY
1	Original document	31May2012	Nicholas Gmür	See signatures above

EMS, FUA and SAD/ASE Checklist for Photon Sources Directorate Reviews

(Photon Sources Directorate ES&H personnel and the Environmental Compliance Representative can assist in completing this form)

Review Committee: PSD personnel **Date: 31May2012**

Project Name (and # if any): NSLS-II USI #5

This checklist identifies issues associated with this project that may impact the Directorate Environmental Management System, Occupational Health & Safety Management System, Facility Use Agreements, Safety Assessment Documents & Accelerator Safety Envelopes, and NEPA documents. This checklist will be completed during a review process, if needed, and form part of the documentation of that review.

SIGNIFICANT ENVIRONMENTAL ASPECTS ASSOCIATED WITH THIS PROJECT:

Check off any environmental aspects that are associated with this project (Photon Sciences Directorate Environmental Management System aspects matrices show the significant aspects). For criteria, go to the SBMS Subject Area titled Identification of Environmental Aspects and Impacts

☐	Industrial Waste Generation	☐	Work with Engineered Nanomaterials	☐	Power Consumption	☐	Historical Contamination (groundwater, soil)
☐	Hazardous Waste Generation	☐	Atmospheric Emissions	☐	Engineered Nanomaterials	☐	Soil Activation
☐	Radioactive Waste Generation	☐	Liquid Effluents	☐	Historical Monuments/Cultural Resources	☐	Transuranic Waste Generation
☐	Mixed Waste Generation	☐	Storage or Use of Chemicals or Radioactive Materials*	☐	Sensitive/Endangered Species and Sensitive Habitats (including Pine Barrens)		Other Regulatory Requirements - recycling
☐	Medical Waste Generation	☐	Water Consumption	☐	Environmental Noise	☐	NONE

*Art 12 registered area, spill potential, transportation of hazmat or rad, backflow devices, PCBs.

Any environmental aspects new to the Photon Sciences Directorate: ☐Y or ☒N? Any aspects associated with new activities: ☐Y or ☒N? If yes, describe below and issue a memo to the appropriate Photon Sciences Directorate ESH Manager:

APPLICABLE REGULATORY REQUIREMENTS:

Check off any BNL Subject Areas that are applicable to this process:
Note: PI's should consider subscribing to the Subject Area Subscription Service as a means of staying informed of changes to the Subject Area requirements.

☐	Drinking Water	☐	Radioactive Waste Management
☐	Environmental Monitoring	☐	Regulated Medical Waste Management
☐	Hazardous Waste Management	☐	Spill Response
☐	Liquid Effluents	☐	Storage and Transfer of Hazardous & Non-hazardous Materials
☐	Mixed Waste Management	☐	Transfer of Hazardous or Radioactive Materials On-Site
☐	National Environmental Policy Act (NEPA) and Cultural Resource Evaluation	☐	Transport of Hazardous or Radioactive Materials Off-Site
☐	Non-Radioactive Airborne Emissions	☐	Underground Injection Control
☐	PCB Management	☐	Regulated Industrial Waste Management
☐	Pollution Prevention and Waste Minimization	☐	Working with Nanomaterials ES&H
☐	Radioactive Airborne Emissions	☐	None

Facility Use Agreement (FUA)

Answer "Yes" or "No" for each category below.

Category	Applicable		Elements and Details
	Yes	No	

Radiological Source Terms	☒	☐	*See FUA Table 4.1.1 for details.*
Chemical, Toxic, Biological & Hazardous Source Terms	☐	☒	*See FUA Table 4.1.2 for details.*
Physical Source Terms	☐	☒	*See FUA Table 4.1.3 for details.*

If yes, do any terms require an update to the FUA: ☐Y or ☒N? If yes, describe below and issue a memo to the appropriate Photon Sciences Directorate ESH Manager: **Note: The FUA for building 740 will be written once construction has been completed. Radiological information would be included at that time.**

<u>Safety Assessment Document (SAD)/Accelerator Safety Envelope (ASE)</u>

Does this project include components that exceed or are not included in the safety boundaries described in the SAD or the ASE: ☐Y or ☒N? If yes, describe below and issue a memo to the appropriate Photon Sciences Directorate ESH Manager: **Activities that may increase the level of a known hazard or may introduce a new type of hazard not examined in a Safety Assessment Document, and therefore may impact the items below must be evaluated through the PSD USI determination process:**

- The radiation hazard personnel protection system (PPS)
- ✓Radiation shielding for personnel protection
  - Shielding horizontal dimensions need to be extended
- ✓Radiation monitoring for personnel protection
  - Operated as originally intended and protected workers
- Radiological source terms identified in the SAD

<u>Job/Facility Risk Assessments (JRA/FRA)</u>

Does this project include components that exceed or are not included in the jobs, hazards, controls or risks described in the JRA/FRAs: ☐Y or ☒N? If yes, describe below and issue a memo to the appropriate Photon Sciences Directorate ESH Manager:

NEPA Environmental Assessment (EA)

Does this project include components that exceed or are not included in the NEPA EA:

☐Y or ☒N? If yes, describe below and issue a memo to the Photon Sciences Directorate ESH Manager:

NSLS-II Unreviewed Safety Issue #5

NSLS-II Linac Commissioning Corrective Actions to Unanticipated Operating Condition

Introduction

This document is prepared as an addendum to the existing National Synchrotron Light Source II (NSLS-II) Linac Commissioning Safety Assessment Document (LCSAD); dated May 11, 2011. The change in the shield downstream of the first dipole (LB-B1) is explained below. This change is analyzed as an Un-reviewed Safety Issue (USI) as defined in DOE Order 420.2C, *Accelerator Safety*.

