Argonne NATIONAL LABORATORY

MANAGEMENT ASSESSMENT REPORT

Management Assessment Number	Management Assessment Title	Assessment Date(s)
HEP-FY07-MA-001	Radiation Safety Interlocks	March 20-24, 2007
Organization	**Assessed Program / Activity**	**Responsible Manager**
High Energy Physics Division, Argonne Wakefield Accelerator (AWA)	Argonne Wakefield Accelerator / Radiation Safety Interlock System (s) access controls	W. Gai
Team Leader	**Team Member(s)**	**ESH/QA Representative**
M. Conde	W. Gai, M. Conde, J. Power, F. Franchini, C. Jing, Z. Yusof, J. Lang, S. Antipov, R. Konecny, F. Gao	L. Reed

Executive Summary

The Argonne Wakefield Accelerator (AWA) is a facility within the High Energy Physics Division, located inside Building 366.

The Argonne radiological control policy ES&H manual (Section 5.1.3) summarizes the elements of the Argonne radiological health and safety policy, and that compliance with the Occupational Radiation Protection Rule (10 CFR 835.502 (b) physical controls) is maintained.

All accelerator facilities and operations must be analyzed to identify radiation hazards. DOE Order 420.2B, Safety of Accelerator Facilities, requires the safety analysis for accelerator facilities and their operations to be provided in a safety assessment document (SAD).

The Argonne Wakefield Accelerator's (AWA) accelerator safety envelope defines the set of physical and administrative bounding conditions for safe operations as based on the safety analysis documented in the SAD.

AWA's physical access controls to high and very high radiation areas were tested to verify that they effectively prevented unauthorized entry. Testing of the entire interlock system was conducted for each area (each key in each key tree, each door switch, each critical device and lockout, each radiation-activated or current/voltage-activated interlock) at intervals not greater than six months with a grace period of one month when the system is in use.

Interlock System Requirements:

Accident 1hr. duration	Alarm System	Access Control Systems	Functional Logic
0.100 rem MCI-I	None	Signs/Ropes	None
0.100-5 rem MCI-I	Visual/Audible	Signs, Barriers*	Maybe
5-25 rem MCI-I	Visual/Audible	Interlocks/Barriers,* Signs	Yes
25-100 rem MCI-I	Visual/Audible	Interlocks/Barriers* Signs/Lights/Audible	Yes
100 rem MCI-I	Visual/Audible	Interlocks/Barriers* Signs/Lights/Audible /RunSafe/Emergency Off Switches	Yes

* Barriers in dose categories normally include shielding materials such as concrete, steel, earth, and lead to reduce the radiation levels in occupied areas to acceptable levels.

If the functional logic software can determine that the interlock switches are functioning properly, the facility manager may petition the independent safety review committee to allow a yearly switch test and a 6-month functionality interlock test.

All interlock tests must be documented and documents kept by the facility manager.

The last documented interlock system safety test was perfomed January 17, 2007 in accordance with ES&H Manual, Section 5.3.3. No adverse conditions of enviromental, health or life-safety protection concerns were idenified.

Purpose

The purpose of this assessment is to determine that AWA operations are conducted in accordance with applicable ANL and DOE requirements, including ANL-E, Ionizing Radiation Protection (ES&H Manual Chap. 5.16), and Radiation Safety Interlock Systems.

Scope

For this assessment, radiation safety interlocks include radiation enclosure interlocks and beam-controlling devices operated at the ANL HEP AWA Accelerator Facilities.

BLDG	FACILITY	ACRONYM
366	Argonne Wakefield Accelerator	AWA

Assessment Details/Results

The Argonne Wakefield Accelerator (AWA) is a facility within the High Energy Physics Division, located inside Building 366 and shares the building with other activities.

Records for AWA interlock testing activities, standard operating procedure (SOP), and SAD were reviewed for flow down of ANL 10 CFR 835 policy requirements and DOE 420.2B implementation guidance.

Argonne National Laboratory policies contained in the ES&H Manual Chapter 5 and AWA documentation were reviewed to verify that the AWA and related facilities are in compliance.

