BNL Electrical Safety Program

Self-Assessment FY03: Interlock Safety

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BNL Electrical Safety Program - Self-Assessment FY02: Interlock Safety

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SUMMARY

The Laboratory Electrical Safety Committee[1] performed a self-assessment of interlock systems at BNL during the Spring of 2003.

Drivers for the program were determined, the existing BNL program was documented, and the program drivers were compared with BNL program elements. The assessment team found that program requirements for interlocks generally derive from requirements for radiation-generating devices, and these are adequately addressed in the Laboratory's existing Standard ESH 1.5.3 *Interlock Safety for Protection of Personnel*.

Implementation of BNL's program within line organizations was then investigated through visits to sixteen facilities. The assessment team found larger facilities generally conform more with provisions of the Laboratory's interlock standard than the smaller facilities. Noteworthy Practices were identified: Labeling interlock system devices to deter tampering was found in the NSLS and C-A; also, local indication of the status of interlock system testing through "calibration tags" was found in the NSLS and Magnet Division. However, the Standard does not adequately define interlocks, or address interlocks supplied with commercial equipment which may not be frequently tested or not at all. This may be linked to another finding of a general lack of understanding or knowledge among many BNL staffers of what is an interlock. Additional findings include not performing daily checks of fork lift safety switches as required by OSHA, instances of overdue interlock tests, and the removal of interlocks without proper authorization.

There were eight findings resulting from this self-assessment, resulting in six recommendations. The major recommendation is that the interlock standard should be revised and updated to better address commercial equipment and to add the topic of hazard analysis to the document. This addition would enable organizations to deal with the commercial interlocks on microwave ovens and centrifuges which may not be necessary to test on a regular basis.

[1] Members of the Laboratory Electrical Safety Committee are: John DiNicola (Chair), Albert Boerner, Jr., Joseph A. Curtiss, Thomas C. Nehring, Jon N. Sandberg,, Stephen Waski, Jr., James Wright, and Emil P. Zitvogel.

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1. INTRODUCTION

Interlock systems for protection of personnel act automatically to protect workers from exposure to hazards. Individuals tend to rely on interlock protection, and a poorly designed interlock or one which is not maintained or tested may actually increase the likelihood of an accident. Thus, these interlock systems include not only technical design requirements, but also requirements for their maintenance, testing, and configuration control. BNL incorporates these requirements in ESH Standard 1.5.3 *Interlock Safety for Protection of Personnel*.

Members of the Laboratory Electrical Safety Committee (LESC) were involved in development of the Standard, and the LESC is currently charged with reviewing the design, construction, operation, and testing of interlock systems, as well as reviewing the adequacy of the Standard and recommending any needed changes. The LESC performed this Laboratory-wide Interlock System self-assessment during FY03. The self-assessment was structured to answer the following questions:

- What are the drivers for interlock system requirements?
- What are the elements of BNL's interlock program?
- Does BNL's program adequately address interlock system requirements?
- Is BNL's interlock safety program being properly implemented by BNL line organizations?
- What improvements can be made to BNL's Interlock Standard, and to related programs?

2. METHODOLOGY

The Interlock Safety self-assessment was performed by the LESC in five parts, designed to respond to the above questions. Drivers for the program were determined, the existing BNL program was documented, and the program drivers and BNL's program were compared. Implementation of the program within BNL line organizations was investigated through interviews and facility tours. Finally, the LESC considered how interlocks and related issues can be improved within the Laboratory.

A checklist was used to track completion of each component of the Safety Interlock Self-Assessment. The checklist, which reflects the methodology of the assessment and the content of each phase, is appended to the report as Attachment A.

Step I - Drivers for the Program

The requirements which apply to work at BNL originate in the contract between DOE and Brookhaven Science Associates (BSA). Appended to the contract is a list of DOE Directives which BSA must follow. These requirements include a DOE Order on protection of workers, which in turn requires compliance with identified OSHA standards, and national consensus standards published by the National Fire Protection Association. In particular, BNL is obliged to conform with the requirements of both NFPA 70, the *National Electrical Code*, and NFPA 70E, *Electrical Safety Requirements for Employee Workplaces*.

In addition to compliance with specific safety standards, DOE requires that environmental, safety, and health requirements appropriate to the work be performed under a DOE-approved process. Effectively, this requires work at the Laboratory to follow BNL's Integrated Safety Management Program. This, in turn, leads to a variety of codes involving interlock systems, mostly those related to protection from hazards not readily evident to a worker.

Step II - Interlocks in BNL Documents

BNL's Integrated Safety Management Program deals with all aspects of protection of the worker and the environment at the Laboratory. This program includes work standards which are posted on BNL's internal web site of the Standards-Based Management System (SBMS), and which are available to all workers. These standards include both new "Subject Areas"and "legacy" documents. Among the legacy documents are the ESH Standards, which includes ESH 1.5.3 *Interlock Safety for Protection of Personnel*.

Step III - Comparison between Requirements and BNL Program

The drivers for the program, and ESH 1.5.3, are compared.

Step IV - Implementation in Line Organizations

The Interlock Self-Assessment included questioning of organizations and workers to determine how the program is implemented by line organizations and by individual workers. A questionnaire prepared by the LESC was used during interviews and workplace visits to be sure all areas of the ESH Standard 1.5.3 were addressed. Walkthroughs or tours were conducted of facilities to verify, on a sampling basis, information that was received either verbally through the interview process or through document reviews.

Interviews were conducted by at least two members of the LESC, generally accompanied by the organization ES&H representative and a representative from DOE's office on site. The interview notes are provided as Attachment J to this report.

Step V - Improvements to BNL's Interlock Standard and to Related Programs

Finally, the LESC considered the assembled responses and walkthrough data to conclude the extent of conformance to the requirements of NFPA 70E by the Laboratory. The item-by-item conclusions form the bulk of the last section of this report, followed only by a section tabulating the findings and recommendations.

3. STEP I - SOURCE DOCUMENTS AND DRIVERS

BNL is a government-owned, contractor-operated facility. The contract between the U.S. Department of Energy (DOE) and Brookhaven Science Associates, LLC (BSA) defines the documents and requirements which apply to the safety of personnel at the Laboratory. The contract also requires a system of Integrated Safety Management at BNL.

CONTRACT No. DE-AC02-98CH10886, defining the relationship between DOE and BSA, was originally drafted on October 22, 1997 and effective January 5, 1998. The contract was extensively restructured early in FY03, to follow DOE's standard uniform contract format and to update various clauses to reflect current Federal Acquisition Regulations (FAR) and Department of Energy Applicable Directives (DEAR). Attachment J.9 of the contract, labeled "Appendix I, DOE Directives,"lists those documents with which BSA must comply. The term "CRD" represents a Contract Requirement Document.

The documents which address interlocks include the following:

- CRD DOE Order O 440.1A *Worker Protection Management for DOE Contractor Employees*;
- CRD DOE Order O 420.2A *Safety of Accelerator Facilities.*

DOE O 440.1A *Worker Protection Management for DOE Contractor Employees*
This order "establishes the framework for an effective worker protection program that will reduce or prevent injuries, illnesses, and accidental losses by providing DOE Federal and contractor workers with a safe and effective workplace." (The entire text of DOE Order 440.1A is appended as Attachment D.) Under Paragraph 4.l, all DOE Elements, Federal and contractor, shall comply with the following worker protection requirements:

(5) National Fire Protection Association (NFPA) 70, *National Electrical Code.*
(6) NFPA 70E, *Electrical Safety Requirements for Employee Workplaces.*

- **NFPA 70, *National Electrical Code.*** The National Electrical Code (NEC) is intended for use primarily by those who design, install and inspect electrical installations, and provides in paragraph 90-2(a) *Introduction*, that "This code covers installations of electric conductors and equipment . . ." The NEC is issued along with a handbook containing explanatory text for many of the articles. Material from the handbook is appended as Attachment E, edited to include only items related to interlocks and including the explanatory material as shaded text.

Interlocks addressed in the NEC are limited to requiring the following:

- Ensuring switching procedures for electrical supply loop distribution systems;
- Ensuring, in space heating, that the fan circuit is energized before any heater circuit;
- Ensuring that ceiling lamps in folding camping trailers are de-energized before folding;
- Acknowledging that hoistway doors have interlocks;
- Ensuring that electric vehicle connectors are de-energized when the connector is unplugged;

- Requiring ventilation for charging electric vehicles; and
- Requiring interlock switches on dielectric heating applications.

■ **NFPA 70E, *Electrical Safety Requirements for Employee Workplaces*.** OSHA had difficulty with adopting the NEC because OSHA regulations address the employer and employee in the workplace. In response to this difficulty, the NFPA developed a new consensus document dealing with workplace issues, NFPA 70E - Electrical Safety Requirements for Employee Workplaces, which OSHA could consider for promulgation. The first edition of NFPA 70E was published in 1979 and included only Part I. The second edition, published in 1981, included Part I as originally published and added a new Part II - Safety-Related Work Practices.

NFPA 70E provides in the *Introduction*, paragraph I-1.1, that "This standard addresses those electrical safety requirements for employee workplaces that are necessary for the practical safeguarding of employees in the pursuit of gainful employment."

Interlocks addressed in NFPA 70E are limited to requiring the following:

- Isolating or disconnecting switches, and fused cutouts, interlocked with load-interrupting device;
- X-Ray and induction/dielectric heating equipment , to prevent access to current-carrying parts;
- Carnivals and Fairs, applied to power connectors;
- Interlocks addressed as part of lockout;
- Fail-safe interlocks on access panels for lasers;
- Interlocks to be maintained in proper working order;
- Only a qualified person is permitted to bypass a safety interlock.

DOE Order O 420.2A *Safety of Accelerator Facilities*
The only appearance of the word "interlock" lies in the description of the required Safety Assessment Document, which then requires documentation and detailed description of engineered controls including interlocks.

OTHER RESOURCES

Additional sources from within DOE and from OSHA were reviewed to determine other requirements applicable to interlocks. Each of the listed documents was edited to retain only material related to interlock systems, and added to the Appendix. These sources include the following:

■DOE guidance document G 441.1 *Radiation Devices;*
■10CFR835 Occupational Radiation Protection, Subpart F - Entry Control Program:
- Sec. 835.501 Radiological Areas,
- Sec. 835.502 High and very high radiation areas;

■ DOE HDBK-1092-98 *DOE Handbook ,Electrical Safety.*

DOE guidance document G 441.1 *Radiation Devices*

Interlocks are defined as "A device for precluding access to an area of radiation hazard by either preventing entry or by automatically removing the hazard. One example is an electro-mechanical control mechanism that interrupts the beam of ionizing radiation or shuts down the radiation installation whenever the interlock is challenged." The RGD Custodian must ensure that inspections of interlocks, warning lights, and other safety features are performed and documented. Posting is required to indicate the maintenance status, including any time a safety device or interlock has been approved to be by-passed or is awaiting repair.

Engineered access controls are required, including measures such as interlocked "photoelectric eye" light beams.) Doors and/or access panels in exempt shielded, shielded, and unattended installations should be equipped with one or more fail-safe safety interlocks to prevent irradiation of an individual (ANSI N43.3(6.5.2)). If an area radiation monitor is incorporated into a safety interlock system, the circuitry should be such that a failure of the monitor shall either prevent normal access into the area or operation of the RGD.

The system design, including interlock control devices, must be such that radiation cannot be produced until the interlock system logic has been completely satisfied, operation cannot be resumed by merely reestablishing the interlock circuit, and the safety circuit must be manually reset.

Warning lights required for a high radiation area or very high radiation area must be interlocked so that failure of the light will prevent operation of the radiation-generating device.

10CFR835 Occupational Radiation Protection, Subpart F - Entry Control Program

- **Sec. 835.501 Radiological Areas**

  Entry control shall be maintained, commensurate with the hazard, using methods including control devices on entrances and locked entrance ways. Use of interlocks is implied, but the word "interlock" is not included in the text.

- **Sec. 835.502 High and Very High Radiation areas**

  Devices are required at each entrance to prevent entry during high levels of radiation, which provides positive control over entry, and which will automatically cause radiation to be reduced when the area is breached. Use of interlocks is implied, but the word "interlock" is not included in the text.

DOE HDBK-1092-98 ***DOE Handbook ,Electrical Safety***.

The DOE Electrical Safety Handbook is an advisory document, and adherence is not contractually required. Nevertheless, it contains a great deal of information related specifically to electrical safety in a laboratory environment. Interlocks addressed in the DOE Handbook include the following:

- Control circuit devices and interlocks shall not be used for deenergizing circuits for lockout;
- Interlocks are included in firing circuits, and in purged systems intended to prevent explosion;
- Elevators include door interlocks;
- Interlocks are used in cabinets and switches when access to exposed live parts is not controlled;
- Interlocks are used in R&D equipment, for capacitors, inductors, lasers and x-ray equipment;
- Interlocks shall not be bypassed except by qualified persons, following written procedures.

