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Revision/Review Log

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INTRODUCTION

The National Synchrotron Light Source (NSLS) is a dedicated synchrotron radiation facility consisting of two electron storage rings with associated synchrotron radiation beamlines, and an injector which provides electrons for the rings. These devices produce ionizing radiation, and interlock systems are required for personnel protection.

The injector consists of an electron LINAC that operates at 120 MeV, and a booster synchrotron that accelerates the electrons to 750 MeV for injection into either storage ring. The radiation levels inside the enclosure could exceed 50 R/hr, therefore this area is classified as a high hazard radiation area.

At the present time, the VUV ring operates at 800 MeV with a stored beam of one ampere. The ring is surrounded by concrete and lead shielding placed close to the beam chamber. This shielding keeps the average levels of radiation on the experimental floor below 1 mR/hr. The shielding on the inside of the ring is less complete, and radiation levels up to 100 mR/hr can be encountered. An interlock system controls access to the central region of the ring.

At present, the operating energy of the X-ray ring is 2.8 GeV with a current of 285 mA. The ring is located in a concrete tunnel, and lead is strategically placed as shielding to keep the average radiation level outside the tunnel below 1 mR/hr. The radiation levels inside the tunnel can exceed 50 R/hr, so the X-ray tunnel is also a high hazard radiation area.

Synchrotron radiation from the X-ray ring is carried through beam pipes tangential to the ring into hutches where the experiments are located. The spectrum of the synchrotron radiation includes photons with energies up to several tens of kilovolts and the radiation flux can be extremely high: in the order of 10^{10} R/hr in the beam. Therefore the X-ray beamlines and experimental stations are treated as high hazard radiation areas. There are 63 X-ray beamlines in place on the experimental floor and almost all are in active use for experiments.

In the VUV area, the synchrotron radiation is typically confined to beam pipes and experimental chambers that are contiguous with the vacuum in the storage ring. In these cases ionizing synchrotron radiation does not emerge into air and does not present a hazard on the VUV experimental floor. A limited number of beamlines have windows that allow x-rays to emerge into accessible areas. These areas will be provided with interlocked enclosures to protect against this hazard and will be treated in the same way as an X-ray hutch. There are currently 16 beamlines in operation on the VUV ring.

High energy bremsstrahlung radiation is produced in both storage rings by interactions between the electron beam and residual gas or other matter in the electron orbit, and can pass down the beamlines to the experimental floor. The shielding to confine this radiation and prevent personnel access is determined during the design review of each beamline and is maintained under a formal configuration control program. When the beamline safety shutters are closed the bremsstrahlung radiation is confined to the storage ring enclosure.

INTERLOCK DESIGN PHILOSOPHY

The function of the NSLS interlock systems is to insure that no one is in an area where there is hazardous radiation, and to turn off the radiation source if a person somehow gains access to such an area. Each system shall provide signs and other indicators of the status of controls on the radiation source and visual and audible warnings of imminent radiation. Successful protection against radiation hazards requires coordination of engineered safety systems with administrative controls and operations procedures, since hardware alone cannot provide full protection. Engineered systems should be designed to support and enforce the proper execution of radiation safety procedures and interlock features must not distract personnel from the attentive and responsible execution of their duties.

The interlock systems for radiation protection at the NSLS must meet the following general requirements:

1. The design must be fail-safe. This means that the most likely failure modes leave the system in a safe condition. For example, the following failures must be safe:
   a) Loss of power in any part of the system,
   b) Any shorts to ground, and
   c) Any open circuits.

2. The interlock system must be designed to be testable, with redundant protections tested independently. Credit may not be taken for protective features that cannot be tested. Test procedures should be non-invasive, without requiring actions such as installing clip lead jumpers or disconnecting electrical wires.