Summary description of potential radiation hazards:

- The AWA electron source accelerates bunches of electrons to peak energy of about 20MeV. These bunches may contain up to 400nC of charge, and may be generated at a peak rate of 30 bunches per second.
- The rf power supply includes a Klystron operating roughly at 290 kV (pulsed) which can produce x-rays.
- Activation of air, water, and materials is possible.

Radiation safety at the AWA is implemented using both passive (shielding, labyrinths) and active (access control, interlock, and fast beam abort) components. The access control system will prohibit access to the AWA vault while the accelerator is operating. Interlocks on the labyrinth doors and rf cabinets will cause the beam to abort if entry is attempted during accelerator operation and will block accelerator startup.

1. Separate key trees, each consisting of six key lock switches are located at the vault entrance. Each person entering the vault must first remove a key from a key tree and retain that key while working in the vault. Removal of any key from the key tree will prevent accelerator startup by inhibiting rf power up.

2. Access to the AWA vault is obtained through two labyrinths, one upstream of the accelerator and the other downstream, (see fig.1 for a diagram location of access control system and other vault safety components). Access to each labyrinth is through electromechanical lock switches. Both doors must be locked to complete the interlock chain and enable accelerator operation.

3. When the downstream labyrinth door is closed and locked, and all the keys have been returned to the downstream key tree, relay K2 is activated which causes the TD-1 timer clutch to close and initiate a countdown. The upstream labyrinth door must be locked, and all the remaining keys returned to the upstream key tree before the end of the 30-second time-out period, or the current path through TD-1 clutch will be interrupted and the interlock will NOT be made up.

4. After the interlock is made up, operations require the operator to turn the laser control key switch in the control room to the "source on" position and return to the main control switch to its lock position and turn the switch from "accelerator safe" to the "accelerator on" position. Any entry to the vault with the accelerator on will break both the laser and radiation interlocks.

5. Similarly, any interruption to current path through TD-1 clutch after interlock is made up, such as removing a key from a key tree or pulling the safety chain in the vault will break the interlock and abort the beam.

Figure 2 is a schematic diagram of the interlock system. The circuit is based on an electromechanical timer and relay technology for reasons of simplicity and reliability.

The last documented interlock system safety test was performed January 17, 2007. Assessment results indicate that the radiation safety interlock system is routinely tested in accordance with ES&H Manual, Section 5.3.3. (fig. 3). No adverse conditions of environmental, health or life-safety protection concerns were identified.

Commendable Practices:

- Since the last Accelerator Safety Review Committee (ASRC) review, June 2005, the AWA SOP was revised to incorporate a separate SAD chapter. None of the updates involved changes to the Accelerator Safety Envelope (ASE).
- The interlock chain uses highly reliable industrial grade switches specified to pass much higher current.
- Housekeeping was improved as evident by the absence of clutter on top AWA roof.
- There has been no loss time at the facility in 20 years
- The operator console is password protected to prevent unauthorized operation to the accelerator.
- Training offered to AWA personnel is in accordance with their respective JHQ. Instruction is given on both the written procedures and hands-on training. This formalized training has been extended to:

A. Authorized laser users

B. Scientific collaborator

C. Spectator

D. Visitor

E. Laser service personnel

Improvement Opportunity:

- It is recommended that permanent training records reflect training courses for each attending staff member.

Additional Comments and/or Information

Assessment checklist (fig. 4) and associated attachments provide more detail related to the radiation safety interlock system (s), test and maintenance activities for AWA.