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4. STEP II - BNL PROGRAM

BNL Standards-Based Management System (https://sbms.bnl.gov/mgtsys/ms0t/ms0td011.htm)

BNL implements Integrated Safety Management through the Standards-Based Management System (SBMS). This vehicle provides BNL staff with policies, standards of performance, and Laboratory-wide procedures and guidelines that are current, accurate, and relevant to their work. BSA implements these drivers, in part, through the establishment of Subject Areas consisting of Laboratory-wide procedures and guidelines. Subject Areas consist of Laboratory-wide procedures and guidelines with text delivered to users on-line using hypertext mark-up language (HTML). The content of the information is protected through a rigorous change control process; the on-line information is the only official copy of the materials. The SBMS system can be viewed using an Internet browser (https://sbms.bnl.gov).

These standards include both new "Subject Areas"and "legacy" documents. Among the legacy documents are the ESH Standards, which includes ESH 1.5.3 *Interlock Safety for Protection of Personnel*.

Laboratory Electrical Safety Committee

BNL management established the Laboratory Electrical Safety Committee (LESC) in 1989. The LESC established the present BNL electrical safety program through having prepared the BNL electrical safety standards subsequently endorsed by BNL management. Functions of the Committee are documented in the Charge to the Committee, found under the LESC listing in the BNL Committee Handbook by selecting "Committee Handbook" at <https://sbms.bnl.gov/>. The LESC has the responsibility to:

- review and recommend changes to the BNL Electrical Safety Policy, embodied in the four ES&H Standards 1.5.0 through 1.5.3.;
- act as the "Authority Having Jurisdiction" for NEC Code interpretations [such as the issue of NFPA 70E]; and
- approve, in conjunction with the Central Training Office, the objectives, content and target audiences of electrical safety-related training programs.

Each member of the LESC is experienced in electrical safety matters. Membership includes representation from the Safety and Health Services Division, Plant Engineering Division, Collider-Accelerator Department, and National Synchrotron Light Source.

BNL Electrical Safety Standards

The LESC prepared the four BNL Electrical Safety Standards which apply to electrical work on site. They address general electrical safety, lockout/tagout, design criteria, and interlocks. The hard-copy legacy documents were converted to on-line delivery in March 1999, and will continue to be delivered on the SBMS web in the old format until they have been converted into subject areas over the next few years. The LESC has been aggressive in revising the first two standards, to incorporate arc flash hazards and the concept of "working on or near energized conductors" in the electrical safety standard and to align the lockout/tagout

standard with OSHA requirements. Updates to both of these standards were issued in June 2003, during the progress of this interlock self-assessment. The latest versions of the documents posted on the SBMS web site are as listed:

- ESH 1.5.0 Electrical Safety, Rev. 4 (June 2003);
- ESH 1.5.1 Lockout/Tagout Requirements, Rev. 3 (June 2003);
- ESH 1.5.2 Design Criteria for Electrical Equipment, Rev. 1 - June 1991 (posted 1999);
- ESH 1.5.3 Interlock Safety for Protection of Personnel, Rev. 1 - March 1999 (posted 2001).

ESH 1.5.3 *Interlock Safety for Protection of Personnel*

The BNL Interlock Standard is intended to provide the minimum requirements for non-commercial (i.e. BNL designed and built) interlock systems installed for personnel protection at the Laboratory. The Standard also provides that commercial interlock systems, and interlock systems currently in place, are not exempt from documentation and testing requirements. The Standard requires that all energy sources, systems or devices that have the potential to cause a fatality or severe injury to personnel must be analyzed to determine whether an interlock system is necessary. Emergency systems such as fire protection are not covered by this Standard. The complete text of ESH 1.5.3 *Interlock Safety for Protection of Personnel* appears in Attachment M.

Contracts and Property Management

Safety requirements imposed by DOE on their contractor, BSA, must "flow down" to subcontractors. This is accomplished by the Division of Contracts and Property Management (DCPM) by appending to each contract for vendor support a document entitled "Work by Contractors on the Brookhaven National Laboratory Site – Supplemental Conditions." This document is available on the BNL web site at <http://www.bnl.gov/ppm/suppl.htm>, and a portion of the text is included in this report as Attachment N. Article 3 requires compliance with BNL's safety program, all OSHA standards, and BNL's ES&H Standards. Article 8 addresses ES&H and work planning, and paragraph (6) requires the contractor to ensure that engineering controls to prevent and mitigate hazards are tailored to the work being performed and the hazards. These provisions effectively require that interlocks necessary for the task be engineered and provided as part of the work.

An important area of electrical work often overlooked is maintenance of office machinery, such as the many Xerox machines on site. DCPM procedure SOP 105.9 covers office machines maintenance and repair. This document is available by selecting "Supply and Materiel Group S.O.P. Manual" at the web site <https://www.bnl.gov/ppm/BNL_ONLY/manual.htm> and a copy is included in this report as Attachment O. The Laboratory has an on-site repair service capability for the minor repair or adjustment of normal business machines which include photo copiers, calculators, time-date machines or typewriters. Requests for this repair or adjustment service are processed through the Office Machine Repair Section, and they arrange for appropriate vendor support if outside services are needed. Both BNL and vendor personnel who perform this service are believed to be qualified to work on this machinery, although no records were checked. Interlocks typically provided on such equipment to protect unqualified personnel are necessarily bypassed

by these service personnel in order that they may perform certain types of troubleshooting and adjustment.

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5. STEP III - COMPARISON BETWEEN REQUIREMENTS AND BNL PROGRAM

Brookhaven National Laboratory is home to a number of radiation-generating devices, including high-energy particle accelerators ranging in size from small cyclotrons used by the Chemistry Department to the Collider-Accelerator complex. Interlocks abound in these machines and facilities. In order to clarify requirements for dealing with interlocks, a committee at BNL drafted an interlock standard (ESH 1.5.3) for use within the Laboratory. The committee, drawn from the accelerator and health physics community, relied on standards and standard practice in the design of particle accelerators, which is evident from the text of ESH 1.5.3.

The Standard developed by the committee, the current ESH 1.5.3, includes all the requirements identified in this report in Section 3 - Source Documents and Drivers.

While the emphasis in the standard was on "non-commercial" interlock systems which were engineered, installed, and maintained by the Laboratory (mostly as part of the particle accelerators), the committee recognized the universal applicability of interlocks. This includes interlocks supplied with commercially-obtained equipment such as large power supplies or lasers. The Standard developed by the committee generally extended these same interlock requirements to all interlocks on site, specifically in requirements for routine testing and documentation. However, this universal applicability approach may not accommodate the variety of devices that:

- have operating switches that resemble (in function) interlocks;
- have interlocks that are not generally tested (e.g., centrifuges);
- have interlocks not used during startup but enabled during routine operation; and
- have interlocks which are routinely defeated by qualified personnel.

Examples of these categories are:

- operating controls on personal lifting devices, such as pallet lifters;
- door switches on microwave ovens, including those used in kitchens or in laboratory spaces;
- setup operations on machine tools, followed by production runs; and
- mechanical interlocks on disconnect switches permitting the door to open while energized.

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6. STEP IV - IMPLEMENTATION IN LINE ORGANIZATIONS

Selected Organizations

A listing of Department and Division Codes is available on BNL's home page, by selecting "Administration" followed by selecting "Department Codes." This list was downloaded and screened to delete organizations having little or no involvement with interlocks. The remaining organizations were contacted by e-mail as an alert that the interlock system self-assessment would take place, to request information on their interlocks, and, later, to schedule the interviews. The organizations selected for participation in this assessment are listed below.

Code	Organization
AD	Collider Accelerator Department
AM	Magnet Division
BO	Biology Department
CO	Chemistry Department
EE	Department of Environmental Sciences
EP	Plant Engineering Division
IO	Instrumentation Division
LS	National Synchrotron Light Source
MO	Medical Department
NN	Nonproliferation and National Security Department
PG	Photography & Graphic Arts Division
PO	Physics Department
RP	Radiological Control Division
SC	Central Shops Division
SE	Safeguards and Security Division
SS	Staff Services Division
WM	Waste Management Division

Scope of the Self-Assessment

Interlocks, as defined in *ESH 1.5.3 - Interlock Safety for Protection of Personnel*, are "engineered systems which function automatically to prevent the use, or operation, of a potentially hazardous system or device in a manner that might endanger personnel."

Access control systems for radiation areas, such as those used at the C-A and NSLS, were not included in the assessment. These systems are designed, reviewed, installed, and maintained by full-time staff devoted to these systems. However, interaction between these controlled areas and the associated energy sources are within the scope of the self-assessment. That is, how does breaching the control system boundary (i.e., opening an interlocked door, etc.) act to control the source of the hazard.

For radiation areas in facilities that do not have a dedicated staff assigned solely to the access control system, the entire access control system was within the scope of the self-assessment. Such devices would include the MRI and PET machines, the CERF installation, and the new Ebco cyclotron in Building 901. Other calibration, irradiation and counting facilities are likewise included.

Areas that are equipped with monitoring devices for hazardous conditions, which start or stop other equipment, also are within the scope of the self-assessment. One example is the RHIC tunnel wherein ventilation systems are started automatically when sensors detect an oxygen deficiency hazard (ODH). Other systems using flammable gas detectors are deployed at the RHIC detectors, and at the LNG refueling station for the Lab's energy-efficient vehicles.

Typical types of systems included in the review were interlocks on power supply access panels, interlocks associated with machine tools, and devices to stop motion of a mechanical drive upon sensing personnel occupancy (such as on motor-driven overhead doors). Interlocks associated with powered industrial trucks (forklifts, pallet movers) and emergency/standby electrical generators (auto start, load sequencing) were included in the review. Fire detection and suppression system interlocks were not included in the self-assessment. Also, interlocks furnished with office-type commercial equipment are not within the scope *of ESH 1.5.3 - Interlock Safety for Protection of Personnel* and therefore excluded from the self-assessment. Examples of such interlocks are those which stop a laser printer when the access panel is opened to replace the toner cartridge.

A "graded approach" was used for the self-assessment. That is, for larger organizations with formal programs the approach was to be more global and for smaller organizations the approach more specific, since with fewer persons involved in smaller facilities the possibility of an unrecognized hazard may be greater.

Interview Process

The requirements of ESH Std. 1.5.3 - *Interlock Safety for Protection of Personnel* were summarized in a questionnaire used for guidance and consistency of the assessment among the departments and divisions assessed. A copy of the questionnaire is furnished in this report as Attachment P.

An assessment team of members of the Laboratory Electrical Safety Committee visited sixteen facilities, and documented interviews with forty-six people. The team was accompanied by one or more members of DOE's Brookhaven Area Office during all but two of the visits.

Results of Site-Wide Interviews

General Results

Throughout the Laboratory, most organizations recognizing they have interlocks are generally conscientious about their design, installation, maintenance, periodic testing, and documentation. In general, for systems with interlocks:

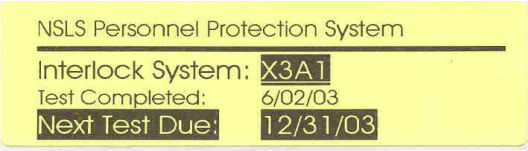
- primary safety is provided through proper operating controls and procedures;
- status of the interlock system is displayed locally or on a control console;
- systems are designed to require operator action for re-start;
- the interlock system design is fail-safe;
- access-control interlock systems arranged so they do not prevent personnel from leaving the area;
- systems requiring sequenced and timed inspection stations are so equipped;
- systems requiring interlocked warning lights and similar devices are so equipped;
- systems and their modifications are reviewed and records maintained of the reviews;
- only authorized persons are permitted to install, modify, test, or maintain interlock systems;
- documentation of the system is available; and
- test procedures are functional and written, with recording of the periodic tests.

Noteworthy Items

The NSLS and C-A have extensive personnel access systems, and they each have unique tags which they apply to enclosures and wiring to deter persons other than their assigned group from entering the enclosures or altering the wiring. The tags used by C-A are orange, with text. The tags used by the NSLS incorporate a graphic, which is especially useful in their facility due to the number and variety of experimenters present during operations.

Another **noteworthy practice** was adopted by two facilities, wherein labels similar to calibration tags are attached to interlock systems. The first facility was the **Magnet Division**, where responsibility for periodic testing and documentation of the interlock system was assigned to their quality control person. Based on the QC practice of applying calibration tags to devices such as radiation meters and electrical test equipment, a copy of the Magnet Division record for testing the interlock on a piece of equipment (generally a magnet power supply) is maintained in a folder affixed to the equipment. Further, all work involving interlocks within the Magnet Division is by approved, web-based procedure, and the first step in each procedure requires the worker to verify that the interlocks on the equipment to be used have been tested within the last six months. (While the labeling of the interlock equipment was noteworthy, instances of out-of-date procedures were found during a walkthrough of Magnet Division buildings.) The second facility was the **National Synchrotron Light Source**. Upon completion of testing for all radiation and laser systems, the interlock test group affixes a sticker both to the equipment and to the operating console, showing that the system successfully passed the test and listing the due date for the next test. The Operations Manager is responsible

for reviewing the information on the sticker before releasing the accelerator for operation. Information on the unique sticker is computer-generated/printed for ease of legibility.



