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Brookhaven National Laboratory National Synchrotron Light Source		Number: LS-PPS-0023	Revision: C
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Subject: <u>X-RAY Ring Radiological Interlock Test</u>			
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*Approval signatures on file with master copy.

[Revision/Periodic Review Log](#)

Test Reason:	Test Result:	<input type="checkbox"/> Passed	<input type="checkbox"/> Failed
	Test Type:	<input type="checkbox"/> Full	<input type="checkbox"/> Partial
Test Date:	Start Time:	Finish Time:	
Tester 1:	Assistant 1:		
Tester 2:	Assistant 2:		

PREPARATION:

Verify that X5 laser hutch, target area, and removable beam pipe are ready so X5 shutter can be enabled.

- Inform control room operator that test will be done.

- LOTO the LINAC as per, "[LINAC LOTO](#)", LS-ESH-0012.

OR

LOTO X-ray injection shutter, if VUV injection is needed. Refer to "[X-Ray Injection LOTO](#)", LS-ESH-0023.

- Verify X-Ray Main magnet power supplies, RF, EPW wiggler P.S. are ready to be turned ON.

Complete a normal search of the x-ray ring to verify a complete search can be accomplished prior to testing. (This step is not necessary if no faults have been reported or no rewiring/modifications has been completed.)

Dump the search.

Tunnel Search Sequence:

1. Close tunnel door A (the main entrance). Press CS-5
 The small sign on the tunnel ceiling comes on
 Open door A.
 The sign goes out

2. Open both halves of door A and place switch holders on the door switches. Place latch device on Kirk lock, and put key in switch at SR-100.
 Press CS-5
 The "Interlocked" sign comes on
 Press CS-4
 The pilot on CS-4 does not come on

3. Press CS-5. Press CS-1.
 The pilot on CS-1 stays on
 Press CS-4
 The pilot on CS-4 does not stay on

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4. Remove the switch holder from switch #1 on the stationary half of door A and replace.
The pilot on CS-1 goes out _____

5. Press CS-5, press CS-1. Remove holder from switch #1 on the active half of door A, and replace.
The pilot on CS-1 goes out _____

6. Press CS-5. Press CS-2.
The pilot on CS-2 stays on _____
Press CS-4
The pilot on CS-4 does not stay on _____
Remove holder on switch #1 on door A and replace
The pilot on CS-2 goes out _____

7. Press CS-5, press CS-1. Press CS-3
Pilot on CS-3 does not stay on _____
Release and replace switch #1 on door A. Press CS-5, press CS-2, press CS-3
Pilot on CS-3 does not stay on _____

8. Press CS-1, press CS-3
Pilot on CS-3 stays on _____
Open and close Emergency Door
Pilot on CS-3 goes out _____
Emergency door light at SR100 goes out _____
Press CS-5
"Interlocked" sign on tunnel ceiling does not stay on _____
Press Emergency door reset button at SR-100 _____

9. Press CS-5, press CS-1, press an emergency stop button and leave it in.
Pilot on CS-1 goes out _____
Press CS-5. "Interlocked" sign on ceiling doesn't come on _____
Reset emergency stop button _____

10. Press CS-5, press CS-1, turn off Red Tag switch
The Kirk Key Secure light goes out. _____
Pilot light on CS-1 goes out _____
Press CS-5
Sign on tunnel ceiling does not come on _____
Turn Red Tag switch back on
Kirk Key secure light comes ON _____

11. Press CS-5, press CS-1, Turn RF test mode Kirk key counter clockwise, then back to captured position
Pilot on CS-1 goes out _____

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12. Press CS-5, press CS-1, turn magnet test mode Kirk key counter clockwise, then back to captured position

Pilot on CS-1 goes out

13. Press and reset an Emergency Stop button. Press CS-5 and then CS-1.

Note time until pilot on CS-1 goes out.

Time-out period is not more than six minutes

Tunnel Search Sequence - Emergency Exit Door:

14. Place switch holders on the three (3) emergency exit door switches.

Reset emergency door fault at SR100.

Press CS-5, CS-1, CS-2, and CS-3. Press CS-5, noting time in seconds. Immediately press and hold CS-4.

Pilot light on CS-4 doesn't light immediately

Pilot light on CS-4 comes on and warning alarm starts in not more than 15 seconds

Remove switch holder #2 and replace.