List of Attachments

(fig. 1) rad_shielding_and_safetysystem (fig. 2) rad_safety_interlock_schematic (fig. 3) rad_safety_test_procedure (fig. 4) rad_safety_checklist

Reviews/Approvals

Performed by:	Cindy Gates for Conde Team Leader	Date: 3/29/07 mm/dd/yy
Reviewed by:	H. Wells	Date: 4/3/07 mm/dd/yy
Approved by:	Cindy Gates Responsible Manager	Date: 3/29/07 mm/dd/yy

File/Distribution: Responsible Manager (retains original)
Next Level Manager
EQO Management Assessment Coordinator
ESH/QA Representative

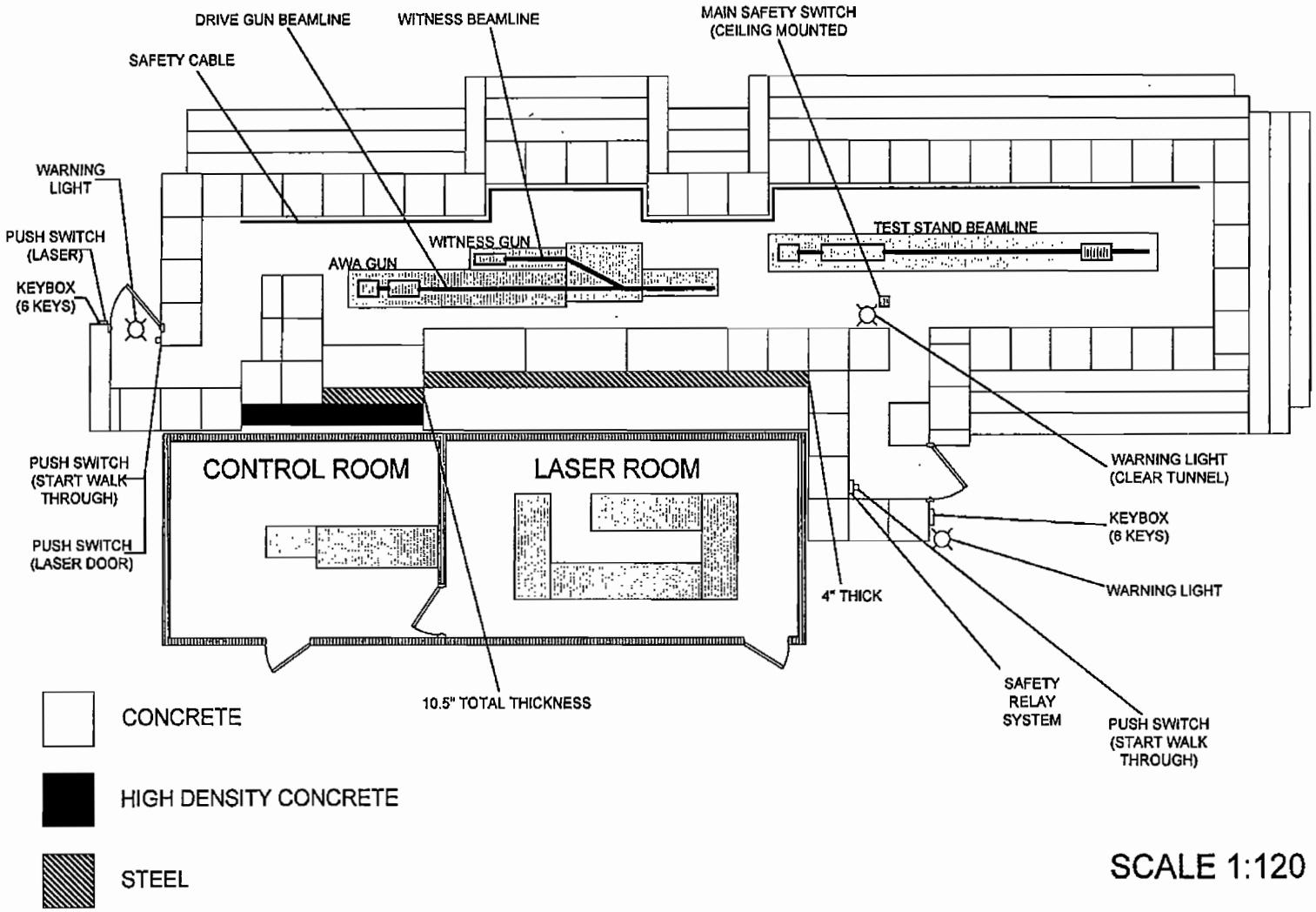

Fig. 1 AWA Shielding and Radiation Safety Systems

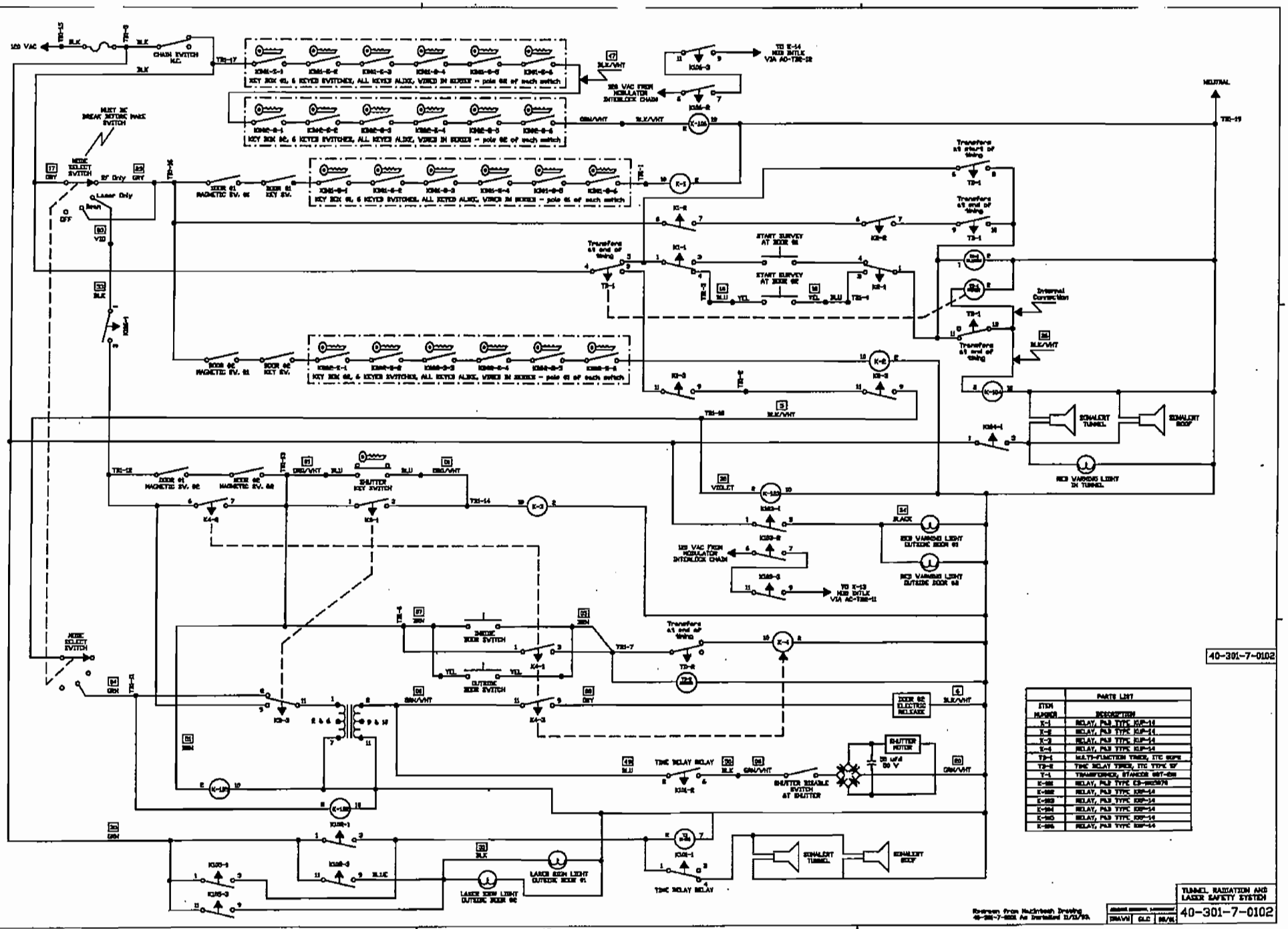

Figure 2 Radiation interlock system

(fig. 3)