Radiation-Generating Devices

Radiation-Generating Devices (RGD's) are used in a number of facilities, including Medical, Biology, Chemistry, Instrumentation, Physics, and Central Shops. Depending upon the hazard, some of these devices must be equipped with red warning lamps that are interlocked with the equipment, so that failure of the lamp (burned-out bulb, etc.) will prevent the device from operating. RGD's throughout the Laboratory were uniformly equipped with appropriate interlocks, were routinely tested using written, functional test procedures, and the results of the tests were documented. There were a few exceptions:

- Examination of interlock test logs revealed some facilities with overdue test dates. ESH 1.5.3 requires testing at six-month intervals. In some cases, the machines were not in use and the machines were not energized just for the sole purpose of performing the interlock test. When the machines were returned to service, the interlocks were apparently tested within a reasonable time frame. However, in most cases the assessment team could not ascertain by record review when the machines were returned to service and when the tests were completed. While testing the interlocks upon return to service is considered an acceptable practice, this practice and its documentation needs to be specified in procedures. Some facilities, however, such as LEAF and an instrumentation laser were found to be overdue for tests while the machines had been operating (not out of service). Regarding LEAF, by the end of the day of the team's visit, the interlock system was tested and the procedure changed to include both posting a testing requirement calendar and assigning specific individuals to test the system on specific dates on the calendar.

- For a table-top Picker x-ray machine, the operating procedure, posted on the side of the machine, includes interlock system checks as the operational initial steps thus the interlocks are tested prior to each use. The tests were reported to be documented every six months.

Configuration Management

The interlock standard requires a written description of the configuration management system for controlling design, modifications, reviews and approvals, replacements, and maintaining complete and accurate documentation. In addition, there should be both of the following:

- A written functional description of the interlock system, including:

Hazards protected against;
Means of protection;
Entry and search protocols including announcements, alarms, and emergency responses;
Response of the system in normal operation;
Response of the system to fault conditions and foreseeable personnel error;
Response of the system to equipment failure; and
A record of management approval of the system.

- Documentation of the physical and electrical configuration of the system, including circuit schematics, logic diagrams, wiring diagrams, and component specifications.

This complete set of documentation generally exists for larger facilities having a dedicated task group assigned to interlock systems, but only the latter documentation and a subset of the first is available for smaller installations. On balance, the configuration information is likely to be sufficient for simple interlock systems, but then again the functional description should not be difficult to prepare if they are so simple.

Access Panels and Other Interlocks

Switches on removable access panels are provided on some equipment throughout the Laboratory, arranged to shut down the device if the panel is removed. Many of these are supplied with commercial equipment, others are specified for equipment designed by the Laboratory and fabricated by others, and still others are installed as a matter of good engineering practice when equipment is constructed within the Laboratory. Facilities like the Collider-Accelerator and the National Synchrotron Light Source have thousands of such devices, ranging in applications from small high-voltage power supplies to room-size experimental magnet power supplies. Such devices are tested during initial installation and thereafter during equipment maintenance, but the maintenance intervals on some equipment could be years. Periodic functional testing each of these switches at six-month intervals is impractical and, moreover, could be hazardous in itself. Rather than deal with the multiplicity of this equipment, most facilities at the Laboratory do not take credit for the switches as interlocks, and state instead that safety is assured by lockout/tagout. This allows the interlocks not to be tested in accordance with ESH 1.5.3.

The assessment team saw a few commercial devices with factory-equipped interlocks that were not routinely tested. The devices included:

- High-speed centrifuges, the size of a top-loading clothes washing machine, with interlocks that cause the covers to lock when the machines are operating;
- Power supplies with interlocks on the rear doors, whose action is unknown since the users never open the rear doors and any necessary maintenance is performed by the vendor;
- A large oven used for drying circuit boards and curing conformal coatings, with a switch on the front access door arranged to stop the recirculating fan.

The assessment team visited machine shops in a number of facilities. In general, equipment guards are not interlocked with machines. The team saw only one large lathe in one facility equipped with an interlock for

the plastic guard over the headstock. There are many small shops having drill presses, vertical belt sanders, and grinding wheels, that are controlled by toggle switches or start-stop mechanical switches on the equipment, with power supplied by connection to wall-mounted 120-volt receptacles. While machinery controlled by magnetic starters with on/off pushbuttons will require operator action to restart after loss of power, these smaller devices will restart by themselves upon restoration of power. This hazardous condition can be corrected by using inexpensive plug-in "SAF-START" automatic anti-restart protectors stocked by the Laboratory.

Central Shops operates a large number of machine tools, and employs nearly thirty machinists who are not simply operators but tool and instrument makers. Use of interlocks on machine tools in Central Shops has been reviewed a number of times by both BNL and DOE. Central Shops is not a production facility, and items they produce are generally one-of-a-kind or short-run. Most work consists of operations where the machinists must have access to the point of operation where the tool meets the work, and most machines in Central Shops do not have interlocks. Central Shops contend that although interlocks are installed on the doors of some machining centers, most modern machine controls enable functionality of the machine tool with the door open when the control is in the setup mode to allow the craft person to set up the first part in a production run.

Although members of the assessment team may generally agree with this position, the team feels further review is warranted of new specific situations, as they occur. As an example, light-curtain interlocks on two trip-type metal brakes and a hydraulic shear were removed without formal review. While the team understands the need to remove or work around installed safety devices from time to time in order to perform the work, there should be more work planning including development of specific procedures for such actions, including appropriate reviews and documentation.

The assessment team saw a new machine tool equipped with a cage holding a variety of tools, with a switch on the cage door to stop the machine if the door were opened during an automated tool change. The team was told that the switch was not an interlock, a position not agreed with by the review team. This situation likely results from inadequate definition of interlocks in the BNL standard, specifically in the area of identifying other-than-radiation situations.

Industrial equipment, used throughout the Laboratory, includes overhead bridge cranes, powered overhead doors, and powered industrial trucks which are defined by OSHA as “any mobile power-propelled truck used to carry, push, pull, lift, stack or tier materials,” whether ridden or controlled by a walking operator. Operators of this equipment are trained periodically through a process of general classroom training followed by job-related equipment certification. The training includes the requirement that the user must test all operating controls before use. OSHA requires that any safety switch/interlock on any powered industrial truck be checked prior to use each day and/or each shift. The assessment team determined that these checks are not being routinely performed as required.

Maintenance of industrial equipment is generally performed by Plant Engineering, under a system of charging by craft and time. The assessment team noted that while Plant Engineering maintains equipment they know about, equipment owned by individual groups may be outside the Plant Engineering maintenance database.

In addition, the team noted at least one pallet lifter that was identified two-and-a-half years ago by the facility as worn out, and that the facility did not want to pay for further periodic maintenance. Unfortunately, the pallet lifter is still located in the facility and still in use due to confusion about who actually owns the device.

Maintenance by Plant Engineering

Information on equipment maintenance by Plant Engineering was obtained by the assessment team during a meeting with Plant Engineering staff. For brevity, the assertions below are recorded as fact although there was no follow-up examination of records by the team.

All standby generators are tested periodically, generally monthly or semi-annually. The generators at Bldg. 449 (Telephone Switch Room), Bldg. 599 (Fire House), and Bldg. 50 (Safeguards & Security) are tested monthly. The routine tests include responding to loss of line power, and annually the generators undergo a 2.5 hour load test.

All building cranes are maintained by Plant Engineering. Cranes are maintained periodically, depending on how much they are used; a typical 30-40 ton crane will be maintained quarterly. Inspections of all cranes are performed at least annually with the aid of a checklist. All overhead building cranes are furnished by Plant Engineering with a laminated "Pre-operational Checklist."

All elevators are serviced and inspected monthly, and twice each year all elevators are inspected by an outside, qualified elevator inspector.

Overhead doors are maintained by the BNL carpenters. Scheduled maintenance is performed by an outside vendor under contract with Plant Engineering. The routine maintenance intervals for the doors depends on use, with some doors checked annually and others every two years. Checks include the drive motors and their overload mechanisms, travel limits, and the safety switch on the bottom of many overhead doors.

Heavy equipment, including both the rigger's heavy lift equipment, and earth moving equipment (bulldozers, payloaders and backhoes) is maintained by Plant Engineering under the PM program.

Powered Industrial Trucks are maintained by Plant Engineering. Machine-type checklists, by type of machine, are used during maintenance. A typical machine checklist states: "Check all controls,"or "Check all interlocks," thus testing procedures are not always directly related to a particular piece of machinery. Specifically for fork lift maintenance, all those on Plant Engineering's PM list are visually checked every six months and they are serviced annually. All limits are checked, including the seat interlock and the neutral safety switch. Plant Engineering also depends on BNL requirements that all forklift operators be trained, which includes the necessity to check a forklift (or any powered industrial truck) before operating. Fork lifts are not furnished by Plant Engineering with a laminated "Pre-operational Checklist." The preventive maintenance described is performed as agreed to, and funded by, operating groups. For equipment not under such agreements, individual Building Managers know they must generate maintenance requests.

All man lifts are maintained by Plant Engineering, including those owned by operating groups. All man lifts are furnished by Plant Engineering with a laminated "Pre-operational Checklist."

Lawn mowers are maintained by Plant Engineering. BNL owns sixteen Toro lawnmowers and three Jacobsen lawn mowers, each on scheduled maintenance. The required preventive maintenance is once per year, however it is usually performed 3-4 times per year due to heavy usage. The normal machinery checks of all operating switches and controls performed under maintenance are supplemented by daily operator checks. The assessment team did not perform field observations to assure that the safety interlock switch on mowers is checked routinely by operators.

7. CONCLUSION AND RECOMMENDATIONS

Discussion of Results of Self-Assessment

Most participants during preparation of the BNL Interlock Standard were members of the particle accelerator community. The ESH 1.5.3 document addresses secured areas and search procedures, and includes the need for operational checks every six months, in conformance with requirements for such machines.

When the only tool you have is a hammer, every problem tends to look like a nail. Likewise, when the Interlock Standard was prepared by folks from the particle accelerator community, all interlocks tended to look like they were intended for application on an accelerator. As a result, the particle accelerator interlock approach was extended to all devices that could be recognized as interlocks.

It appears that the particle accelerator approach may have been overly cautious. For example, a microwave oven is automatically stopped when the door is opened. There are no testing requirements for a microwave oven in a facility's kitchen. If the microwave oven is moved to a lab, with a sign posted on the oven's door that warns "No Food, Specimens ONLY," is it now necessary to periodically test and document action of the same door interlock?

There is confusion about what, exactly, is an interlock. Switches are engineered into devices for a number of reasons including controlling temperature and limiting mechanical motion. While proper operation of these switches may prevent injury to personnel, they are simply operating controls. Interlock devices, on the other hand, are <u>not</u> necessary for operation but are <u>additional</u> equipment furnished with the intention of preventing injury to personnel. Some interlocks ensure one condition before allowing another condition, as when a driver must press on the brake pedal before the gear shift can be moved out of the park position. Other interlocks include arrangements to automatically force a device into a state intended to prevent injury to personnel, as when a fork lift truck shuts down if the seat switch does not sense the weight of a driver, or when a laser is de-energized when an access panel is opened.

The assessment team believes there are some interlocks that may not have to be tested periodically, and some which should never be tested. Defeat mechanisms on motor starters and disconnect switches allow the panel door to be opened without placing the switch lever in the OFF position. The following text is part of the consensus standard NFPA 70B *Recommended Practice for Electrical Equipment Maintenance:*

> *Chapter 9 Motor Control Centers, Paragraph 9-9 Interlocks*
>
> **9-9.3 Mechanical Interlocks.** Mechanical interlocks can be classified in two categories according to their application: safety and functional performance. Safety interlocks are designed to protect operating personnel by preventing accidental contact with energized conductors and the hazards of electrical shock. Functional interlocks, such as those found on reversing contactors, are designed to prevent the inadvertent closing of parallel contactors wired to provide alternate motor operating conditions. ....

9-9.3.3 Defeat Mechanisms. Most starters are equipped with defeater mechanisms that can be operated to release door interlock mechanisms with the disconnect device in the "ON" position. The use of this release mechanism should be limited to qualified maintenance and operating personnel.

The defeater mechanism furnished on commercial electrical equipment is an interlock. Certain troubleshooting operations require qualified persons to make measurements while equipment is energized, and the NFPA 70B text recognizes and allows for this procedure when performed by qualified persons. However, the LESC would discourage routine testing of defeater mechanisms as inappropriately exposing personnel to electrical hazards.

The source of difficulty may lie in two areas. First, while the scope of ESH 1.5.3 emphasizes non-commercial interlock systems, the requirements for testing and documentation are extended to include interlock systems supplied with commercial equipment. The team believes that some organizations read the document as applying only to non-commercial interlocks, while other organizations interpret the document as applying to anything resembling an interlock. This disparity in approach, and the varied and unique hazards abounding in the Laboratory, leads the LESC to conclude that it would be appropriate to recommend application of the Laboratory's hazard analysis to interlock systems as part of work planning. A simplified risk analysis table would be as follows:

Risk Screening Matrix Questions

CONSEQUENCE	FREQUENT Likely to occur repeatedly in life cycle	PROBABLE Likely to occur several times in life cycle	OCCASIONAL Likely to occur some time in life cycle	REMOTE Unlikely to occur in life cycle but possible	EXT. REMOTE Likelihood of occurrence ~ zero	IMPOSSIBLE Physically impossible to occur
Multiple deaths or serious injury	HIGH RISK	HIGH RISK	HIGH RISK	MODERATE RISK	LOW RISK	
A death or serious injury	HIGH RISK	HIGH RISK	MODERATE RISK	LOW RISK	LOW RISK	
Multiple moderate injuries	MODERATE RISK	MODERATE RISK	LOW RISK	LOW RISK		
Minor injuries						

Key*	*Hazard Rating Results from Hazard Identification Tool.
High Risk = 3 Moderate Risk = 2 Low Risk = 1 Routine Risk = 0	

Under risk screening, consider machinery such as the centrifuges used in Biology and other locations. The users are likely to be trained and qualified laboratory workers, dealing routinely with myriad biological and other hazards, and the centrifuges are viewed simply as tools and part of their working environment. That the centrifuge cover is held closed until the rotor spins down is likely to be part of their training as laboratory workers, and these workers may not be aware that this action is considered to be an interlock. The probability of injury to these qualified workers would be remote, and using this equipment in a laboratory with trained individuals would present a routine risk. How different is the centrifuge from the microwave oven?