The audible warning stops

The signs by the entrance doors go out

The emergency door light on SR100 goes out

Press emergency door reset

15. Press CS-5, CS-1, CS-2, CS-3. Press CS-5, noting time in seconds. Immediately press and hold CS-4.

Pilot light on CS-4 doesn't light immediately

Pilot light on CS-4 comes on and warning alarm starts in not more than 15 seconds

Remove switch holder #1 and replace.

The audible warning stops

The signs by the entrance doors go out

The emergency door light on SR100 goes out

Press emergency door reset

16. Remove switch holder #3.

The Kirk Key secure light goes out

Replace switch holder.

Remove switch holders from emergency exit door. Test door switches. All Three switches move freely and have proper click. Close emergency door.

Reset Emergency Door fault.

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Tunnel Search Sequence (cont.):

17. Press CS-5, CS-1, CS-2, CS-3, CS-5, and CS-4. Press an emergency stop button
 - The audible warning stops _____
 - The signs by the entrance doors go out _____
 - The emergency stop light on SR100 goes out _____
 Reset ES

18. Press CS-5, CS-1, CS-2, CS-3, CS-5, and CS-4
 - Verify that all four audible alarms are sounding (Located above even numbered ES buttons) _____
 - The alarm interval is not less than 30 seconds _____
 - The "Time Delay Completed" light on the security rack doesn't come on until the end of the warning interval _____
 - "Area Interlocked" light in Control Room comes on _____

19. Remove holder from switch #2 on active half of door A.
 - Tunnel Secured (or Allow Beam) light stays on _____
 - Entrance sign stays on _____
 - Kirk Key Secure light goes out _____
 Replace holder on switch #2

20. Remove holder from switch #2 on stationary half of door A
 - Tunnel Secured (or Allow Beam) light stays on _____
 - Entrance sign stays on _____
 - Kirk Key Secure light goes out _____
 Replace holder on switch #2

21. Release switch #1 on stationary half of door A.
 - The Tunnel Secured (or allow beam) light goes out _____
 - The signs by the entrance doors go out _____
 - Time Delay Completed light goes out _____

22. Remove switch holders on stationary door from x-ray ring entrance. Test door switches.
 - Both switches move freely and have proper click _____

23. **Emergency Stops:** Test each ES switch listed below.

	ES1	ES2	ES3	ES4	ES5	ES6	ES7	ES8
Press ES button.								
"Emergency Stop Armed" light goes out.	_____	_____	_____	_____	_____	_____	_____	_____
"Kirk Key Secured" light goes out.	_____	_____	_____	_____	_____	_____	_____	_____
Reset ES button.								
"Emergency Stop Armed" light comes ON.	_____	_____	_____	_____	_____	_____	_____	_____
"Kirk Key Secured" light comes ON.	_____	_____	_____	_____	_____	_____	_____	_____

In the Control Room, press and reset the "X-Ray and LINAC" crash button
The "Emergency Stop Armed" light goes out and comes back ON

**** In Test Steps 24 To 29, Control Room Indicator Lights Are Observed ****

- The LINAC must be LOTOed as per "[LINAC LOTO](#)", LS-ESH-0023 before proceeding with the next step.
- Upon completion of LINAC LOTO, the x-ray injection shutter LOTO may be removed (if applicable).

24. Remove switch holders and latch device from all X-ray tunnel entrance doors. Search/secure X-ray tunnel insuring that no one remains in the tunnel. Transfer door key to SR100.
Open the X5 Tag Cave, place a latch device on the lock, place a holder on the 'Lower' door switch and return the key to the SRU. Observe the "Tag Cave Secured" light. Release the switch.
 The Tag Cave light goes from ON to OFF

Remove holder from switch and latch device from lock. Check switch for free motion and click. Return key to SRU.

25. Remove Kirk Key from SR100 and replace.
 The "Kirk Key Secure" light goes OFF & ON

26. Turn on the dipoles and set to injection energy.
 The "Dipole Current in Range" light comes on

At the back of rack SR104, adjust the A channel current trip module up by two digits from preset value, then back to the original setting. Note if more than a two-digit adjustment is required.

Orig.	New

The "Dipole Current" light goes OFF & ON

Repeat for the B channel current trip module.