3. Critical protective features of interlock systems for High Hazard Radiation Areas (potential of more than 50 R in an hour) must be redundant, so that no single failure can render the system unsafe. This may be implemented by providing two independent chains of protection with no common elements. In so far as possible, the two chains should be physically different to minimize the possibility of related coincident failures. Critical protective features include:
   a) Perimeter control of the area,
   b) Emergency crash system,
   c) Beam stops, and

d) Radiation source shutdown.

4. Personnel access to High Hazard Radiation Areas must be locked when radiation is present in the area, with the locks incorporated in the interlock system.

INTERLOCK SYSTEM DETAILS

A logic diagram of the protective features of the NSLS interlock systems is shown in Figure 1. Many functions are summarized on the diagram, for example the search sequence for each area requires several devices and logical elements but is shown only as a completed condition. Controls for beam shutters are not shown, and a command to close a shutter is not credited with providing safety. Instead, the closed position of each beam shutter is sensed redundantly and the independent signals are provided to each chain of the interlock. If these signals do not show that a shutter is closed when the area downstream is not safe for beam, then permission for the radiation source to operate is removed. In this way the system "reaches back" to turn off the radiation source if an unsafe condition is detected.

The interrelation of the different areas can be seen on the diagram. The extent of the action of a given interlock function is determined by the various shutters. Consider an X-ray beamline ready for operation with the hutch interlocks secured, but the safety shutter closed. If the interlock is broken, by opening the hutch door for example, the X-ray ring is not affected. When the safety shutter is open, however, breaking the interlock interrupts the RF and magnet power supplies in the X-ray ring, dumping the stored beam. If the transfer shutter between the injector and the X-ray ring is open, the LINAC is turned off as well. The system is designed to avoid these inconvenient shutdowns; a shutter cannot be opened unless the area downstream is properly interlocked. For the same reason, the key to a hutch door is captured, and cannot be released unless the shutter is closed.

The two interlock chains (A and B) are independent with no interconnections. Chain A includes all the critical protective functions plus other logic including search sequence, warning signals, time-outs, status indicators, and control functions. Chain B provides the redundant protective functions using a minimum number of relays or other active logic devices resulting in a much simpler circuit. This chain lacks "bells and whistles" but also has few failure modes, reducing the chance of coincident related failures and loss of protection. Another feature of the NSLS interlocks is that the system is modular, with the access control and protective logic for each area isolated from the logic of other areas. The only logical connections are the beam permit signals for the two protective chains that pass from each area to the radiation source upstream. These permit signals can be disconnected downstream of the beam shutter that isolates an area so that the interlock for that area may be repaired or modified without concern that erroneous permit signals could be transmitted to the radiation source. Alternatively or in addition, the beam shutter can be mechanically locked closed to provide a safeguard that is independent of electrical circuits. The modular arrangement of interlock systems means that a logical fault in one area cannot compromise protection in another area and greatly simplifies maintenance and testing of the many interlock systems at the NSLS.

Radiation safety interlocks at the NSLS were originally designed using relay logic, but recent upgrades have used Programmable Logic Controllers (PLCs) to provide part of the logic. At present (early 2002) the interlocks for the LINAC/Booster area and the VUV Ring incorporate PLC logic. In these systems, the PLC services the A chain and the B chain remains as a simple protective circuit using relays for logic.

Doors and gates for personnel access to interlocked areas are provided with dual interlock switches that act in the two protective chains, disabling the source of radiation to that area. The entrances to the LINAC/booster, the X-ray ring, and the X-ray beamline hutches are also locked with Kirk keys that disable the radiation source when they are removed for use in the door lock. The Kirk keys are captured in the lock when the door is open. Other openings to interlocked areas are provided for the movement of large apparatus, for maintenance and service purposes and the like. In many cases it is not possible to attach switches to these openings, or if switches were in place it would be impractical to test them during the periodic interlock tests. Equivalent safety is provided with electrical connectors, locks associated with the interlock system, or other means. These arrangements are reviewed for suitability and security as part of the design review of each interlock system and the conclusions of these reviews are recorded. The keys and locks associated with the NSLS interlock systems are described in Appendix A.