Accordingly, the assessment team concludes that commercial devices may not have to have their interlocks checked every six months, and that the proper approach would be to conform with instructions in the vendor manual, and complete a hazard analysis for the equipment and any associated operation. The hazard analysis should include consideration of the qualifications of persons exposed to the hazard, and note that summer students or post-docs undergoing training in the laboratory should be a factor in the analysis. Certainly, any change of functionality or alteration of vendor-supplied commercial interlocks might place the affected equipment into the class of devices having laboratory-equipped interlocks, triggering the requirement for six-month testing. Also, any transfer of equipment between departments, or having new owners, should require re-evaluation of any interlock system on the equipment.

A hazard analysis approach could resolve interlock issues in Central Shops. On minor equipment of a conventional machine shop nature, like the two lathes, access to the headstock is necessary for setup and adjustment. Access into the working space of large, tool-changing machines, on the other hand, presents major exposure of body parts and interlocks should be recognized and routinely tested, documented, and utilized. The LESC believes that clarification of the definition and implementation of interlocks, coupled with toolbox talks as part of an awareness program, could bring closure to current concerns regarding the approach to interlocks in Central Shops.

Findings and Recommendations

The LESC would like to draw attention to two noteworthy practices, and point out a number of findings and associated recommendations. The LESC is limiting these items to issues related directly to the ESH 1.5.3 Standard, and issues that are important for the Laboratory to address. The assessment teams came across a number of minor issues, or organization-specific issues, during the course of this self-assessment. While only a few issues are highlighted in the findings, there is no intention to put aside information that can improve safety and operations within the Laboratory. Following distribution of this report, the LESC intends to methodically compile a list of items to be addressed, and pursue resolution of each of these items.

Table of Noteworthy Practices	
No.	Noteworthy Practice
1	A noteworthy practice by the NSLS and C-A, was labeling of interlock system devices to deter tampering.
2	A noteworthy practice by the NSLS and Magnet Division, was local indication of the status of interlock system testing, similar to calibration tags.

Table of Findings		
No.	Finding	Recommendation
1	Large facilities generally conform with provisions of the Laboratory's safety interlock standard.	none
2	The safety interlock standard does not adequately address interlocks supplied with commercial equipment.	1
3	The safety interlock standard does not adequately define interlocks; for example, are crash buttons, emergency stops, and limit switches considered to be interlocks.	1
4	The safety interlock standard does not adequately address interlocks that are infrequently or never tested.	1
5	BNL hosts an extraordinary variety of work, and some organizations do not clearly understand the BNL definition of interlock systems, the protection they afford, and the resulting requirements.	2
6	It is unclear who is responsible for what equipment, such as powered industrial trucks (pallet lifters and fork lifts). There should be a clear avenue for corrective action.	3,4
7	Preventive Maintenance documents are not specific to items of equipment, so that all control switches and interlocks are identified.	5
8	A hazardous device which was not acknowledged as having an interlock switch was deployed within the Laboratory without an Operational Readiness Evaluation (ORE). Since the extent of having equipment installed without proper reviews is unknown, the team considers this to be a site-wide finding that goes beyond interlocks, and should include receipt inspection of equipment, etc.	6

Table of Recommendations	
No.	Recommendation
1	The interlock standard should be revised and updated to better address commercial equipment, and to add the topic of hazard analysis to the document. This revision is expected to be more difficult than the recent revisions to ESH 1.5.0 and 1.5.1.
2	An awareness program should be pursued by the Laboratory Electrical Safety Committee, to create training and disseminate goals of the interlock safety program among ES&H Coordinators, Facility Representatives and others, including those who might be involved in Tier I inspections.
3	Safety Coordinators should identify equipment that is not listed for routine maintenance by Plant Engineering.
4	Safety Coordinators should establish that maintenance is being performed equipment on by Plant Engineering or their own organization, and assure that equipment not being maintained is taken out of service.
5	Plant Engineering Maintenance should develop maintenance procedures/checklists specific to items of equipment which include all control switches and interlocks.
6	Criteria which trigger an ORE, currently listed in the SBMS Subject Area on Operational Readiness Evaluations, should be expanded to include devices which have operating controls and interlocks. The LESC understands that a self-assessment of the ORE process is scheduled to be completed by the end of fiscal year 03, and expects that this subject area will be updated by the end of calendar year 2003.

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ATTACHMENTS

(Some attachments have been edited to underscore the word "interlock," edited to eliminate extraneous material, and partially reduced in font.)

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Attachment A

A - Master Checklist

Item	Description / Notes	Reference	Acceptable
Phase I	**Source Documents and Drivers**		
1.1	Current version of DOE/BNL contract	Confirm from web sites <http://www.bnl.gov/prime/searchprime.asp>	Yes
1.2	Path from contract to required stds.	Appendix I, dated 8/2/2000 <http://www.bnl.gov/prime/searchprime.asp>	Yes
1.3	Safety Directive(s)	O 420.1A - Worker Protection Management for DOE Contractor Employees (3/27/98), cited in Appendix I	Yes
1.4	DOE Order 420.1A (3/27/98) current	Download from DOE Web Site, requiring NFPA 70 and 70E: <http://www.directives.doe.gov>, search for “”420.1A”	Yes
1.5	NFPA Standard 70	NFPA 70: National Electrical Code, 2002 Edition, current hard copy	Yes
1.6	NFPA Standard 70E	NFPA 70E, Standard for Electrical Safety Requirements for Employee Workplaces, 2002 Edition, current hard copy and disk	Yes
Phase II	**BNL Program**		
2.1	Integrated Safety Management	Download from BNL Web Site: <https://sbms.bnl.gov>	Yes
2.2	Electrical Safety Standards	Downloaded from BNL Web Site: Select “ESH Standards” from location <https://sbms.bnl.gov/>	Yes
2.4	Contracts and Property Management	Downloaded from BNL Web Sites: <http://www.bnl.gov/ppm/>, select “Terms and Conditions Index, then select “Work by Contractors on the Brookhaven National Laboratory Site - Supplemental Conditions.”	Yes
Phase III	Comparison between Source Documents and Drivers, and BNL Program		
3.1	Conformance with Standards	Comparison between resource documents and ESH Std. 1.5.3.	
Phase IV	Implementation in Line Organizations		
4.1	Questionnaire	Includes Working Hot, Critical Systems, Training, Other Issues	Complete
4.2	Response	Organizations responded	Complete

Item	Description / Notes	Reference	Acceptable
4.3	Follow-up Interviews	Interviews arranged and conducted	Complete
4.4	Analysis	Program and interviews considered, conclusions drawn	
Final	**Conclusions and Recommendation**		
5.1	Conclusions and Recommendations	Compiled	

Attachment B

B - Modification MO. NO90 to Contract No. DE-AC02-98CH10866

MODIFICATION NO. MO90
CONTRACT NO. DE-ACO2-98CHlO886

1 of 2

MODIFICATION NO. MO90
SUPPLEMENTAL AGREEMENT TO
CONTRACT NO. DE-ACO2-98CHIO886

MODIFICATION NO. MO90

CONTRACTOR AND ADDRESS: Brookhaven Science Associates, LLC
Brookhaven National Laboratory
Upton, NY 11973

MODIFICATION FOR: Restructuring the format of the Contract to follow the uniform standard format and updated clause to reflect current FAR and DEAR

THIS MODlFICATION, effective the 13th day of January 2003, by and between the UNITED STATES OF AMERICA(hereinafter referred to as the "Government"), as represented by the UNITED STATES DEPARTMENT OF ENERGY (hereinafter referred to as "DOE"), and BROOKHAVEN SCIENCE ASSOCIATES, LLC (hereinafter referred to as the “Contractor"),

WITNESSETH THAT:

WHEREAS, the Government and the Contractor entered into Contract No. DE-ACO2-98CHIO886 on the 5th day of January 1998, for the operation of the Brookhaven National Laboratory; and

WHEREAS, said contract has been modified previously, and the parties desire to modify said contract further, as hereinafter provided; and

WHEREAS, this modification is authorized by law, including 41 U.S.C. 252(c)(15), P.L. 95-91and other applicable law;

Attachment B

MODIFICATION NO. MO90
CONTRACT NO. DE-ACO2-98CHlO886

2 of 2

NOW, THEREFORE. said contract, as modified previously, is hereby further modified as follows:

1. Contract: Restructure the entire Contract, including all Articles and Appendices, to follow the standard uniform contract format as stated on Standard Form 26 (Rev 4-85) and update various clauses to reflect current FAR and DEAR.

IN WITNESS WHEREOF, the parties have executed this document.

UNITED STATES OF AMERICA
DEPARTMENT OF ENERGY
BY: Robert P. Gordon
Contracting Officer
DATE: 1/13/03

BROOKHAVEN SCIENCE ASSOCIATES, LLC
BY: Brian P. Sack
Chief Financial Officer
DATE: 1/13/03

Attachment C

C - Appendix I, DOE Directives

Contract No. DE-AC02-98CH10886
ATTACHMENT J.9

Appendix I
Modification No. M094
Supplemental Agreement to
Contract No. DE-AC02-98CH10886

APPENDIX I
DOE DIRECTIVES

There is no List A to this Appendix.

List B to this Appendix contains two parts as follows:

Part I: " Directives List"

This section contains a list of Directives that are considered by DOE as applicable to the BNL contract.

Part II: "Partial Deletions of Directives"

This section contains a list of Directives that were accepted and implemented by the previous contractor but have subsequently been revised by DOE to remove certain sections.

Appendix I - Part I
CRD=Contract Requirements Document

DIRECTIVES LIST		
DATE	DOE DIRECTIVE NUMBER	SUBJECT TITLE
7/14/99	N 142.1	UNCLASSIFIED FOREIGN VISITS AND ASSIGNMENTS (Extended until 5/14/03 by DOE N 251.47 dated 8/14/02)
2/26/01	N 153.1	CONNECTIVITY TO ATMOSPHERIC RELEASE ADVISORY CAPABILITY
10/02/00	N 203.1	CRD - SOFTWARE QUALITY ASSURANCE (Extended until 12/31/01 by DOE N 251.40 dated 5/3/01)
7/26/99	N 205.1	CRD - UNCLASSIFIED CYBER SECURITY PROGRAM
11/1/99	N 205.2	CRD - FOREIGN NATIONAL ACCESS TO DOE CYBER SYSTEMS (Extended until 2/16/04 by DOE N 205.5 dated 2/14/03)

DATE	DOE DIRECTIVE NUMBER	SUBJECT TITLE
11/23/99	N 205.3	CRD - PASSWORD GENERATION, PROTECTION, AND USE (Extended until 2/16/04 by DOE N 205.5 dated 2/14/03)
3/18/02	N 205.4	CRD - HANDLING CYBER SECURITY ALERTS AND ADVISORIES AND REPORTING CYBER SECURITY INCIDENTS
1/15/02	N 231.1	CRD - ENVIRONMENT, SAFETY, AND HEALTH REPORTING NOTICE (Extended until 1/15/04 by DOE N 231.2 dated 12/30/02)
1/12/01	N 350.6	CRD - ACCEPTANCE OF VALID WORKERS' COMPENSATION CLAIMS
9/30/95	N 441.1	RADIOLOGICAL PROTECTION FOR DOE ACTIVITIES (using ORNL/TM-11497 in lieu of Attachment 1)(Extended until 6/30/00 by DOE N 441.4 dated 11/20/98)
2/5/01	N 450.4	CRD - ASSIGNMENT OF RESPONSIBILITIES FOR EXECUTIVE ORDER 13148, GREENING THE GOVERNMENT THROUGH LEADERSHIP IN ENVIRONMENTAL MANAGEMENT (Extended until 3/1/03 by DOE N 450.9, dated 9/3/02)
10/17/01	N 450.7	CRD - THE SAFE HANDLING, TRANSFER, AND RECEIPT OF BIOLOGICAL ETIOLOGIC AGENTS AT DOE FACILITIES (Extended until 03/30/03 by DOE N 450.10 dated 12/30/02)
12/15/00	N 470.2	CRD - REPORTING UNOFFICIAL FOREIGN TRAVEL (Extended until 12/31/01 by DOE N 251.40 dated 5/3/01)
4/13/01	N 471.3	CRD - REPORTING INCIDENTS OF SECURITY CONCERN (Extended until 06/30/03 by DOE N 251.51 dated 12/19/02)
5/26/00	N 473.4	CRD - DEPARTMENT OF ENERGY BADGES (Extended until 12/31/01 by DOE N 251.40 dated 5/3/01)
6/5/00	N 473.5	CRD - SECURITY AREA VOUCHING AND PIGGYBACKING (Extended until 12/31/01 by DOE N 251.40 dated 5/3/01)
10/26/00	N 473.7	CRD - EXPLOSIVE DETECTION PROGRAM (Extended until 12/31/01 by DOE N 251.40 dated 5/3/01)
8/7/02	N 473.8	CRD - SECURITY CONDITIONS
2/28/03	N 481.1	CRD - REIMBURSABLE WORK FOR DEPARTMENT OF HOMELAND SECURITY
11/3/99	O 110.3	CRD - CONFERENCE MANAGEMENT
9/29/95	O 130.1	CRD - BUDGET FORMULATION PROCESS (Extended until 5/1/03 by "DOE N 251.45 dated 5/29/02)
9/30/95	O.135.1	BUDGET EXECUTION-FUNDS DISTRIBUTION AND CONTROL (Extended until 5/1/03 by DOE N 251.45 dated 5/29/02)
11/01/00	O 151.1A	CRD - COMPREHENSIVE EMERGENCY MANAGEMENT SYSTEM
9/30/96	O 200.1	CRD - INFORMATION MANAGEMENT SYSTEM
9/27/95 10/26/95 5/1/95	O 210.1 Change 1 Change 2	CRD - PERFORMANCE INDICATORS AND ANALYSIS OF OPERATIONS INFORMATION
3/22/01	O 221.1	REPORTING FRAUD, WASTE AND ABUSE TO THE OFFICE OF INSPECTOR GENERAL
3/22/01	O 221.2	CRD - COOPERATION WITH THE OFFICE OF INSPECTOR GENERAL
11/26/97	O 225.1A	CRD - TYPE A AND B ACCIDENT INVESTIGATIONS
9/30/95 10/26/95 11/7/96	O 231.1 Change 1 Change 2	CRD - ENVIRONMENT, SAFETY & HEALTH REPORTING (DOE O 470.2A, dated 3/1/00, cancels Paragraph 5b(2).

