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National Synchrotron Light Source II, Brookhaven National Laboratory			
Doc No. PS-C-ASD-PRC-166	Author: T. Shaftan	Effective Date: 27Jun2016 Review Frequency: 3 yrs	Version 5
Title: NSLS-II Insertion Devices and Front Ends Commissioning Sequence			Administrative

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6/23/2016	6/24/2016	6/23/2016
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<p><b>Approved by:</b></p> <p style="text-align: right;">6/23/2016</p> <p><b>X</b> Ferdinand Willeke  <hr/>                 Ferdinand Willeke                  Accelerator Division Director                  Signed by: Willeke, Ferdinand</p>
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### VERSION HISTORY LOG

VERSION	DESCRIPTION	DATE
1	First Issue	08July2014
2	Added new step 6.2.1; general formatting.	06Nov2014
3	Increased the beam current from 5 mA to 25 mA in step 6.3.1.	01Dec2014
4	Updated personnel titles as necessary; removed references to Photon Sciences Directorate; changed the maximum beam current from 50 mA to 75 mA throughout; added 5.7 and note before 6.1.12.	10Jun2015
5	Removed the maximum allowable current of 75 mA; added requirements for the 3PW and BM FEs (section 6.3 and throughout).	27May2016
6	Revised to remove hold points prior to Phase 1, 2 and 3 surveys; Added responsibility for Lead Beamline Scientist or designee (3.6); removed the performance of Phase 1 and 2 surveys at low current; added requirements for RCTs to perform general area radiation surveys during commissioning activities; changed step 6.4.1 beam current from 75 mA to 1/3 the existing operating current; added Phase 1 and 2 surveys to 3PW or BM FE commissioning (6.3.2-6.3.4); added step 6.4.15.	27Jun2016

#### ACRONYMS

3PW	Three Pole Wiggler	LOTO	Lockout/Tagout
AD	Accelerator Division	mA	milli-Ampere
AIE-ID	Active Interlock Envelope for ID	NSLS-II	National Synchrotron Light Source II
AIS	Active Interlock System	PPS	Personnel Protection System
ASE	Accelerator Safety Envelope	RCT	Radiological Control Technician
BM	Bending Magnet	SAD	Safety Assessment Document
BPM	Beam Position Monitor	SME	Subject Matter Expert
EPS	Equipment Protection System	SR	Storage Ring
ESH	Environment, Safety & Health	SRP	Synchrotron Radiation Protection
FE	Front End	USI	Unreviewed Safety Issue
FOE	First Optical Enclosure		
ID	Insertion Device		

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## 1 PURPOSE AND SCOPE

The purpose of this procedure is to provide the sequence of activities during the commissioning of the NSLS-II IDs and FEs. This document is not intended to absolutely define the specific commissioning tasks that should be performed at each step, but rather provide a guideline for the commissioning sequence. This document also provides radiological safety guidance and establishes hold points for safety reviews prior to progression to the next commissioning step.

## 2 DEFINITIONS

- 2.1 Bending Magnet (BM): A single dipole magnet that serves as a source of synchrotron radiation.
- 2.2 Front End (FE): Elements in the path of the emitted synchrotron radiation, which collimates the beam and provides shielding against Bremsstrahlung radiation and accommodates safety shutters to isolate the beamline from synchrotron radiation. The FE is located upstream of the FOE.
- 2.3 Insertion Device (ID): Magnet array with an alternating magnetic field for controlled periodic distortion of the SR beam orbit to emit intense synchrotron radiation.
- 2.4 Three Pole Wiggler (3PW): Set of permanent magnets with three poles creating small local orbit bump for emission of synchrotron radiation.

## 3 RESPONSIBILITIES

- 3.1 Accelerator Coordination Group
  - 3.1.1 Responsible for schedule and sequence of the commissioning activities.
- 3.2 NSLS-II Lead and Scientific Operators
  - 3.2.1 Commission the IDs, 3PWs, BMs and FEs within the operating envelope established by the NSLS-II operating procedures.
- 3.3 AD Director
  - 3.3.1 In conjunction with the ESH Manager, approves commencement of the commissioning sequence.