INJECTION AREA INTERLOCK

The floor plan of the LINAC-booster area and the location of interlock system devices is shown in the operations procedure for securing the Linac/Booster area (LS-OPS-0003). The area must be searched before the LINAC can be operated to ensure that no one remains inside. There are three check stations that must be pushed in the proper order to complete the search, ensuring that all the areas where a person might be hidden are visited. This interlocked area is open and sight lines are not obscured so the search may be conducted by one person. There is a three-minute time limit on the search process that insures that the system is never left in a partially searched condition. When the last button at the exit is pushed, there is a thirty-second audible alarm period after which the LINAC may be turned on. Beacons and strobes provide visual warning during the alarm period and remain on during the “Beam Ready” state. On the logic diagram (Figure 1) this search and warning function is denoted by "search sequence". There are limit switches on the doors, and if a door is opened LINAC operation is stopped and the search is dumped. Six prominently labeled emergency stop buttons are placed around the area. Pressing any of these stops LINAC operation and dumps the search. Finally, the doors are locked by a Kirk transfer key system: when a door is unlocked the key is captured in the door lock; the key cannot be removed unless the door is closed and locked. The keys must be in a holding unit in the control rack in order to satisfy the injector interlock.

There are shutters in the electron beam transport lines to the VUV and X-ray rings, and either these shutters must be closed or the interlocked areas downstream of the shutters must be ready for beam in order for LINAC operation to be permitted.

Control of the radiation source is accomplished by turning off the high voltage to the LINAC modulators. This positively prevents the acceleration of electrons to energies at which significant radiation is produced, and also prevents the generation of radiation by the high field gradients in the accelerating structure. The redundant chains of the interlock system act independently to disable the high voltage to the modulators. Chain A provides a permit to the power contactor inside each modulator power supply that is also used for normal on-off control of the supply. Chain B acts on a contactor in the primary power feed to each high voltage power supply. The chain B contactors are dedicated to the interlock function and do not have other functions or circuitry.

The logic for chain A of the interlock system is provided by a programmable logic controller. This system receives inputs from switches on each door, closed and open switches on the beam shutters, beam permits from the A chains of the VUV and X-ray storage rings, contacts from each emergency stop, and a signal from the magnet test mode key. Outputs are provided as permits to the LINAC modulator power supplies and to the booster magnet power supplies. The PLC also receives signals from the check stations and manages the search sequence, time-outs, and warning functions. Control of beam shutters and modulator turn-on and status indications at the control room panel are also provided by the chain A PLC. Chain B is much simpler, receiving inputs from door switches, beam shutter closed switches, Chain B permits from the storage rings, emergency stop contacts, door key holder switch and magnet test mode key. Chain B outputs are provided as permits to the dedicated power contactors on the LINAC modulators and to the booster magnet power supplies.

The Linac/Booster access control interlock supplies permits to the booster magnet power supplies to ensure electrical safety for these systems. This interlock also protects against the possibility of stored electron beam in the booster ring. Magnet turn-off before entry into the area ensures against exposure from this unlikely circumstance. A magnet test feature is provided in the interlock system that allows access to the magnets for measurement and test without requiring that the area interlock be secured. This is accomplished with a Kirk key transfer system that disables the radiation source and the area search sequence. The Kirk key may then be used to enable the power supplies for test operation. Operation in Magnet Test Mode is done under a procedure of the NSLS Electrical Engineering Group (Ring Access for Magnet Measurements; #LS-PSG-T001) that includes the appropriate electrical safety precautions.