Executive Summary

The NSLS-II Linac is being constructed as part of the injection system for the new NSLS-II Storage Ring. During commissioning of the Linac, the combination of Linac electron beam energy and the power supply setting for dipole bending magnet LB-B1were such that the resulting beam path exceeded the downstream shadow shield width and was directed to the Linac shield wall. This resulted in elevated radiation in a radiation monitored controlled area within the Booster enclosure. This USI describes the events and the corrective actions taken.

Discussion

On May 29, 2012 two Linac operators were commissioning the NSLS-II Linac. The beam conditions were 15 nC/s at 100 MeV. This is the full charge and half of the nominal beam energy of the Linac. The operators were steering the beam through the first dipole bending magnet (LB-B1) to the second beam dump. In the process of steering, the dipole power supply went to its maximum current because of a typographical error in the input. At the maximum current and one half of the nominal beam energy, the beam is bent four times more than designed. This caused the beam to miss the downstream shadow shield and strike the concrete shield wall on the Linac tunnel.

Local radiation alarms in the Booster tunnel near the wall adjoining the Linac sounded at the increased radiation levels. Two workers who were in the Booster tunnel, outside of the barricaded controlled area, GERT trained and wearing TLD badges, heard the alarms and left the area to inform the local control room of the situation. When the operators received word of the local alarm, they responded according to procedure and informed Radiological Control Division (RCD) personnel. The operators then attempted to diagnose the alarm situation again in accordance with procedure.

RCD personnel responded and verified the higher radiation levels existed in the area (20 mr/h at the radiation monitor). Upon immediate investigation, it was determined that the radiation levels at the Controlled Area boundary near the workers was 50 uR/h and that the workers had received no additional dose. RCD personnel instructed the operators to terminate the beam.

Causal Analysis
The radiological consequences of miss-steered beam at the LB-B1 magnet were discussed in section 4.15.2.2.1 of the Linac Commissioning SAD and were evaluated to be less than 5 mrem/h in the Booster enclosure. The radiation levels measured during the follow-up study of radiological conditions during this scenario were found to be considerably higher for the following reason: miss-steered beam was considered for the maximum current that the magnet power supply could provide at electron energy of 200 MeV. In this case the electron energy was 100 MeV when the power supply for the magnet was increased to maximum current. At this energy and current, the electron beam was bent beyond the shadow shield and the electron beam struck the wall rather than the installed shield (at a higher beam energy, the beam would not have bent as much at this dipole magnetic field setting).

Corrective Actions
A subsequent meeting with the Linac Commissioning Coordinator, injection systems group leader, an operator on the shift, RCD and ESH personnel determined the following actions needed to be taken:

1. A more detailed radiation survey was needed (done).
2. The controlled area would need to be extended (done).
3. A display window would be in the control room showing the readbacks of the radiation monitors including the alarm status.
4. The alarm status of the radiation alarms would also be included in the alarm handler application. The alarm handler application informs the operators of the status of all alarms.
5. The dipole power supply would have a confirmation step, so that if the operator mistypes a number, they will have the chance to correct it prior to the power supply acting.
6. The Linac Commissioning Coordinator will email the operators training them in what to do if the power supplies ramp in an unexpected way.

The subsequent radiological surveys with 100 MeV electrons and the dipole magnet ramped to maximum current showed that the beam was indeed striking the Linac tunnel wall. The peak radiation level measured during this survey was ~ 1.7 R/h in contact with the wall and that the rate at a foot was ~ 350 mR/h. It was then determined that the following additional corrective action will need to be taken:

7. Shielding would need to be installed to supplement the horizontal extent of the existing shield downstream of dipole magnet LB-B1. In this way, any miss-steered beam would strike either the extended shield or the iron dipole magnet itself. Subsequent radiological surveys will confirm this shield (done; subsequent survey showed 0.6 mrem/hr dose outside shield wall in Booster enclosure).

Corrective Actions 1, 2 and 7 are considered pre-start items to this mode of commissioning. The other items on this list improve operator training, operator awareness of radiological alarms, and reduce the operator error traps.

Conclusion

Caution and careful planning of Linac activities and fault studies are expected when commissioning a 200 MeV accelerator. It is certainly to be anticipated that errors in the controls, weaknesses in shielding or analysis maybe determined during the commissioning and fault study process, and therefore, the entire process should be performed with caution. This event identified a weakness which has been immediately corrected. Because of the potential for such weaknesses, a conservative set of radiological controls have been in place from the beginning of Linac commissioning. As a result no radiation exposures were incurred by workers in the area since they were outside the controlled area and immediately contacted the control room.

The corrective actions listed above:

1. Improve operator training and knowledge of machine conditions
2. Improve the ability for the operator to respond more immediately to radiological alarm conditions
3. Reduce the probability of inadvertently miss-steering the beam
4. Reduce the radiological hazard by expanding the supplementary shielding

These improved conditions result in safer operations of the NSLS-II Linac and reduced radiological hazard to workers.

Linac Commissioning Accelerator Safety Envelope limits were not exceeded, and a determination was made that this does not constitute a USI.