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### 3.4 ESH Manager

3.4.1 In conjunction with the AD Director, approves commencement of the commissioning sequence.

3.4.2 Approves progression from each step in the commissioning sequence.

### 3.5 AIS Expert

3.5.1 Commissions the SRP Active Interlock System.

### 3.6 Lead Beamline Scientist or Designee

3.6.1 Operates beamline controls for positioning of beamline components located in the FE.

## 4 PREREQUISITES

4.1 If commissioning an ID, 3PW or BM Beamline, LOTO has been applied to the associated FE photon shutters and safety shutters in accordance with PS-C-ASD-PRC-114, *Front End Photon Shutter and Safety Shutter Centrally Controlled Lockout/Tagout Procedure*, in the case that beamlines are not authorized for beam commissioning.

4.2 LOTO has been removed from the associated ID gap and 3PW drive mechanism.

4.3 If commissioning a 3PW or BM Beamline, LOTO has been removed from the BM Photon Shutter and the 3PW has been moved into nominal operating position.

4.4 Injector and SR operations have been established.

4.5 The masks are in the correct position.

4.6 Cooling is provided to the FE devices.

4.7 The control system for IDs, 3PWs and FEs has been tested and is available.

4.8 The EPS for IDs and FEs has been tested.

4.9 The PPS for the FEs has been tested.

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- 4.10 The System Readiness Checklist/Beam Authorization Form is complete in accordance with PS-C-ASD-PRC-063, *Authorizing Operations and Performing Accelerator Maintenance*.
- 4.11 The AIS Database for the IDs is complete and current.
- 4.12 Slits shall be retracted and any FE optics have been positioned as specified in the beamline specific Radiation Survey Plan.

## 5 PRECAUTIONS AND LIMITATIONS

- 5.1 NSLS-II Lead and Scientific Operators are trained and instructed to commission the IDs, 3PWs and FEs. NSLS-II Engineers and Technical Staff may operate the equipment for which they are responsible for, and perform machine studies in accordance with PS-C-ASD-PRC-095, *Scheduling and Performing NSLS-II Machine Studies*. They shall perform these actions only with the knowledge and approval of the on-duty Lead Operator, in accordance with PS-C-ASD-PRC-036, *Control Area Activities*.
- 5.2 Modifications to, or suspension of, operations that may be necessary to respond to conditions observed during ID, 3PW and FE commissioning shall be managed as follows:
  - The AD Director or designee may authorize interim operating conditions, including changes in current and beam energy as long as these interim conditions are within the limits defined in this document and the ASE. These changes shall be formally documented in shift plans issued and revised in accordance with PS-C-ASD-PRC-043, *Shift Routines and Operating Practices*.
  - The AD Director or designee may direct the suspension of commissioning to resolve equipment issues or problems; such suspensions of operations shall be conducted in accordance with PS-C-ASD-PRC-063, *Authorizing Operations and Performing Accelerator Maintenance*.
  - IF the conditions involve a potential USI, THEN the process and requirements provided in PS-C-ESH-PRC-002, *Unreviewed Safety Issue Determination Procedure* shall also be followed.
- 5.3 Performing the procedure, including skipping or modifying safety related elements, shall not violate any SAD or ASE requirements.

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- 5.4 The actual sequence of the commissioning activities and steps described in this procedure are contingent on the actual state of the IDs/3PWs/FEs observed during commissioning and may be modified and/or determined unnecessary. Sequence modification and/or skipping steps can be initiated by the Accelerator Coordination Group. However, skipping or modifying safety related elements of this procedure, such as fault study or modifying beam intensity limits, shall not result in a potential USI, and requires the approval of the AD Director and the ESH Manager.
- 5.5 Additional radiation surveys may be performed at the discretion of the AD Director and ESH Manager in accordance with PS-C-ESH-PRC-061, *NSLS-II Insertion Devices and Front Ends Radiation Survey Plan*.