VUV RING INTERLOCK

The layout of the VUV ring and location of interlock devices is shown in NSLS Operations procedure LS-OPS-0002 that also describes the search procedure. The interlocked area is the center of the ring at ground level, not including the mezzanine level above. The potential radiation levels in the interlocked area are below those that define a high hazard radiation area with maximum whole body exposure levels measured during beam injection of approximately 100 mR/hr and maximum during stored beam of less than 5 mr/hr. The interlock system for this area meets all the BNL requirements for a High Hazard area (with the exception of a locked entrance door), and also meets all requirements for a High Radiation area.

The area is searched by one person who follows a prescribed path, pressing the check stations in turn, and ensuring that no one remains in the area. There is a two minute time limit on the search and a thirty second audible warning is sounded when the search is complete. Flashing beacons show when the area is interlocked and indicate that the magnets may be energized and electron beam may be present. There are redundant switches on the entrance gate, and if the door is opened the search is dumped, the magnets turn off, and if the injection shutter from the booster is open at the time, the LINAC is also turned off. The VUV interlock has a Controlled Access Mode, described below, that allows passage through the gate under controlled conditions while the area is secured. There are three emergency stop buttons that dump the search, turn off the magnets, and interrupt LINAC operation if injection is in progress. There are also controls to ensure safe injection conditions: the injection shutter cannot be opened unless all beamline safety shutters are closed and the VUV dipole magnet current is correct for acceptance of the injected beam. If either of these conditions fails during injection, LINAC operation is interrupted. Radiation levels in the center of the VUV ring are relatively low during stored beam operation, and access to this area is needed for measurements and adjustments to storage ring support equipment located in the interlocked area. A Controlled Access Mode has been provided in the interlock system to accommodate these activities. "Access Mode" can be selected by the Control Room Operator using a switch in the control room, and doing so disables injection from the Linac/Booster and enables the gate pass-through mechanism. The operator writes in the control room log the name and time of entry and exit for each person and observes and communicates via a TV monitor and intercom. A button in the control room bypasses the gate switches and changes the illuminated sign indicating passage is permitted. The procedure LS-ESH-0013 "Controlled Access to the VUV Ring" describes the process, and this document also serves as a training guide for those entering on controlled access. When the Controlled Access is complete, with all personnel out of the area, the operator switches from Access mode to Normal mode. This sounds the audible alarm in the VUV area, disables the gate bypass system, and permits injection to take place.

The magnet power supplies are also interlocked to provide electrical safety. There is no Magnet Test Mode for the VUV ring since testing can be done under Controlled Access without requiring a bypass of the radiation protection interlock. Such testing is done under procedures controlled by the NSLS Electrical Engineering Group (Ring Access for Magnet Measurements; #LS-PSG-T001) with due provision for electrical safety.

X-RAY RING INTERLOCK

The layout of the X-ray ring and location of interlock devices is shown in NSLS Operations procedure LS-OPS-0001 that also describes the search procedure. The search requires two people who move in opposite directions around the circular tunnel. The entrance door is guarded during the search so that no one may enter when the door is not under observation by the searchers. A button inside the entrance door sets the door guard and starts the search and is also used to reset the door guard at the end so the searchers can exit. Three other check stations inside enforce the proper paths of the searchers and one outside the door is for search completion. There is a six-minute time limit on the search, and a 30 second warning at the conclusion. There are switches on the doors and if the doors are opened the magnets and RF systems turn off, dumping the stored beam. If the injection shutter is open at the time, the interlock reaches back and turns off the LINAC as well. There is a Kirk lock on the entrance door that must be locked and the key placed in a holder at the interlock control rack in order to satisfy the interlock. The emergency exit door which is on the opposite side of the ring from the entrance does not have a lock or other external hardware but can be opened by a crash bar on the inside of the door. If this door is opened the interlock is disabled and must be reset at the control rack before the area can be secured for operation. There are eight emergency stop buttons that dump the search, turn off the magnets, and interrupt LINAC operation if injection is in progress. There are also controls to ensure safe injection conditions: the injection shutter cannot be opened unless all beamline safety shutters are closed and the X-ray dipole magnet current is correct for acceptance of the injected beam. If either of these conditions fails during injection, LINAC operation is interrupted.