AWA ELECTRON-LINAC, BUILDING 366
RADIATION SAFETY TESTING PROCEDURE
RF ONLY CONDITION
(April 1994)

Date Tested Jan. 17th, 2007

By _____ Jidong Lan, Haitao Wang
ESH **AWA**

The test is started with the following conditions:

A. Tunnel Door #1 - closed
B. Tunnel Door #2 - open
C. Survey Box #1 keys - captive position
D. Survey Box #2 keys - captive position
E. AC Cabinet Doors - open. & bypassed
F. CONTROL POWER BREAKER ON
G. ENERGIZE FIBER OPTIC INTERLOCK [CONTROL ON/OFF ON PANEL]

1. Verify that relay K-14 (Safety Switches Closed) in AC Cabinet is energized if all key switches are in the captive (run) position and de-energizes if any key switch is turned to the non-captive (safe) position.

	Box #1		Box #2	
	ESH	AWA	ESH	AWA
Key #1	____	✓	____	✓
Key #2	____	✓	____	✓
Key #3	____	✓	____	✓
Key #4	____	✓	____	✓
Key #5	____	✓	____	✓
Key #6	____	✓	____	✓

AWA ELECTRON-LINAC, BUILDING 366
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A. Tunnel Door #1 - closed
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D. Survey Box #2 keys - captive position
E. AC Cabinet Doors - open. * bypassed
F. CONTROL POWER BREAKER ON
G. ENERGIZE FIBER OPTIC INTERLOCK [CONTROL ON/OFF ON PANEL]

1. Verify that relay K-14 (Safety Switches Closed) in AC Cabinet is energized if all key switches are in the captive (run) position and de-energizes if any key switch is turned to the non-captive (safe) position.

	Box #1		Box #2	
	ESH	AWA	ESH	AWA
Key #1	___	✓	___	✓
Key #2	___	✓	___	✓
Key #3	___	✓	___	✓
Key #4	___	✓	___	✓
Key #5	___	✓	___	✓
Key #6	___	✓	___	✓

2. Starting with Door #1 closed and Door #2 open,verify that survey cancels at end of timing if any safety key switch is in the non-captive position and door #2 closed prior to end of timing. K-13 (Survey Complete) in the AC Cabinet is de-energized.

	Box #1		Box #2	
	ESH	AWA	ESH	AWA
Key #1	____	✓	____	✓
Key #2	____	✓	____	✓
Key #3	____	✓	____	✓
Key #4	____	✓	____	✓
Key #5	____	✓	____	✓
Key #6	____	✓	____	✓

3. Starting with Door #2 closed and Door #1 open, verify that survey cancels at end of timing if any safety key switch is in the non-captive position and door #1 closed prior to end of timing. K-13 (Survey Complete) in the AC Cabinet is de-energized.

	Box #1		Box #2	
	ESH	AWA	ESH	AWA
Key #1	____	✓	____	✓
Key #2	____	✓	____	✓
Key #3	____	✓	____	✓
Key #4	____	✓	____	✓
Key #5	____	✓	____	✓
Key #6	____	✓	____	✓

2. Starting with Door #1 closed and Door #2 open,verify that survey cancels at end of timing if any safety key switch is in the non-captive position and door #2 closed prior to end of timing. K-13 (Survey Complete) in the AC Cabinet is de-energized.

	Box #1		Box #2	
	ESH	AWA	ESH	AWA
Key #1	___	✓	___	✓
Key #2	___	✓	___	✓
Key #3	___	✓	___	✓
Key #4	___	✓	___	✓
Key #5	___	✓	___	✓
Key #6	___	✓	___	✓

3. Starting with Door #2 closed and Door #1 open, verify that survey cancels at end of timing if any safety key switch is in the non-captive position and door #1 closed prior to end of timing. K-13 (Survey Complete) in the AC Cabinet is de-energized.