DATE	DOE DIRECTIVE NUMBER	SUBJECT TITLE
9/30/95 11/7/96 01/28/00	M 231.1-1 Change 1 Change 2	ENVIRONMENT, SAFETY, AND HEALTH REPORTING MANUAL DOE O 470.2A, dated 3/1/00, cancels Chapter IV. DOE N 231.1, dated 1/15/02, cancels (Paragraphs 2a, 2a(1), 2a(2), 2b(1), 2b(2), 2i(3)(a) through 2i(3)(d) of Chapter II and Appendix A
8/1/97	O 232.1A	CRD - OCCURRENCE REPORTING AND PROCESSING OF OPERATIONS INFORMATION (As modified by letter Grahn/Gordon, dated 4/10/98, effective 5/5/98)
7/21/97	M 232.1-1A	OCCURRENCE REPORTING AND PROCESSING OF OPERATIONS INFORMATION (As modified by letter Grahn/Gordon, dated 4/10/98, effective 5/5/98)
4/9/01	O 241.1A	CRD - SCIENTIFIC AND TECHNICAL INFORMATION MANAGEMENT
1/30/98	O 251.1A	CRD - DIRECTIVES SYSTEM
11/19/99	O 252.1	CRD - TECHNICAL STANDARDS PROGRAM
9/30/96 5/8/98	O 350.1 Change 1	CRD - CONTRACTOR HUMAN RESOURCE MANAGEMENT PROGRAMS CRD - EMPLOYEE BENEFITS
7/12/01	0 350.2	CRD - USE OF FACILITY CONTRACTOR EMPLOYEES FOR SERVICES TO DOE IN THE WASHINGTON, D.C. AREA
04/20/99	O 412.1	CRD - WORK AUTHORIZATION SYSTEM
4/18/02	O 413.1A	CRD - MANAGEMENT CONTROL PROGRAM
1/08/01	O 413.2A	CRD - LABORATORY DIRECTED RESEARCH AND DEVELOPMENT
10/13/00	O 413.3	CRD - PROGRAM AND PROJECT MANAGEMENT FOR THE ACQUISITION OF CAPITAL ASSETS
11/24/98	O 414.1	CRD - QUALITY ASSURANCE
5/20/02	O 420.1A	CRD - FACILITY SAFETY
1/08/01	O 420.2A	CRD - SAFETY OF ACCELERATOR FACILITIES
12/21/00	O 425.1B	CRD - STARTUP AND RESTART OF NUCLEAR FACILITIES
10/14/98	O 430.1A	CRD - LIFE CYCLE ASSET MANAGEMENT (DOE O 430.2A, dated 4/15/02, cancels Paragraphs 6d(2), 6h, 7b(2), and 7e(16).)
4/15/02	O 430.2A	CRD - DEPARTMENTAL ENERGY AND UTILITIES MANAGEMENT
6/01/01	O 433.1	CRD - MAINTENANCE MANAGEMENT PROGRAM FOR DOE NUCLEAR FACILITIES
7/9/99 8/28/01	M 435.1-1 Change 1	CRD - RADIOACTIVE WASTE MANAGEMENT
7/9/99 6/19/01	M 435.1-1 Change 1	RADIOACTIVE WASTE MANAGEMENT MANUAL
3/27/98	O 440.1A	CRD - WORKER PROTECTION MANAGEMENT FOR DOE CONTRACTOR EMPLOYEES
3/8/02	O 440.2	CRD - AVIATION MANAGEMENT AND SAFETY
6/6/01	O 442.1A	CRD - DEPARTMENT OF ENERGY EMPLOYEE CONCERNS PRG.
5/15/00	O 443.1	PROTECTION OF HUMAN SUBJECTS
1/15/03	O 450.1	CRD - ENVIRONMENTAL PROTECTION PROGRAM
10/26/00 9/28/01	O 451.1B Change 1	NATIONAL ENVIRONMENTAL POLICY ACT COMPLIANCE PROGRAM
10/2/96	O 460.1A	CRD - PACKAGING AND TRANSPORTATION SAFETY
9/27/95 10/26/95	O 460.2 Change 1	CRD - DEPARTMENTAL MATERIALS TRANSPORTATION AND PACKAGING MANAGEMENT
9/23/02	M 460.2-1	CRD - RADIOACTIVE MATERIAL TRANSPORTATION PRACTICES MANUAL

DATE	DOE DIRECTIVE NUMBER	SUBJECT TITLE
9/28/95 6/21/95	O 470.1 Change 1	CRD - CONTRACTOR SAFEGUARDS AND SECURITY PROGRAM REQUIREMENTS (Extended until 5/14/03 by DOE N 251.47 dated 8/14/02)
10/30/02	M 470.1-1	CRD - SAFEGUARDS AND SECURITY AWARENESS PROGRAM
10/31/02	O 470.2B	CRD - INDEPENDENT OVERSIGHT AND PERFORMANCE ASSURANCE PROGRAM
6/30/00	O 471.1A	CRD - IDENTIFICATION AND PROTECTION OF UNCLASSIFIED CONTROLLED NUCLEAR INFORMATION
6/30/00 10/23/01	M 471.1-1 Change 1	IDENTIFICATION AND PROTECTION OF UNCLASSIFIED CONTROLLED NUCLEAR INFORMATION MANUAL
3/27/97	O 471.2A	CRD - INFORMATION SECURITY PROGRAM (Extended until 5/14/03 by DOE N 251.47, dated 8/14/02)
1/6/99	M 471.2-1B	CRD - CLASSIFIED MATTER PROTECTION AND CONTROL MANUAL
8/3/99	M 471.2-2	CRD - CLASSIFIED INFORMATION SYSTEMS SECURITY MANUAL (DOE N 205.3, dated 11/23/99 cancel Paragraphs 4j(2) and 4j(6) of Chapter VI, and Paragraph 12a(2)(a) of Chapter VII.) (Notice 205.4 dated 3/18/02 cancels Chapter III Section 8)
3/24/97	O 472.1B	CRD - PERSONNEL SECURITY ACTIVITIES (Extended until 5/14/03 by DOE N 251.47 dated 8/14/02)
12/23/02	O 473.1	CRD - PHYSICAL PROTECTION PROGRAM
12/23/02	M 473.1-1	CRD - PHYSICAL PROTECTION PROGRAM MANUAL
6/30/00	O 473.2	CRD - PROTECTIVE FORCE PROGRAM
6/30/00	M 473.2	PROTECTIVE FORCE PROGRAM MANUAL
1/17/02	M 473.2-1A	FIREARMS QUALIFICATION COURSES MANUAL
6/30/00 12/20/01	M 473.2-2 Change 1	PROTECTIVE FORCE PROGRAM MANUAL
11/20/00	O 474.1A	CRD - CONTROL AND ACCOUNTABILITY OF NUCLEAR MATERIALS
11/20/00	M 474.1-1A	CRD - MANUAL FOR CONTROL AND ACCOUNTABILITY OF NUCLEAR MATERIALS
2/10/98 4/27/98 11/16/98	M 474.1-2 Change 1 Change 2	MANUAL FOR NUCLEAR MATERIALS MANAGEMENT AND SAFEGUARDS SYSTEM REPORTING AND DATA SUBMISSION (Extended until 2/11/04 by DOE N 474.2 dated 2/11/03)
5/8/98	M 475.1-1	CRD - IDENTIFYING CLASSIFIED INFORMATION
9/28/01	O 481.1B	CRD - WORK FOR OTHERS (NON DOE FUNDED WORK)
1/03/01 9/28/01	M 481.1-1A Change 1	REIMBURSABLE WORK FOR NON-FEDERAL SPONSORED PROCESS MANUAL
1/12/01	O 482.1	CRD - DOE FACILITIES TECHNOLOGY PARTNERING PROGRAMS
1/12/01	O 483.1	CRD - DOE COOPERATIVE RESEARCH AND DEVELOPMENT AGREEMENTS
1/12/01	M 483.1-1	DOE COOPERATIVE RESEARCH AND DEVELOPMENT AGREEMENTS
1/6/03	O 534.1B	CRD - ACCOUNTING
8/25/00 11/8/02	O 551.1A Change 1	CRD - OFFICIAL FOREIGN TRAVEL
7/12/00	M 573.1-1	MAIL SERVICES USER'S MANUAL
5/2/01	P 141.1	DEPARTMENT OF ENERGY MANAGEMENT OF CULTURAL RESOURCES
6/10/00	P 413.1	PROGRAM AND PROJECT MANAGEMENT POLICY FOR THE PLANNING, PROGRAMMING, BUDGETING, AND ACQUISITION OF CAPITAL ASSETS
5/08/01	P 470.1	INTEGRATED SAFEGUARDS AND SECURITY MANAGEMENT POLICY

DATE	DOE DIRECTIVE NUMBER	SUBJECT TITLE
5/20/02	P 580.1	MANAGEMENT POLICY FOR PLANNING, PROGRAMMING, BUDGETING, OPERATION, MAINTENANCE AND DISPOSAL OF REAL PROPERTY
6/23/92	1270.2B	SAFEGUARDS AGREEMENT WITH THE INTERNATIONAL ATOMIC ENERGY AGENCY
7/14/88 10/5/88 5/18/92	2110.1A Change 1 Change 2	PRICING OF DEPARTMENTAL MATERIALS AND SERVICES
6/8/92	2300.1B	AUDIT RESOLUTION AND FOLLOWUP
2/8/90 6/5/90 1/7/93	5400.5* Change 1 Change 2	RADIATION PROTECTION OF THE PUBLIC AND THE ENVIRONMENT
5/15/84 5/16/88 5/16/89 9/20/91	5480.4* Change 1 Change 2 Change 3	ENVIRONMENTAL PROTECTION, SAFETY, AND HEALTH PROTECTION STANDARDS
7/9/90 5/18/92 10/23/01	5480.19 Change 1 Change 2	CONDUCT OF OPERATIONS REQUIREMENTS FOR DOE FACILITIES
11/15/94	5480.20A	PERSONNEL SELECTION, QUALIFICATION AND TRAINING REQUIREMENTS FOR DOE NUCLEAR FACILITIES
1/19/93	5480.30	NUCLEAR REACTOR SAFETY DESIGN CRITERIA
9/20/91	5530.1A	ACCIDENT RESPONSE GROUP
1/14/92 4/10/92	5530.3 Change 1	RADIOLOGICAL ASSISTANCE PROGRAM
5/8/85	5560.1A	PRIORITIES AND ALLOCATIONS PROGRAM
8/1/80	5610.2	CONTROL OF WEAPON DATA
5/26/94	5660.1B	MANAGEMENT OF NUCLEAR MATERIALS
9/4/92	5670.3	COUNTERINTELLIGENCE PROGRAM
ACCOUNTING PRACTICES AND PROCEDURES HANDBOOK		
5/2/83	Chapter V	INVENTORIES
6/30/80	Chapter X	PRODUCT COST ACCOUNTING

Appendix I - Part II

PARTIAL DELETIONS OF DIRECTIVES				
DATE	**DOE DIRECTIVE NUMBER**	**SUBJECT TITLE**	**DELETION DIRECTIVE DATE**	**SECTIONS DELETED**

2/8/90 6/5/90 1/7/93	5400.5 Change 1 Change 2	RADIATION PROTECTION OF THE PUBLIC AND THE ENVIRONMENT	O 231.1 9/30/95 Change 1 10/26/95	Chapter II: Para 1a(3) (a)
5/15/84 5/16/88 5/16/89 9/20/91	5480.4 Change 1 Change 2 Change 3	ENVIRONMENTAL PROTECTION, SAFETY, AND HEALTH PROTECTION STANDARDS	O 440.1 9/30/95 Change 1 10/26/95	Attachment 2: Paras 2c, 2d(2) - (3), 2e(1) - (8); and Attach. 3: Paras 2c,; 2d(2) - (3), 2e(1) - (7)

Attachment D

D - DOE Order 440.1A
Approved: 05-20-02
Review Date: 05-20-04

(Download from DOE Web Site <http://www.directives.doe.gov>)
Edited to show requirement for NFPA 70 and NFPA 70E.