The electrical connections to the X-ray magnets are exposed inside the tunnel, and the power supplies are interlocked to the X-ray ring to provide electrical safety. A magnet test feature is provided in the interlock system that allows access to the magnets for measurement and test without requiring that the area interlock be secured. This is accomplished with a Kirk key transfer system that disables the radiation source and the area search sequence. The Kirk key may then be used to enable the power supplies for test operation. Operation in Magnet Test Mode is done under a procedure of the NSLS Electrical Engineering Group that includes the appropriate electrical safety precautions.

X-RAY BEAMLINE INTERLOCKS

Most X-ray experiments using synchrotron radiation require frequent access to the sample and the equipment. The hutch interlock systems are designed to permit a properly trained experimenter to gain access to the hutch, then restore the system to a safe condition and continue the experiment, all without intervention from NSLS operations. Radiation levels in these hutches may exceed 50 rem/hour, and the interlock design meets BNL requirements for this hazard level.

Hutches are provided with dual switches and Kirk locks on the personnel access door(s), emergency stop buttons, and check stations for the search process. Each beamline has a safety shutter that isolates it from the storage ring, and monochromatic beamlines also have photon shutters between the monochromater and the hutch. If all shutters between the ring and the hutch are open, then breaking an interlock at the hutch (by releasing a door switch, removing a Kirk key from its holder, or crashing an emergency stop button) will reach back and dump the beam in the storage ring, thus removing the radiation source. If any shutter in a beamline is closed, the hutch is isolated from the radiation source and breaking a hutch interlock does not affect the storage ring, although opening a door or hitting an emergency stop will dump the search of the hutch. To prevent inconvenient and time-consuming storage ring dumps, the system is designed so the door key cannot be released from the holder unless a shutter is closed.

Each hutch has one or two check stations inside the hutch, located to ensure that the search path provides a view of all parts of the hutch, and a search complete button outside. The lighting is dimmed to warn that a search is in progress and audible warning sounds for 15 seconds in small hutches and 30 seconds in large ones before beam can be introduced, providing ample time to reach an emergency stop or an exit. A search time-out ensures that the hutch is not inadvertently left in a partially searched state.

There are several keys and locks associated with the beamline interlocks. The hutch door Kirk keys are mentioned above and are used routinely during the progress of an experiment at a beamline. The Beamline Lockout Key is a Kirk key that takes a beamline "off line" by opening both interlock chains and disabling the safety shutter when it is removed from the lock switch at the beamline. The lockout keys are kept in the Control Room when not at the beamlines, and often an operations yellow tag is attached which lists beamline status, restrictions on operations, or other information. Beamline component keys are Kirk keys in the same transfer system as the lockout keys and are used to lock maintenance hatches and other devices that are manipulated during service or reconfiguration of the beamline. The use of either the lockout or the component key sets a latch at the beamline that must be reset with a key carried by the Operations Coordinator before return to on-line status. At that time, safety checklists or other actions are done as required. Vacuum flanges on the beamlines may give access to high radiation areas if removed and are controlled with beamline padlocks. A set of padlocks, keyed alike, is assigned to each beamline for control of flanges and other devices that are important to operational safety. The padlock key for each beamline is attached to a "Shutter Enable Key" located in an array of lock switches near the control room. Removal of this key disables the safety shutter for that beamline and opens one chain of the beamline interlock After the beamline padlock is opened, the attached keys are tagged to indicate which lock was opened for what reason along with any other pertinent information and placed on a storage rack. There is also a formal padlock checklist and status log at each beamline to ensure that the beamline is not returned to service until all components are properly restored and locked. Appendix A is a summary of keys and locks used in the NSLS interlock system.