Orig.	New

The "Dipole Current" light goes OFF & ON

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27. Issue a computer "Injection On" command.
 The ENABLE READY light comes on _____
 Press INJECTION SHUTTER ENABLE button.
 The Green Enable On light on the button comes on _____
 The Green Injection Shutter OPEN light comes on _____
 Press "BEAMLINE MASTER SHUTTER ENABLE" button.
 The light on the button does not come on _____
 Close injection shutter. Press Master Shutter Enable.
 Master Shutter button light comes on _____
 Attempt to open Injection Shutter.
 Injection Shutter does not open _____
 Enable light is Off _____
 Disable Master Shutters.
28. With dipole current in range and other injection conditions satisfied, open the x-ray injection shutter. Note nominal injection energy for x-ray.
 Nominal injection energy _____ Mev
 Reduce dipole energy until injection shutter closes. Note dropout energy is not more than 5% below nominal injection energy (about 38 Mev lower)
 Injection shutter "OPEN" light is out, and "CLOSE" light is ON _____
 X-ray ring energy (more than 95% of nominal) _____ Mev
- X-5 Tagging Cave:**
29. Assure X5 Cross-Pipe is installed across the aisle. Secure the X5 Laser Hutch, fan loft, and Target Area. Jumper "user interlock" if necessary to get a "shutter enable" light at the beamline.
 Open the x-ray injection shutter. Open the X5 shutter by pressing the manual button on the shutter solenoid.
 The Injection Shutter closes _____
 At X5, neither RIA nor RIB trips _____
 Close X5 shutter. "Cheat" the Tagging Cave KK in SRU. _____
 Open Injection Shutter.
 Remove Tag Cave key from SRU.
 Injection Shutter closes, Tag Cave light goes out _____
 Open the X5 areas and lock out beamline. _____

Beam Line Reach-Back:

30. Enable an x-ray beamline (e.g. X6A) and secure the hutch, using switch holders and a latch device. Open the Photon Shutter, if applicable. The Safety Shutter Enable light must be on. Turn on all three LINAC modulators. Station an observer at the modulators to watch the interlock lights. During these “reach back” tests, the lights blink off only momentarily (less than one second) while the injection shutter is closing. In addition, a person must be stationed in the Control Room, at SR100, at the beamline hutch, and at the safety shutter solenoid for the line being tested.

Open the Injection Shutter. Manually Open the beamline safety shutter using a rod or bolt to press the solenoid button (this must be held open for a minute or more during the test).

The Injection Shutter remains open				
RIA and RIB <u>do not</u> trip				
Remove holder from switch 2 at the hutch				
RIB trips at beamline and at SR100				
Three modulators turn off momentarily				
Three “Interlock B” lights blink off				
Three “Interlock A” lights stay on				
X-ray dipole trips				
Injection Shutter closes				
Replace switch holder, reset RIB and RIBX, close shutter				

31. Turn on x-ray dipole and set to injection energy. Turn on all four x-ray RF systems and monitor RF signals to verify turn-off (do not use computer read back). Open injection shutter and open beamline shutter using button on solenoid.

RIA trips at beamline and at SR100				
Three modulators turn off momentarily				
Three “Interlock A” lights blink off				
Three “Interlock B” lights stay on				
Four RF systems trip				
Injection Shutter closes				
Release beamline shutter. Reset RIA and RIAX. Remove holders from hutch door switches and latch device from lock.				
Test door switches for free motion and click				
Lock out the beamline.				

X-Ray Security/SR100:

32. Turn on the modulators and the x-ray dipole. Open the injection shutter. Remove the Kirk key at SR100.

Three modulators turn off momentarily				
Three “Interlock B” lights blink off				
Three “Interlock A” lights stay on				
X-ray dipole trips				
Injection Shutter closes				
Replace Kirk Key.				

33. Turn on the supplies for the x-ray magnets including the EPW. The dipole may be left off. Remove the Kirk key at SR100. The power supplies turn off.

QA	
QB	
QC	
QD	
SEXT F	
SEXT D	
EP Wiggler	

Turn Kirk key back on.

X-ray Tunnel Reach Back:

34. Open main entrance door to x-ray tunnel and place switch holders on the door switches. Place a latch device on the door Kirk lock, transfer door key to SRU at SR-100, and turn key fully CW.