SUBJECT: FACILITY SAFETY

APPLICABILITY.

b. Contractors.

(1) Except for the exclusions in 3c, the Contractor Requirements Document (CRD), Attachment 2, sets forth requirements that are to be applied to the universe of contractors awarded management and operating contracts.
(2) Contractor compliance with the CRD will be required to the extent set forth in a contract.

(4) Regardless of the performer of the work, contractors with the CRD incorporated into their contracts are responsible for compliance with the requirements of the CRD. Affected contractors are responsible for flowing down the requirements of the CRD to subcontracts at any tier to the extent necessary to ensure the contractor's compliance with the requirements.

c. Exclusions.

(5) Accelerator facilities that are covered by DOE O 420.2A (excluded from 4.1 and 4.3 but not from 4.2 and 4.4.).

(From previous BNL self-assessment)
ATTACHMENT 2 - CONTRACTOR REQUIREMENTS DOCUMENT
WORKER PROTECTION MANAGEMENT FOR DOE CONTRACTOR EMPLOYEES
The contractor shall comply with the requirements below; however, the requirements for the specific functional areas that are addressed in paragraphs 14 through 22 apply only if the contract is involved in these activities.

.....

12. Comply with the following worker protection requirements:

.....

k. National Fire Protection Association (NFPA) 70, National Electrical Code.
l. NFPA 70E, Electrical Safety Requirements for Employee Workplaces.

(Blank)

E - NFPA 70 - National Electrical Code

National Electrical Code, NFPA 70
2002 Edition, Code text and highlighted Code Handbook text (interlock underlining added)

Chapter 2 Wiring and Protection
Article 225. Outside Branch Circuits and Feeders
225.30 Number of Supplies.
(E) Documented Switching Procedures. Additional feeders or branch circuits shall be permitted to supply installations under single management where documented safe switching procedures are established and maintained for disconnection.
Handbook: Buildings on college campuses, multibuilding industrial facilities, and multibuilding commercial facilities are permitted to be supplied by secondary loop supply (secondary selective) networks, provided that documented switching procedures are established. These switching procedures must establish a method to safely operate switches for the facility during maintenance and during alternate supply and emergency supply conditions. Keyed interlock systems are often used to reduce the likelihood of inappropriate switching procedures that could result in hazardous conditions.

Chapter 4 Equipment for General Use
Article 424. Fixed Electric Space-Heating Equipment
424.63 Fan Circuit Interlock.
Means shall be provided to ensure that the fan circuit is energized when any heater circuit is energized. However, time- or temperature-controlled delay in energizing the fan motor shall be permitted.

Chapter 5 Special Occupancies
Article 551. Recreational Vehicles and Recreational Vehicle Parks

II. Low-Voltage Systems
551.10 Low-Voltage Systems.
(A) Low-Voltage Circuits. Low-voltage circuits furnished and installed by the recreational vehicle manufacturer, other than automotive vehicle circuits or extensions thereof, are subject to this Code. Circuits supplying lights subject to federal or state regulations shall comply with applicable government regulations and this Code.
Handbook: The wiring referred to in 551.10(A) is the low-voltage wiring within the recreational vehicle that would be used in place of 120-volt ac supplies and does not refer to the wiring of the automotive vehicle circuits (e.g., circuits used for ignition, headlights, or other vehicle functions).

(G) Luminaires (Lighting Fixtures). All low-voltage interior luminaires (lighting fixtures) rated more than 4 watts, employing lamps rated more than 1.2 watts, shall be listed.
Handbook: Ceiling luminaires (fixtures) in camping trailers shall be automatically de-energized by an interlock when folding down the trailer, or it shall be physically impossible to fold down the trailer unless the ceiling luminaire(s) (fixtures) are disconnected.

Chapter 6 Special Equipment
Article 620. Elevators, Dumbwaiters, Escalators, Moving Walks, Wheelchair Lifts, and Stairway Chair Lifts
620.11 Insulation of Conductors.
Hoistway door interlock wiring is required to be suitable for 200˚C (392˚F).

Article 625. Electric Vehicle Charging System
625.18 Interlock.
Electric vehicle supply equipment shall be provided with an interlock that de-energizes the electric vehicle connector and its cable whenever the electric connector is uncoupled from the electric vehicle. An interlock shall not be required for portable cord-and-plug-connected electric vehicle supply equipment intended for connection to receptacle outlets rated at 125 volts, single phase, 15 and 20 amperes.

Handbook: To reduce shock hazard, a pilot or communications interlock establishes power through the electric vehicle supply equipment. Loss of the pilot or communications circuit locks out power, isolating possible hazardous situations in the electric vehicle supply equipment. See 625.29(D) for mechanical ventilation interlock requirements.
For ventilation interlock, see 625.29(D)(3) for 125-volt receptacles intended to charge electric vehicles.

Article 625.29 Indoor Sites
D) Ventilation Required. Where the electric vehicle supply equipment is listed or labeled as suitable for charging electric vehicles that require ventilation for indoor charging and marked in accordance with 625.15(C), mechanical ventilation, such as a fan, shall be provided. The ventilation shall include both supply and exhaust equipment and shall be permanently installed and located to intake from, and vent directly to, the outdoors. Positive pressure ventilation systems shall be permitted only in buildings or areas that have been specifically designed and approved for that application. Mechanical ventilation requirements shall be determined by one of the methods specified in 625.29(D)(1) through (D)(4).
Handbook: The interlock described in 625.29(D) prevents a vehicle requiring ventilation from being charged unless ventilation is provided. This interlock feature is included in the pilot connection of the standard electric vehicle supply equipment connection. See Exhibit 625.4 for an illustration of electric vehicle supply equipment with interlocked ventilation.

Article 665 Induction and Dielectric Heating Equipment
665.25 Dielectric Heating Applicator Shielding.
Protective cages or adequate shielding shall be used to guard dielectric heating applicators. Interlock switches shall be used on all hinged access doors, sliding panels, or other easy means of access to the applicator. All interlock switches shall be connected in such a manner as to remove all power from the applicator when any one of the access doors or panels is open.

Appendix F

F - NFPA 70E - Std. for Electrical Safety Requirements for Employee Workplaces

Standard for Electrical Safety Requirements for Employee Workplaces
2000 Edition

Introduction

I-1 Scope.
I-1.1
This standard addresses those electrical safety requirements for employee workplaces that are necessary for the practical safeguarding of employees in their pursuit of gainful employment.

3-1 Wiring Methods.

3-10 Equipment for General Use.
3-10.6 Capacitors.
3-10.6.1 Switching.
3-10.6.1.2 Isolation.
3-10.6.1.2.3
Isolating or disconnecting switches (with no interrupting rating) shall be interlocked with the load-interrupting device or shall be provided with prominently displayed caution signs to prevent switching load current.
3-10.6.1.3 Additional Requirements for Series Capacitors.
The proper switching sequence shall be ensured by use of one of the following:
(1) Mechanically sequenced isolating and bypass switches
(2) Interlocks

4-6 X-Ray Equipment.
4-6.1 Disconnecting Means.
4-6.1.1 Disconnecting Means.
4-6.1.2 Independent Control.
4-6.2 Control — Industrial and Commercial Laboratory Equipment.
4-6.2.1 Radiographic and Fluoroscopic Types.
All radiographic- and fluoroscopic-type equipment shall be effectively enclosed or shall have interlocks that de-energize the equipment automatically to prevent ready access to live current-carrying parts.
4-6.2.2 Diffraction and Irradiation Types.
Diffraction- and irradiation-type equipment or installations not effectively enclosed or provided with interlocks to prevent access to live current-carrying parts during operation shall be provided with a positive means to indicate when they are energized. The indicator shall be a pilot light, readable meter deflection, or equivalent means.

4-7 Induction and Dielectric Heating.
4-7.1 Scope.
4-7.2 Guarding, Grounding, and Labeling.
4-7.2.1 Enclosures.
4-7.2.2 Panel Controls.
All panel controls shall be of dead-front construction.
4-7.2.3 Access to Internal Equipment.
Doors or detachable panels shall be employed for internal access. Where doors are used giving access to voltages from 500 to 1000 volts ac or dc, either door locks shall be provided or interlocks shall be installed. Where doors are used giving access to voltages of over 1000 volts ac or dc, either mechanical lockouts with a disconnecting means to prevent access until voltage is removed from the cubicle, or both door interlocking and mechanical door locks, shall be provided. Detachable panels not normally used for access to such parts shall be fastened in a manner that will make them inconvenient to remove.

4-7.2.4 Warning Labels or Signs.
4-7.2.5 Work Applicator Shielding.
Protective cages or adequate shielding shall be used to guard work applicators other than induction heating coils. Induction heating coils shall be permitted to be protected by insulation or refractory materials, or both. Interlock switches shall be used on all hinged access doors, sliding panels, or other easy means of access to the applicator. All interlock switches shall be connected in such a manner as to remove all power from the applicator when any one of the access doors or panels is open. Interlocks on access doors or panels shall not be required if the applicator is an induction heating coil at dc ground potential or operating at less than 150 volts ac.
4-7.3 Remote Control.
4-7.3.1 Selector Switch.
Where remote controls are used for applying power, a selector switch shall be provided and interlocked to provide power from only one control point at a time.

4-11 Carnivals, Circuses, Fairs, and Similar Events.

4-11.2.5 Portable Distribution or Termination Boxes.
Portable distribution or termination boxes shall comply with 4-11.2.5.1 through 4-11.2.5.4.
4-11.2.5.1 Construction.
4-11.2.5.2 Busbars and Terminals.
4-11.2.5.3 Receptacles and Overcurrent Protection.
4-11.2.5.4 Single-Pole Connectors.
Where single-pole connectors are used, they shall comply with the following:
(a) General. Where ac single-pole portable cable connectors are used, they shall be listed and of the locking type. Strain relief requirements and marking requirements other than those found in Section 4-11 of Part I, shall not apply to listed single-pole separable connections and single-conductor cable assemblies utilizing listed single-pole separable connectors. Where paralleled sets of current-carrying single-pole separable connectors are provided as input devices, they shall be prominently labeled with a warning indicating the presence of internal parallel connections. The use of single-pole separable connectors shall comply with at least one of the following conditions.
(1) Connection and disconnection of connectors are only possible where the supply connectors are interlocked to the source and it is not possible to connect or disconnect connectors when the supply is energized.
(2) Line connectors are of the listed sequential-interlocking type so that load connectors shall be connected in the following sequence:
a. Equipment grounding conductor connection
b. Grounded circuit-conductor connection, if provided
c. Ungrounded conductor connection, and that disconnection shall be in the reverse order

Chapter 6 Special Systems

6-1 Systems Over 600 Volts, Nominal.
6-1.5 Circuit-Interrupting Devices.
6-1.5.1 Circuit Breakers.
6-1.5.2 Power Fuses and Fuseholders — Use.
6-1.5.3 Distribution Cutouts and Fuse Links — Expulsion Type.
6-1.5.3.1 Installation.
6-1.5.3.2 Operation.
Where fused cutouts are not suitable to interrupt the circuit manually while carrying full load, an approved means shall be installed to interrupt the entire load. Unless the fused cutouts are interlocked with the switch to prevent opening of the cutouts under load, a conspicuous sign shall be placed at such cutouts reading:

6-1.6 Isolating Means.
Means shall be provided to completely isolate an item of equipment. The use of isolating switches shall not be required where there are other ways of de-energizing the equipment for inspection and repairs, such as drawout-type metal-enclosed switchgear units and removable truck panels.
Isolating switches not interlocked with an approved circuit-interrupting device shall be provided with a sign warning against opening them under load.

A fuseholder and fuse, designed for the purpose, shall be permitted as an isolating switch.

2-3 Electrical Safety Program.
2-3.11 Safety Interlocks.
Only a qualified person following the requirements for working inside the restricted approach boundary as covered by 2-1.3.4 of Part II shall be permitted to defeat or bypass an electrical safety interlock over which the person has sole control, and then only temporarily while the qualified person is working on the equipment. The safety interlock system shall be returned to its operable condition when the work is completed.

Chapter 5 Lockout/Tagout Practices and Devices

5-3 Equipment.
5-3.5 Electrical Circuit Interlocks.
Up-to-date diagrammatic drawings shall be consulted to ensure that no electrical circuit interlock operation can result in reenergizing the circuit being worked on.

5-4 Procedures.
5-4.2 Elements of Control.
5-4.2.5 Verification.
The procedure shall verify that equipment cannot be restarted. The equipment operating controls, such as pushbuttons, selector switches, and electrical interlocks, shall be operated or otherwise shall be verified that the equipment cannot be restarted.