VUV BEAMLINE SAFETY CONTROLS

The synchrotron radiation from the 800 MeV beam in the VUV ring is of much lower energy than that from the X-ray ring, and it has little penetrating power. All beamlines on the VUV ring are configured to contain ionizing synchrotron radiation inside the vacuum chambers. However, it has been demonstrated that there can be hazardous radiation close to a thin beryllium window that admits the beam to air, and any proposed beamline with such a window would be required to include a suitable personnel protection interlock. There is a potential hazard from bremsstrahlung radiation that will occur if the electron beam targets near the source point of a beamline. This is controlled by shielding collimators that confine the cone of potential bremsstrahlung, and by exclusion zones, consisting mainly of the beam pipes, which prevent access to that cone. The bremsstrahlung shielding, exclusion zones, and access to the excluded area is administratively controlled.

INTERLOCK TESTING

A personnel protection system that has been inadequately tested is not reliable. It is not possible to completely eliminate errors in construction (or in design) or to be certain that components are not faulty. The best insurance against these problems is a comprehensive, functional test of the system.

The design of interlock system tests at the NSLS is part of the interlock design process, insuring that protective features provided in the system can be tested without undue difficulty and without requiring invasive actions such as inserting electrical jumpers or removing wires. Component and circuit testing is part of the QA process during construction and maintenance, but the validation tests done at system commissioning and periodically thereafter, are functional tests and are largely independent of the logical hardware. The various protective elements: door switches, emergency stop switches and the like, are operated, and the resulting action observed. The tests verify that redundant protections are functional and independent, and verify not only that the system works as expected but also that improperly executed operations do not lead to unsafe conditions. For example, short cut search sequences are checked to see that they do not satisfy the interlock. In designing tests and interpreting the results it is important not to rely too heavily on the system logic, since this is one of the things being tested.

In some cases it is necessary to defeat part of the protection to test another part. For example, the door lock must be circumvented in order to test the door limit switches. At the NSLS we use a spare “latch device” (the part of the lock assembly that is attached to the door frame) to allow the key to be removed with the door open. The door cannot be closed completely when the latch device is in place, so the system is not in an operational state when the lock is defeated. An electrical jumper is less obvious and might inadvertently be left in place.

Interlock tests are carried out using check sheets that list the test actions and have check spaces where the results are verified. The check sheets are retained as a record of system tests. An interlock system at the NSLS may not be used to provide protection unless it has been tested within the previous six calendar months. In addition, an interlock system must be tested before it is first put in service and after any work has been done on the system, after any bypass or jumper has been installed, and after the bypass or jumper has been removed. In the event an interlock system is tested, fails, and cannot be repaired/verified prior to system operations or the system has not passed an interlock test prior to its due date and system operations, the system is locked out/tagged out (LOTO).

CONFIGURATION CONTROLS

Modification, maintenance or repair work on NSLS radiation safety interlock systems may be done only under the control of an Authorization for work on NSLS Accelerator Safety Systems or an Authorization for Work on NSLS Beamline Safety Systems as applicable, as provided in LS-ESH-PRM-3.4.1b. An exception to this requirement is during initial construction of an interlock system, before it is connected to control a radiation source.

Interlock connections to external devices such as power supplies or RF switches for the purpose of control of a radiation source shall be marked as part of the interlock system with "Do Not Disturb" warnings and contact information.