## 6 PROCEDURE

### 6.1 ID Commissioning

**Note:** The objective of this phase is to commission the IDs with the gap near nominal height with the beam current below 2 mA.

**Note:** RCTs perform general radiation surveys during ID commissioning. If the recorded dose rate is greater than 5 mrem/hr, commissioning activities shall be terminated.

- 6.1.1 **HOLD POINT:** AD Director in conjunction with the ESH Manager, approves commencement of the commissioning sequence.
- 6.1.2 Establish, correct AND save reference orbit.
- 6.1.3 Characterize the SR lattice with the beam current below 2 mA.
- 6.1.4 Verify that the orbit is centered with respect to the ID Straight Section BPM.
- 6.1.5 Verify that the orbit is centered with respect to the BPMs that are adjacent to the dipole chamber.
- 6.1.6 Gradually reduce the ID gap to near nominal height.
- 6.1.7 Correct the orbit and tunes while reducing the gap:
- Record the orbit position in the ID.

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b. Record the gap position.

6.1.8 Correct the lattice functions, as required.

6.1.9 Verify the beam optics with the gap closed.

6.1.10 Monitor temperature sensors and EPS status.

6.1.11 Improve injection efficiency with the gap closed.

## 6.2 ID FE Commissioning

**Note:** The following steps are performed with the beam current below 2 mA.

**Note:** RCTs perform general radiation surveys during ID FE commissioning. If the recorded dose rate is greater than 5 mrem/hr, commissioning activities shall be terminated.

6.2.1 Notify the RCT(s) that ID FE commissioning is going to commence AND that radiological controls should be established, as required.

6.2.2 Center the photon beam in the center of the FE Fixed Mask exit aperture.

6.2.3 Define vertical and horizontal offsets along the FE.

6.2.4 HOLD POINT: AIS Expert evaluates the vertical and horizontal offsets along the FE.

6.2.5 Test functioning of the blades of the X-Y slits AND reference the motion control to the beam center position.

6.2.6 Perform initial vacuum conditioning of the FE chambers and elements.

6.2.7 Verify good vacuum in the FE.

6.2.8 Verify stay clear of the beam path through the aperture.

6.2.9 Determine Origin Offset of the AIE-ID at the direction of the AIS Expert.

6.2.10 Perform the Phase 3 Fault Study in accordance with section 6.3 of PS-C-ESH-PRC-061, *NSLS-II Insertion Devices and Front Ends Radiation Survey Plan*.

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6.2.11 HOLD POINT: The ESH Manager gives AD Staff permission to proceed with commissioning.

- a. Verify changes to operating conditions are in accordance with those specified in the Interim Radiation Survey Report.

6.2.12 Perform SRP AIS adjustment and testing at the direction of the AIS Expert.

### 6.3 3PW or BM FE Commissioning

**Note:** The objective of this phase is to commission the 3PW/BM FE with the beam current below 2 mA.

**Note:** RCTs perform general radiation surveys during 3PW and BM FE commissioning. If the recorded dose rate is greater than 5 mrem/hr, commissioning activities shall be terminated.

6.3.1 Establish, correct, and save reference orbit.

6.3.2 Notify the RCT(s) that 3PW or BM FE commissioning is going to commence AND that radiological controls should be established, as required.

6.3.3 For FEs that contain mirrors that need to be aligned:

- a. Align synchrotron beam using signals from the FE slits.
- b. Adjust mirror positions (within the limits specified in the beamline specific Radiation Survey Plan) to establish beam on diagnostics after the mirror in the FE.

6.3.4 Observe the photon beam on the FE Beam Screen.

6.3.5 Reference and record the position of the blades of the X-Y slits and mirror motors with respect to the beam center.

6.3.6 Perform initial vacuum conditioning of the FE chambers and elements.

6.3.7 Verify good vacuum in the FE.

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6.3.8 Prepare devices in the FE in accordance with the beamline specific Radiation Survey Plan.

6.3.9 Perform the Phase 3 Fault Study in accordance with section 6.3 of PS-C-ESH-PRC-061, *NSLS-II Insertion Devices and Front Ends Radiation Survey Plan*.