Part II, Appendix E, Sample Lockout/Tagout Procedure
E-1 Purpose.
E-2 Responsibility.
E-3 Preparation for Lockout (Tagout).
E-3-1
Review current diagrammatic drawings (or other equally effective means), tags, labels, and signs to identify and locate all disconnecting means to determine that power is interrupted by a physical break and not deenergized by a circuit interlock. Make a list of disconnecting means to be locked (tagged).

Part III SAFETY-RELATED MAINTENANCE REQUIREMENTS

Chapter 2 General Maintenance Requirements
2-1 Qualified Persons.
Employees who perform maintenance on electrical equipment and installations shall be qualified persons as required in Part II and shall be trained in and familiar with the specific maintenance procedures and tests required.
2-6 Safety Equipment.
Locks, interlocks, and other safety equipment shall be maintained in proper working condition to accomplish control purpose.

Part IV Safety Requirements for Special Equipment

Chapter 4 Safety Related Work Practices for Use of Lasers

4-1 Scope.
The requirements of this chapter shall apply to the use of lasers in the laboratory and the workshop.
4-2 Definitions.
The following terms will, for the purpose of this chapter, have the meanings indicated below:
4-2.1 Fail Safe.
The design consideration in which failure of a component does not increase the hazard. In the failure mode, the system is rendered inoperative or non-hazardous.
4-2.2 Fail Safe Safety Interlock.

An interlock which in the failure mode does not defeat the purpose of the interlock, for example, an interlock which is positively driven into the OFF position as soon as a hinged cover begins to open, or before a detachable cover is removed, and which is positively held in the OFF position until the hinged cover is closed or the detachable cover is locked in the closed position.

Attachment G

G - DOE G 441.1-5 1, Radiation-generating Devices

DOE G 441.1-5 1, RADIATION-GENERATING DEVICES

04-15-99

2. DEFINITIONS
Interlock: A device for precluding access to an area of radiation hazard by either preventing entry or by automatically removing the hazard. One example is an electro-mechanical control mechanism that interrupts the beam of ionizing radiation or shuts down the radiation installation whenever the interlock is challenged.

4.1 ADMINISTRATIVE ORGANIZATION AND CONTROLS
4.1.1 Contractor Management
4.1.2 Specific responsibilities of the RGD Custodian should include the following:
• ensuring that inspections of RGD interlocks, warning lights, and other safety features are performed and documented;

4.2 DEVELOPMENT OF SITE-SPECIFIC DOCUMENTS
4.2.3 Area Posting
4.2.3.1 Radiological Conditions
4.2.3.3 Maintenance Status
Any time an installation requires maintenance, the entrance to the area in which the installation is located and the inside of the installation should be conspicuously posted to indicate the maintenance status of the installation. Posting should be established:
• during the performance of maintenance and alignment procedures if the procedures require the presence of radiation; and
• any time an inspection or monitoring reveals a deficient condition for any safety device. When a safety device or interlock has been approved to be by-passed or is awaiting repair, the entrance to the installation and the RGD enclosure should be posted with a prominent sign bearing the words "SAFETY DEVICE NOT FUNCTIONING" or a similar message.

4.3 ENGINEERED SAFETY CONTROLS
4.3.1 Shielding, Controls, & Safety Devices
4.3.1.1 Shielding
The purpose of access control devices is to prevent unauthorized or inadvertent entry into a radiological area and/or to warn of a hazard. If locked entryways are used, the keys used for one RGD installation or storage facility should not provide access to another RGD installation or storage facility. Additional measures shall be implemented to ensure individuals are not able to gain unauthorized or inadvertent access to very high radiation areas (10 CFR 835.502(c)). Such measures (i.e., physical constraints) should include locking or securing service doors and panels with tamper resistant fasteners or the use of multiple and redundant access controls. Due to the lack of intrinsic shielding and the nature of use, access to a very high radiation area could be possible for an "open" installation. Additional measures (e.g., interlocked "photoelectric eye" light beams) should be established to meet this requirement.

4.3.1.3 Interlocks
Doors and/or access panels in exempt shielded, shielded, and unattended installations should be equipped with one or more fail-safe safety interlocks to prevent irradiation of an individual (ANSI N43.3(6.5.2)). If an area radiation monitor is incorporated into a safety interlock system, the circuitry should be such that a failure of the monitor shall either prevent normal access into the area or operation of the RGD.

4.3.1.5 Run-Safe and Emergency Shutdown Devices
Administrative procedures should be implemented to ensure that the RGD installation and the RGD safety interlock control devices are such that:

• radiation cannot be produced until the interlock system logic has been completely satisfied;
• production of radiation cannot be resumed by merely reestablishing the interlock circuit at the location where an interlock was tripped; and

• the safety circuit cannot be re-energized or reestablished automatically (i.e., there should be a manual safety circuit reset on or near the main control console).

For each area designated as a high radiation area or very high radiation area, 10 CFR 835.502 provides an option that permits a control device to automatically generate audible or visible alarm signals to alert individuals and the cognizant RGD Operator of a potential entry into the area before it occurs. In order to meet ANSI N43.3 guidance, warning devices should be provided as an addition to any other access control feature in accordance with the installation specific requirements delineated in Section 4.3.2, Guidance for Specific RGD Installations, of this Guide. These warning devices are typically warning lights. All RGD warning lights should be red or magenta for consistency. A sufficient number of lights should be installed so that at least one light is easily visible from all reasonably occupied areas that may have dangerous radiation levels and from reasonable avenues of approach to such areas. However, warning lights (even though interlocked to fail-safe if burnt out) are only passive in nature. When operating, they generally do not prevent an individual from physical access to a radiation beam unless they are used as part of a photosensitive circuit. Such a circuit would remove the radiation beam or field if any individual intercepted the light beam. Due to the passiveness (i.e., reliance on worker attention and action) of this safety feature and the potential for failure, at least one interlocked warning light should be used in all circumstances. The interlocked warning light should be used to provide visual indication that radiation is being produced, and should be used in conjunction with any interlocked safety device which restricts physical access to a radiation beam or field. This is recommended above and beyond the installation specific requirements in this Guide, or the minimum required by 10 CFR 835.502. When used in this fashion, the RGD should not be operable when the warning light is out. It should not be possible to override the operation of any warning device activated by a fail-safe function without positive actions by the operator such as resetting controls at the control console.

Attachment H

H - 10CRF835.501 Entry Control, Radiation Areas

[Code of Federal Regulations]
[Title 10, Volume 4]
[Revised as of January 1, 2003]
From the U.S. Government Printing Office via GPO Access
[CITE: **10CFR835.501**]

TITLE 10--ENERGY

CHAPTER III--DEPARTMENT OF ENERGY

PART 835--OCCUPATIONAL RADIATION PROTECTION--Table of Contents

Subpart F--Entry Control Program

Sec. 835.**501** Radiological areas.

(a) Personnel entry control shall be maintained for each radiological area.

(b) The degree of control shall be commensurate with existing and potential radiological hazards within the area.

(c) One or more of the following methods shall be used to ensure control:

(1) Signs and barricades;

(2) Control devices on entrances;

(3) Conspicuous visual and/or audible alarms;

(4) Locked entrance ways; or

(5) Administrative controls.

[[Page 482]]

(d) Written authorizations shall be required to control entry into and perform work within radiological areas. These authorizations shall specify radiation protection measures commensurate with the existing and potential hazards.

(e) No control(s) shall be installed at any radiological area exit that would prevent rapid evacuation of personnel under emergency conditions.

[58 FR 65485, Dec. 14, 1993, as amended at 63 FR 59684, Nov. 4, 1998]

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Attachment I

I - 10CFR835.502 - Entry Control, High and Very High Rad. Areas

[Code of Federal Regulations]
[Title 10, Volume 4]
[Revised as of January 1, 2003]
From the U.S. Government Printing Office via GPO Access
[CITE: **10CFR835.502**]

TITLE 10--ENERGY

CHAPTER III--DEPARTMENT OF ENERGY

PART 835--OCCUPATIONAL RADIATION PROTECTION--Table of Contents

Subpart F--Entry Control Program

Sec. 835.**502** High and very high radiation areas.

(a) The following measures shall be implemented for each entry into a high radiation area:
(1) The area shall be monitored as necessary during access to determine the exposure rates to which the individuals are exposed; and
(2) Each individual shall be monitored by a supplemental dosimetry device or other means capable of providing an immediate estimate of the individual's integrated deep dose equivalent during the entry.
(b) Physical controls. One or more of the following features shall be used for each entrance or access point to a high radiation area where radiation levels exist such that an individual could exceed a deep dose equivalent to the whole body of 1 rem (0.01 sievert) in any one hour at 30 centimeters from the source or from any surface that the radiation penetrates:
(1) A control device that prevents entry to the area when high radiation levels exist or upon entry causes the radiation level to be reduced below that level defining a high radiation area;
(2) A device that functions automatically to prevent use or operation of the radiation source or field while individuals are in the area;
(3) A control device that energizes a conspicuous visible or audible alarm signal so that the individual entering the high radiation area and the supervisor of the activity are made aware of the entry;
(4) Entryways that are locked. During periods when access to the area is required, positive control over each entry is maintained;
(5) Continuous direct or electronic surveillance that is capable of preventing unauthorized entry;
(6) A control device that will automatically generate audible and visual alarm signals to alert personnel in the area before use or operation of the radiation source and in sufficient time to permit evacuation of the area or activation of a secondary control device that will prevent use or operation of the source.
(c) Very high radiation areas. In addition to the above requirements, additional measures shall be implemented to ensure individuals are not able to gain unauthorized or inadvertent access to very high radiation areas.
(d) No control(s) shall be established in a high or very high radiation area that would prevent rapid evacuation of personnel.
[58 FR 65485, Dec. 14, 1993, as amended at 63 FR 59684, Nov. 4, 1998]

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Attachment J

J - DOE 420.2A Safety of Accelerator Facilities

DOE 420.2A

U.S. Department of Energy
Washington, D.C.

ORDER
DOE O 420.2A

Approved: 01-08-01

SUBJECT: SAFETY OF ACCELERATOR FACILITIES

4. REQUIREMENTS. DOE elements, including the NNSA, must require the following of the contractor:
a. Safety Assessment Document.

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CONTRACTOR REQUIREMENTS DOCUMENT

DOE O 420.2A, SAFETY OF ACCELERATOR FACILITIES

The following items are required of the contractor organization.

1. Safety Assessment Document.

a. A Safety Assessment Document (SAD) must identify hazards and associated on-site and off-site impacts to workers, the public, and the environment from the facility for both normal operations and credible accidents.

b. The SAD must contain sufficient descriptive information and analytical results pertaining to specific hazards and risks identified during the safety analysis process to provide an understanding of risks presented by the proposed operations.

c. The SAD must provide appropriate documentation and detailed description of engineered controls (e.g., interlocks and physical barriers) and administrative measures (e.g., training) taken to eliminate, control, or mitigate risks of operation.
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Attachment K

K - DOE HDBK-1092-98 DOE Handbook, Electrical Safety

DOE-HDBK-1092-98
January 1998
DOE HANDBOOK, ELECTRICAL SAFETY

1.0 INTRODUCTION
1.1 PURPOSE
Electrical Safety Handbook presents the Department of Energy (DOE) safety standards for DOE field offices or facilities involved in the use of electrical energy. It has been prepared to provide a uniform set of electrical safety guidance and information for DOE installations to effect a reduction or elimination of risks associated with the use of electrical energy. The objectives of this handbook are to enhance electrical safety awareness and mitigate electrical hazards to employees, the public, and the environment.

2.13 WORK PRACTICES
2.13.1 TRAINING
2.13.1.1 LIVE PARTS
2.13.1.2 SAFE PROCEDURE
2.13.1.3 CIRCUITS AND EQUIPMENT
Circuits and equipment to be worked on shall be disconnected from all electric energy sources. Control circuit devices such as push-buttons, selector switches, and interlocks shall not be used as the sole means for deenergizing circuits or equipment per 29 CFR 1910.147(b) and 1910.333(b)(2).

3.4 INSPECTION
One guidance on how to determine inspection frequency is described in various sections of NFPA 70B, including but not limited to the following sections:
16. 19-4.3.4; Inspection and Testing of Power Supplies, 19-4.4.2; Functional Systems Testing of Interlock and Logic Systems, 19-4.6.2; Visual Inspection of Level Devices, 19-4.10.1; Frequency of Testing Safety and Shutdown Systems, 19-4.11.1; Frequency of Testing Alarm Systems, and 19-4.12.1; Visual Checking of Wiring Systems for Process Instrumentation and Control

5.0 SPECIAL OCCUPANCIES
5.1 EXPLOSIVES
5.1.6 TESTING
5.1.6.1 TEST SETUP
In setting up a test at a firing site, all preparatory work shall be completed before explosives are received. Such work shall include the following items:
1. Checking all firing site safety devices at regular intervals. Such safety devices include warning lights, door and gate firing circuit interlocks, emergency firing circuit cutoff switches, and grounding devices (including those that are remote from the firing bunker).