Caution:
One person must stand guard at the tunnel entrance
and not permit anyone to enter or go near the tunnel entrance.

Turn on the x-ray magnets including the EPW and the dipole. Turn on the modulators and open the injection shutter. *Remove the holder on switch 2* on the x-ray ring entrance door.

Three modulators turn off momentarily			
Three “Interlock B” lights blink off			
Three “Interlock A” lights stay on			
Injection Shutter closes			
X-ray dipole trips			
QA, QB, QC, and QD trip			
Sext F and Sext D trip			
The EP Wiggler trips			

Replace the holder on the ring door switch.

35. Turn on x-ray magnets and RF systems and the LINAC modulators. Observers must be in place to verify turn-off. Open the injection shutter. *Remove holder from switch 1* on x-ray ring door.

Three modulators turn off momentarily			
Three “Interlock A” lights blink off			
Three “Interlock B” lights stay on			
Four RF systems trip			
Injection Shutter closes			
X-ray dipole trips			
QA, QB, QC, and QD trip			
Sext F and Sext D trip			
The EP Wiggler remains ON			

Replace switch holder.

36. **Plug Door Reach-Back:**

Search and Secure X-Ray Tunnel

Turn on x-ray magnets, RF systems, and the LINAC modulators. Observers must be in place to verify turn-off. Open the injection shutter. Remove '**RIA**' connector (#1) from a plug door: _____

Three modulators turn off momentarily

Three "Interlock A" lights turn off and then come back ON

Three "Interlock B" lights Remain ON

Four RF systems trip

Injection Shutter closes

X-ray dipole trips

QA, QB, QC, and QD trip

Sext F and Sext D trip

The EP Wiggler remains ON

RIAX fault comes ON

Time delayed completed indicator is off

Attempt to reset RIAX.

RIAX will not reset.

Replace plug door connector.

Attempt to reset RIAX.

RIAX reset.

37. Turn on x-ray magnets, RF systems, and the LINAC modulators. Observers must be in place to verify turn-off. Open the injection shutter. Remove '**RIB**' connector (#2) from same plug door in previous step.

Three modulators turn off momentarily

Three "Interlock A" lights turn off and then come back ON

Three "Interlock B" lights turn off and then come back ON

Four RF systems trip

Injection Shutter closes

X-ray dipole trips

QA, QB, QC, and QD trip

Sext F and Sext D trip

The EP Wiggler trips off

RIBX fault comes ON

Verify X-Ray security drops out:

Tunnel secured fault

Plug door closed fault

Time delayed completed indicator is off

Kirk Key Secured fault

Attempt to reset RIAX/RIBX.

RIBX will not reset.

Replace plug door connector.

Attempt to reset RIBX.

RIBX reset.

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38. Reset RIAX & RIBX faults at SR100.
 Perform the following for each plug door interlock and check off completion below:
1. Disconnect Interlock Connector #1 on plug door.
 2. Verify RIAX.
 3. Verify fault cannot be reset unless plug door connector is back in place.
 4. Disconnect Interlock Connector #2 on plug door.
 5. Verify RIBX & Plug door closed fault
 6. Verify faults cannot be reset unless plug door connector is back in place.

Plug door	Connector/Fault		Plug door	Connector/Fault			
	#1 (RIA)	#2 (RIB)		#1 (RIA)	#2 (RIB)	#1 (RIA)_	#2 (RIB)
X1/2	_____	_____	X17/18 (Door 1 & 2)	_____	_____	_____	_____
X3/4	_____	_____	X19/20	_____	_____	_____	_____
X5/6	_____	_____	X21/22	_____	_____	_____	_____
X7/8	_____	_____	X23/24	_____	_____	_____	_____
X9/10	_____	_____	X25/26	_____	_____	_____	_____
X11/12	_____	_____	X27/28	_____	_____	_____	_____
X13/14	_____	_____	X29/30	_____	_____	_____	_____
X15/16	_____	_____					

39. Remove switch holders and latch device from x-ray ring main entrance door. Test door switches. Both switches move freely and have proper click _____
40. Remove LOTO and turn on LINAC low level RF and open LEPT valve. _____
41. Inform operator that test is completed and request an entry be made in the shift log. _____

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