	Box #1		Box #2	
	ESH	AWA	ESH	AWA
Key #1	___	✓	___	✓
Key #2	___	✓	___	✓
Key #3	___	✓	___	✓
Key #4	___	✓	___	✓
Key #5	___	✓	___	✓
Key #6	___	✓	___	✓

4. With all Key Safety Switches in the "run" position, verify that a tunnel survey cannot be made, using either start survey switch, with both tunnel doors closed.

____ V

5. With all Key Safety Switches in the "run" position, re-open Door #1 and complete a survey. Verify that the red strobe lights adjacent to the tunnel doors operate and K-13 in the AC Cabinet is energized and that the lights and relay de-energize when Door #1 is opened and do not re-energize when the door is closed.

____ V

6. Resurvey the Tunnel as in step #5. Verify that the red strobe lights adjacent to the tunnel doors operate and K-13 in the AC Cabinet is energized and that the lights and relay de-energize when Door #2 is opened and do not re-energize when the door is closed.

____ V

7. With all Key Safety Switches in the "run" position and Door #2 open, complete a survey. Verify that the red strobe lights adjacent to the tunnel doors operate and K-13 in the AC Cabinet is energized and that the lights and relay de-energize when Door #2 is opened and do not re-energize when the door is closed.

____ ____

8. Resurvey the Tunnel as in step #7. Verify that the red strobe lights adjacent to the tunnel doors operate and K-13 in the AC Cabinet is energized and that the lights and relay de-energize when Door #1 is opened and do not re-energize when the door is closed.

____ V

4. With all Key Safety Switches in the "run" position, verify that a tunnel survey cannot be made, using either start survey switch, with both tunnel doors closed.

____ V

5. With all Key Safety Switches in the "run" position, re-open Door #1 and complete a survey. Verify that the red strobe lights adjacent to the tunnel doors operate and K-13 in the AC Cabinet is energized and that the lights and relay de-energize when Door #1 is opened and do not re-energize when the door is closed.

____ V

6. Resurvey the Tunnel as in step #5. Verify that the red strobe lights adjacent to the tunnel doors operate and K-13 in the AC Cabinet is energized and that the lights and relay de-energize when Door #2 is opened and do not re-energize when the door is closed.

____ V

7. With all Key Safety Switches in the "run" position and Door #2 open, complete a survey. Verify that the red strobe lights adjacent to the tunnel doors operate and K-13 in the AC Cabinet is energized and that the lights and relay de-energize when Door #2 is opened and do not re-energize when the door is closed.

____ ____

8. Resurvey the Tunnel as in step #7. Verify that the red strobe lights adjacent to the tunnel doors operate and K-13 in the AC Cabinet is energized and that the lights and relay de-energize when Door #1 is opened and do not re-energize when the door is closed.

____ V

9. Resurvey the tunnel as in step #7. Verify that placing any key safety switch in the "safe" position cancels the survey (K-13 in AC cabinet de-energizes). and does not re-energize when key is returned to the "run" position.

	Box #1		Box #2	
	ESH	AWA	ESH	AWA
Key #1	____	✓	____	✓
Key #2	____	✓	____	✓
Key #3	____	✓	____	✓
Key #4	____	✓	____	✓
Key #5	____	✓	____	✓
Key #6	____	✓	____	✓

9. Resurvey the tunnel as in step #7. Verify that placing any key safety switch in the "safe" position cancels the survey (K-13 in AC cabinet de-energizes). and does not re-energize when key is returned to the "run" position.

	Box #1		Box #2	
	ESH	AWA	ESH	AWA
Key #1	____	✓	____	✓
Key #2	____	✓	____	✓
Key #3	____	✓	____	✓
Key #4	____	✓	____	✓
Key #5	____	✓	____	✓
Key #6	____	✓	____	✓

(fig. 4)