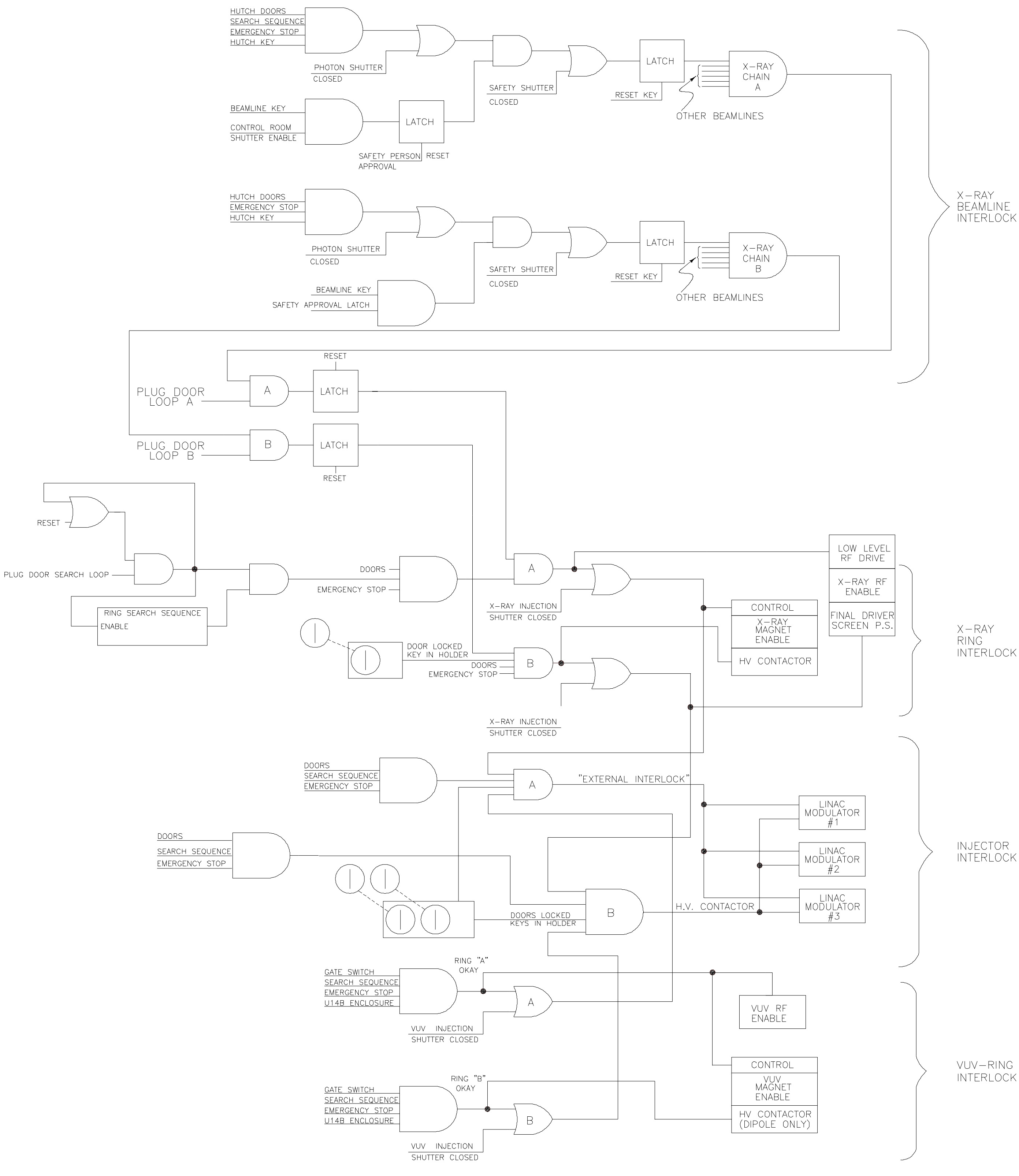
Proposed modifications to interlock systems and designs for new systems are reviewed by the NSLS Interlock Working Group. If the designs go beyond established practice at the NSLS or if the systems will deal with new safety issues, the matter is referred to the NSLS ES&H Committee which may decide to recommend an independent review. Examples of NSLS interlock systems that were reviewed by committees with membership from outside the NSLS are the Linac/Booster upgrade which was the first use of PLC logic for radiation interlocks at the NSLS, and beamline X17B2 which involved medical research with human subjects.

The records of design reviews and the engineering documentation such as circuit schematics and PLC ladder diagrams are maintained and controlled under the NSLS QA program.