6.3.10 **HOLD POINT:** The ESH Manager gives AD Staff permission to proceed with commissioning.

- a. Verify changes to operating conditions are in accordance with those specified in the Interim Radiation Survey Report.

#### 6.4 Increase the SR Beam Current

**Caution:** The SRP AIS shall be tested and functional prior to increasing the beam current beyond 2 mA.

**Note:** RCTs perform general area radiation surveys while gradually increasing beam. If the recorded dose rate is greater than 5 mrem/hr, commissioning activities shall be terminated.

**Note:** Phase 2 Radiation Survey shall be repeated with beamline optics in “retracted out of the path of the direct beam” and “in direct beam path” modes in accordance with PS-C-ESH-PRC-061, *NSLS-II Insertion Devices and Front Ends Radiation Survey Plan*.

6.4.1 Gradually increase circulating beam current to 1/3<sup>rd</sup> the present operating beam current.

6.4.2 Monitor and record the temperature of the ID and FE vacuum systems for a given value of the beam current (total and bunch current).

6.4.3 Correct the orbit, tunes and lattice functions, as required.

6.4.4 Verify good vacuum in the ID and FE.

6.4.5 Perform the Phase 1 and Phase 2 Radiation Surveys in accordance with sections 6.1 and 6.2 of PS-C-ESH-PRC-061, *NSLS-II Insertion Devices and Front Ends Radiation Survey Plan*.

6.4.6 **HOLD POINT:** The ESH Manager gives AD Staff permission to proceed with commissioning.

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- a. Verify changes to operating conditions are in accordance with those specified in the Interim Radiation Survey Report.

**Note:** Upon the completion of the final increase in current (including repeating the required steps) proceed to step 6.4.8.

**Note:** Not all FEs have slits or optics, therefore Phase 2 Radiation Surveys will not be applicable at these beamlines.

- 6.4.7 After reaching  $1/3^{\text{rd}}$  the present operating beam current, steps 6.4.2-6.4.6 shall be repeated until the beam current increases three times over the previous Phase 1 and 2 Radiation Surveys.
- 6.4.8 Perform beam conditioning AND out gassing of the photon mask and photon shutter at the photon exit port of the downstream dipole magnet.
- 6.4.9 Measure lifetime versus gap, as applicable.
- 6.4.10 Measure the orbit AND tune shift with varying gap, as applicable.
- 6.4.11 Study full current beam stability with gaps closed, as applicable.
- 6.4.12 Prepare look-up tables for feed forward correction of orbit, tunes and lattice functions.
- 6.4.13 Evaluate impact on chromaticity and emittance coupling.
- 6.4.14 Test the undulator gap control system for users, as applicable.
- 6.4.15 When three times the present operating beam current is reached, repeat steps 6.4.2-6.4.6, 6.4.8-6.4.10 and 6.4.13 up to and including at the nominal (500 mA) operating beam current.

## 7 REFERENCES

- 7.1 PS-C-ESH-PRC-061, *NSLS-II Insertion Devices and Front Ends Radiation Survey Plan*
- 7.2 PS-C-ASD-PRC-036, *Control Area Activities*
- 7.3 PS-C-ASD-PRC-043, *Shift Routines and Operating Practices*
- 7.4 PS-C-ASD-PRC-063, *Authorizing Operations and Performing Accelerator Maintenance*

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- 7.5 PS-C-ASD-PRC-095, *Scheduling and Performing NSLS-II Machine Studies*
- 7.6 PS-C-ASD-PRC-114, *Front End Photon Shutter and Safety Shutter Centrally Controlled Lockout/Tagout Procedure*
- 7.7 PS-C-ESH-PRC-002, *Unreviewed Safety Issue Determination Procedure*
- 7.8 PS-C-ESH-PRC\_061, *NSLS-II Insertion Devices and Front Ends Radiation Survey Plan*
- 7.9 Beamline Specific Radiation Survey Plans

## **8 ATTACHMENTS**

None.

## **9 DOCUMENTATION**

None.

**-END-**