Radiation Safety Interlock Assessment Checklist for Procedures & Records

Facility: AWA

Supervisor of Activity Wei Gai Date: 3/19/07

Requirement	Met?	Notes
1) Interlock systems are documented by a complete set of drawings, a written functional description and written test procedures. These documents are kept current with system modifications.	✓	in AWA procedure manual
2) Interlock tests are documented.	✓	in AWA control Room
3) Interlock components are bypassed or jumpered only when using written and approved procedures. The procedures include: a. obtaining approval for the bypassing or jumpering from the line organization's director or designee; b. documenting installation, removal, and verification testing of interlock bypassing or jumpering; c. obtaining ESH-HP area office concurrence when the interlock system's level of safety will be affected; and, d. performing an annual inventory of any jumpers that are specially made devices.		Bypass or disable interlocks are not allowed at the AWA
4) Keys and locks used in radiation safety interlock systems are accountable under written and approved procedures. The procedures include: a. performing an annual inventory of all interlock keys unless all keys must be present and in use to operate the machine; b. issuing written controls if extra keys are to be maintained; and, c. requiring the line organization's director or designee to sign all purchase orders for interlock keys and/or locks.	✓	
5) Written and approved search and secure procedures are used to ensure that exclusion areas have been cleared of all personnel before beam is permitted.	✓	

Radiation Safety Interlock Assessment Checklist for Procedures & Records

Requirement	Met?	Notes
6) If the maximum dose that a missed person could receive is greater than 5 rem, the facility has an auditable program for verifying the adequacy of its search and secure procedures.	✓	
7) Written and approved procedures are used to control access to enclosures with the beam off (power on but with no radiation production in the enclosures).	✓	
8) Written and approved procedures are used to control access to enclosures with beam on (radiation is being produced in the enclosures).	✓	No access allowed with beams on
9) Written and approved procedures are used to perform maintenance or repair work on the interlock system.	✓	
10) Auditable records exist of any maintenance and repair work performed on the interlock or radiation measurement system since January 1, 1995. These records include specific descriptions of what in fact was done, the date the work was performed, the date the equipment was removed from and returned to service, and by whom the work was performed.	✓	
11) Written and approved procedures specify the control measures allowing removal of equipment access shielding blocks and include controls to be taken to prevent beam line startup before the shielding is restored.	✓	
12) Copies of the above relevant procedures, revised interlock tests, interlock related reportable occurrences, and similar pertinent documentation are made available to ESH.	✓	
13) All area radiation monitors incorporated into the safety interlock system have circuitry such that a failure of the monitor shall either prevent normal acces into the area or operation of the radiation-generating device.	✓	
14) Redundancy of devices or methods is provided where the MCI-I exceeds 5 rem.	✓	

Radiation Safety Interlock Assessment Checklist for Procedures & Records

Requirement	Met?	Notes
15) Run/Safe and Emergency Off Switches are provided for areas where the MCI-I exceeds 100 rem.	✓	
16) Emergency shut-off devices are clearly visible, unambiguously labeled, and readily accessible.	✓	
17) Safety system components should be labeled or color coded and are secured or supervised to prevent unauthorized access.	✓	
18) Two redundant methods are used to monitor each personnel access point.	✓	
19) A full search-and-secure is required by the hardware of the interlock system at startup and after each gate trip.	✓	
20) Data logging of the computer interlock and radiation meters should be performed at intervals no longer than 10 minutes.	N/A	The AWA interlock is not computer controlled.
21) Where the MCI-I is greater than 5 rem in an hour, a) An indication of device status is provided at each access point, where applicable. b) Two redundant methods to prevent or detect beam going down the wrong beam tube are provided, where appropriate. c) A program is in place for verifying the adequacy of the search and secure procedures.	✓	
22) There should be a device or procedure to prevent unintended radiation exposure to people working near the radiation-producing device.	✓	
23) There should be devices that operate independently from the interlock system to indicate the presence of beam.	✓	
24) Interlock keys not in use are kept in a locked location under the control of the chief operator or designee.	✓	
25) For entry into High Radiation Areas each individual is provided with an alarming dosimeter.	✓	

Radiation Safety Interlock Assessment Checklist for Procedures & Records

Requirement	Met?	Notes
26) Shielding blocks are secured in a manner such that the facility manager can assure against inadvertent removal.	✓	
27) Signs should be conspicuously posted on shielding blocks, hatch covers, and locks to indicate whom to contact and to warn about the consequences of inadvertent removal.	✓	

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