DOCUMENTATION

The BNL ES&H Standard 1.5.3 "Interlock Safety for Protection of Personnel" lists several documentation requirements for interlock systems. These requirements are satisfied at the NSLS as follows:

1. A written functional description of the interlock system. This document "Radiation Safety Interlocks at the NSLS" provides that description.
2. A record of management approval of the system. The inclusion of this document in the SAD of the NSLS shows management approval of the basic design and implementation of the interlock systems at the NSLS. In addition, the Interlock Working Group, the NSLS ES&H Committee, and the Beamline Review Committee provide ongoing scrutiny and oversight of interlock system design and implementation. These are standing committees that are agents of NSLS management and records are kept of their deliberations and actions.
3. Documentation of the physical and electrical configuration of the system. Maintenance of technical documentation of the interlock systems is an assigned responsibility of an engineer in the NSLS electrical group and is done according to the requirements of the NSLS QA program.
4. A description of configuration management. This is summarized in the "Configuration Controls" section above and details are provided in the references therein.
5. Written test procedures. This is summarized in the "Interlock Testing" section above. A member of the NSLS safety staff has the assigned responsibility for ensuring that interlock testing is performed according to BNL and NSLS requirements and that accurate records are maintained.



NSLS-SECURITY SYSTEMS LOGIC BLOCK DIAGRAM

Figure 1.

Appendix A
KEYS AND KEY CONTROL

There are eight different types of keys associated with the personnel interlock systems:

A. Kirk keys, used on the injector and X-ray tunnel doors.
B. Kirk keys, used on the X-ray hutch doors.
C. Kirk keys, used on X-ray beamline components and auxiliary access ports.
D. Kirk keys, used as beamline lock-out keys.
E. Control Room shutter enable keys.
F. Beamline flange padlock keys.
G. Safety shutter padlock keys.
H. Beamline reset keys.

With the exception of the last, which are portable keys, there are specified locations for each of these keys for each set of circumstances.

The first three Kirk keys are always in one lock or another, as different access states of the interlock systems are defined. The control of these keys is defined by the mechanical and electrical features of the Kirk system.

There is a beamline lockout Kirk key at each X-ray beamline that disables both chains of the beamline interlock when it is removed from its lock. This key used as part of the administrative control of experimental activities at the beamline and also may be used to disable the beamline when shielding is removed, a controlled flange is opened, or other condition makes the beamline unsafe for beam. A reset by the Operations Coordinator is required after the lockout key is replaced before the beamline is enabled and can be operated.

There are beamline Kirk keys for some X-ray beamlines that are used on auxiliary ports and other devices. These keys are part of a transfer system and can be used only when the beamline lockout key has been removed. The same interlock disable and reset conditions apply.

There is a Control Room shutter enable key for each X-ray beamline safety shutter, located in an array of key switches near the NSLS Control Room. When a shutter is to be disabled, the key is removed from the switch, tagged with the reason and other information, and placed in a locked cabinet. This is most commonly done when beamline flanges are unlocked. Removal of this key disables one chain of the beamline interlock as well as safety shutter operation.

The beamline flange padlock keys are always fastened to the corresponding shutter enable keys, and both are carried to the beamline when it is to be unlocked, then placed on the storage cabinet as noted above.

Special padlocks are used to lock beamline safety shutters in the closed position when the associated interlock system is not operational and hence the beamline lockout cannot be used. The keys are kept in a locked cabinet along with the shutter padlocks that are not in use.

Each Safety Operator carries a beamline reset key, and uses it to reset the safety person approval latch after inspecting the beamline to verify that it is safe to operate. This key is also used to reset the latches on emergency stop and the two interlock chains if these should be tripped.

These keys are part of the primary radiation protection system, and are carefully controlled. The spare keys are kept in a locked cabinet and an accurate inventory is maintained. Access to these keys may occur only with authorization from the NSLS Safety Officer or the NSLS Safety Coordinator.