5.2 PREVENTION OF EXTERNAL IGNITION AND EXPLOSION
5.2.6 PURGING/PRESSURIZATION SYSTEMS
Pressurized enclosures require:
1. A source of clean air or inert gas
2. A compressor to maintain the required pressure on the system

3. Pressure control valves to prevent the power from being applied before the enclosures have been purged and to deenergize the system should pressure fall below a safe value.
In addition, door-interlock switches are required to prevent access to the equipment while the circuits are energized. All of these accessories can add up to a considerable expenditure. For a detailed description of purging/pressurizing systems see NFPA 496, "Purged and Pressurized Enclosures for Electrical Equipment in Hazardous Classified Locations."

6.3 ELEVATORS AND ESCALATORS
6.3.2.2 CONDUCTORS
Hoistway door conductors from the door interlocks to the hoistway riser shall be flame retardant, suitable for a temperature of at least 200˚C, and Type SF or equivalent.

9.4.3 POWER SWITCHES AND INTERLOCK DEVICES SPECIFIC REQUIREMENTS
For all electrical/electronic enclosures utilizing power switches or interlocks, the following should apply:
1. Interlocks should be utilized where exposed voltages (50 volts or greater) are present in equipment and access to the exposed live parts is not controlled (See Section 9.6.4).
2. Ensure all line side unprotected contacts are guarded on interlocking contactors or other switching equipment.

9.6.4 POWER INTERLOCK DEVICES
Cabinets and equipment having potentially dangerous currents and/or voltages present should have a means of controlling access, or a power interlock device designed to interrupt the power to the cabinet. Provisions shall also be made to discharge any stored energy, such as in capacitors or inductors, to less than 50 volts within 10 seconds when the safety interlock is opened. Interlocks may not be used as a substitute for lockout/tagout. (29 CFR1910.333(c) and ANSI/ISA S82.01-1988, Section. 9.3.5.2)

9.7 DISCONNECTING MEANS
9.7.1 GENERAL
Interlock systems are not a recommended disconnecting means for cabinets and equipment having potentially dangerous currents and/or voltages present. (See Section 9.6.4). Permanently connected equipment and multi-phase equipment should employ a switch or circuit breaker as means for disconnection.

10.5 EQUIPMENT NOT LISTED BY A NATIONALLY RECOGNIZED TESTING LABORATORY
10.5.1 HAZARDS
10.5.2 DESIGN AND CONSTRUCTION
Equipment should be examined for safety as extensively as possible. Areas of consideration include but are not limited to:
11. Interlocks

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10.8.4 RADIO-FREQUENCY/ MICROWAVE RADIATION AND FIELDS
10.8.4.2 DESIGN AND CONSTRUCTION
4. Interlocks. Chamber or oven-type equipment that uses microwave radiation must have interlocks designed to (1) prevent generation of the radiation unless the chamber is sealed and (2) shut off such equipment if the door is opened.

10.9.2 UNCONVENTIONAL PRACTICES
10.9.2.1 GROUNDING

10.9.2.2 MATERIALS USED IN AN UNCONVENTIONAL MANNER
10.9.2.2.2 DESIGN AND CONSTRUCTION
During design, special consideration should be given to installing interlocks and protective barriers.

10.10 REQUIREMENTS FOR SPECIFIC R&D EQUIPMENT
Electrical equipment and components used in research may pose hazards not commonly found in industrial or commercial facilities. Special precautions are required to design, operate, repair, and maintain such equipment. Electrical safety and personnel safety circuits (e.g., interlocks) are covered in this section as a guide to reduce or eliminate associated hazards.

10.10.1 CAPACITORS
10.10.1.2 DESIGN AND CONSTRUCTION
The following cautions in design and construction should be considered:
2. Interlock the circuit breakers or switches used to connect power to capacitors.

10.10.1.3 OPERATION AND MAINTENANCE
1. The protective devices (interlocks) shall not be bypassed unless by qualified electrical personnel when inspecting, adjusting, or working on the equipment. Proper procedures need to be followed when bypassing interlocks.
2. Procedures should be established for tagging the interlock and logging its location and the time when bypassed and restored. Written approval shall be obtained from an appropriate authority before bypassing an interlock .

10.10.2 INDUCTORS
10.10.2.2 DESIGN AND CONSTRUCTION
The following should be considered:
1. Provide sensing devices (temperature, coolant-flow) that are interlocked with the power source.

10.10.5 LASERS AND X-RAY EQUIPMENT
10.10.5.1 HAZARDS
5. Failure of interlocks and safety devices may allow access to energized parts.

DEFINITIONS APPLICABLE TO SECTIONS 1 THROUGH 10
Interlocked access areas—Areas in which the sources of power must be interlocked with the access doors because of the hazards the areas contain.

Personnel safety interlock system—One or more of the emergency-shutdown systems or personnel access control systems or both.

Safety interlock—An electrical or mechanical device that prevents operation of equipment or precludes access to hazardous areas, enclosures, or equipment.

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Attachment L

L - Committee Handbook - Laboratory Electrical Safety Committee
(Select "Committee Handbook" from <https://sbms.bnl.gov/>)

I. Charge

The Laboratory Electrical Safety Committee (LESC) is the principal advisory committee to the Brookhaven National Laboratory (BNL) Directorate, the Safety and Health Services Division, and to individual operating organizations on safety matters relative to electrical systems, equipment, and components. The primary vehicle for dissemination of this information is the Environment, Safety and Health (ES&H) Standards Manual.

The committee is the technical body which will recommend approval to the Assistant Laboratory Director for ESH & Quality for significant electrical safety issues and with responsibilities as designated below.

Areas of committee responsibility:

a. Advise individual organizations and the Directorate, as appropriate, about electrical safety-related items which are brought to the committee's attention by a member of the committee, an operating organization, the Safety & Health Services Division (SHS) or the Director's Office.

b. Review at least biannually and recommend for approval changes, as necessary, to the BNL Electrical Safety Policy, ES&H Standards 1.5.0 (Electrical Safety), 1.5.1 (Lockout/Tagout Requirements), 1.5.2 (Design Criteria for Electrical Equipment) and 1.5.3 (Interlock Safety Standards).

c. Approve in conjunction with the Central Training Office the objectives, content and target audiences of electrical safety-related training programs.

d. Review internal and external electrical accident and incident reports for applicable "lessons learned."

e. Act as the "Authority Having Jurisdiction" for NEC Code interpretations.

f. When requested by the SHS Division or the Directorate:

1. Recommend for approval proposed changes or modifications to existing facilities or new construction which significantly affect electrical safety.
2. Advise as to Conformance-to-Standards of departmental/divisional Electrical-Safe-Work rules and procedures (construction, maintenance and operation of electrical devices and interlock systems).
3. Review proposed or established Hazard Assessments.
4. Review Safety Interlock Systems.

II. Membership: a. Appointed by: The Assistant Laboratory Director for ESH & Quality.
b. Term: Three years.
c. Membership List (Varies)

III. Meeting Frequency: Meetings are held quarterly or at the request of the Chair.

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Attachment M

M - ESH 1.5.3 Interlock Safety for Protection of Personnel

ESH 1.5.3 Interlock Safety for Protection of Personnel, Rev. 1

I. Introduction

Safety interlocks are appropriate for personnel protection in many situations where there is danger from sources of energy. The use of interlocks for personnel protection rather than sole reliance on administrative controls, depends on the nature and severity of the hazard and on the interactions of personnel with the hazard.

Interlock systems act automatically to protect personnel from danger, and are valuable where exposure to a hazard is frequent or routine and human error is likely. Primary safety shall be provided by proper operating procedures. When appropriate a Safety Analysis Document (SAD) or Safety Analysis Report (SAR) shall be in place which embodies commitments to operate the facility according to stated procedures and within a stated safety envelope. If an interlock system is required, the design and implementation must be adequate to assure that the facility operates in compliance with the SAD/SAR. Individuals tend to rely on interlock protection, and a poorly designed interlock or one which is not maintained or tested may actually increase the likelihood of an accident. For this reason the use of a safety interlock system carries technical design requirements, as well as an ongoing responsibility for maintaining, testing and controlling its configuration.

This Standard defines requirements for interlock systems used for personnel protection at BNL, and in addition, provides guidance for selecting an appropriate system. Throughout this Standard, the word "shall" is used to denote actions which are mandatory to meet this standard; the word "should" indicates recommended practice.

II. Scope

This Standard shall provide the minimum requirements for non-commercial interlock systems, not currently in place, which are installed for personnel protection at the Laboratory. For those interlock systems in place prior to 1/95, any proposed modification to the system shall be designed to maximize compliance with this Standard. Exceptions that are required for compatibility with the original system design shall be reviewed and documented. The Laboratory Electrical Safety Officer should be included in that review and documentation process.

Commercial interlock systems and interlock systems currently in place are not exempt from documentation and testing requirements outlined in this standard.

All energy sources, systems or devices that have the potential to cause a fatality or severe injury to personnel shall be analyzed to determine whether an interlock system is necessary. Emergency systems such as fire protection and detection shall not be covered by this Standard.

III. Definitions

Configuration Control includes the provision of physical security and labeling of the components of an interlock system, as well as the hierarchy of approvals and procedures required to modify an interlock system installed for personnel protection.

Electrical Hazards are all hazards associated with the use of electricity. Electrical hazards are discussed in ES&H; Standard 1.5.0, Electrical Safety.

Fail Safe is a design arrangement such that the most likely failure events, will leave the protected system in a safe state.

Hazard Severity Levels for the purposes of this Standard are broken into three distinct categories: Catastrophic, Critical, and Marginal. Definitions of each can be found in ES&H; Standard 1.3.3, Safety Analysis Reports/Safety Assessment Documents.

Interlocked Areas are any zones into which entry is restricted by positive means, so that personnel are protected from exposure to potentially hazardous conditions. Interlocks are engineered systems which function automatically to prevent the use, or operation, of a potentially hazardous system or device in a manner that might endanger personnel.

Laser Hazards are the hazards associated with the operation of any Laser equipment. Laser hazards are discussed in ES&H; Standard 2.3.1, Lasers.

Occupational Worker is an individual who is either an employee of BNL or a BNL contractor; an employee of a subcontractor; or an individual who visits to perform work for or in conjunction with BNL, or uses BNL facilities.

Other Hazards that may require appropriate interlocks for personnel protection include hazards associated with pressure, thermal, mechanical, and chemical systems or devices.

RF and Microwave Hazards are those associated with the use of equipment that produce radio-frequency or microwave radiation, respectively. These hazards are discussed in ES&H; Standard 2.3.2, RF and Microwaves.

Radiation Hazards are the hazards associated with radiation from the use of radioactive materials or radiation generating devices. Radiation hazards are discussed in the BNL Radiation Control (RadCon) Manual.

Redundant Interlock Protection Systems use multiple, independent equipment arrangements such that each interlock system is isolated from the others to perform similar safety functions such that any single failure will not result in loss of protection.

IV. Responsibilities

Department Chairs/Division Heads or their designees are responsible for ensuring the implementation of this Standard by requiring that systems are designed, constructed, installed, operated, and maintained in conformance with this Standard. They also are charged with ensuring that operating, initial and periodic testing, and contingency procedures are written; that the system is accurately documented; and that records are properly maintained. They shall:

1. Develop formal designs and procedures that are reviewed and approved by the Department/Division. When required by this Standard, the Laboratory Electrical Safety Committee (LESC) and the Safety & Environmental Protection Division shall be consulted. Interlock schemes that use innovative technology, not previously evaluated and employed at BNL, must be submitted for review by the LESC.
2. Ensure that Interlocked Areas are established whenever required to protect personnel.
3. Ensure that the requirements imposed by this Standard in each hazard classification are met.
4. Ensure that all designs, procedures, and modifications of the interlock system are properly documented and independently reviewed. Ensure that modifications or additions shall not compromise the integrity of the interlock system. Ensure that records are maintained (e.g., log books) for the interlock system.
5. Ensure that only authorized employees in accordance with configuration control procedures are permitted to modify, test, or maintain an interlock system.
6. Ensure that all Department/Division members have received instruction and training in safety interlock procedures consistent with the extent of their exposure to potentially hazardous systems or devices.
7. Ensure that guests and/or contractors are trained to, and comply with, the BNL interlock policy before beginning work with or near hazardous systems or devices.

Laboratory Electrical Safety Committee (LESC) is responsible for the tasks listed below when so requested by the Director's Office, Departments, Divisions, the BNL ES&H; Committee, a member of the LESC or the Laboratory Electrical Safety Officer (LESO). The LESC shall fulfill these responsibilities by forming an Ad Hoc subcommittee, the Laboratory Interlock Safety sub-Committee (LISC), enlisting the necessary expertise from the laboratory community to sit on this subcommittee. The LESC shall:

1. Review the design, construction, operation, and testing of interlock systems considering whether they provide adequate personnel protection from potentially hazardous energy sources.
2. Provide clarification and guidance to line organizations on the need for any combination of written procedures, system design, and guidance about the integrity of interlock logic.
3. Guide Departments/Divisions in developing interlock systems that conform to all applicable standards.
4. Review the appropriate facility SARs and facility SADs with respect to required interlocks.
5. Review the adequacy of this Standard and recommend any needed changes.

Safety and Environmental Protection Division is responsible for:

1.Auditing interlock programs for compliance with this Standard.
2.Reviewing submitted plans for new interlock systems, and modifications to existing systems for compliance with this Standard.
3.Reviewing the interlock procedures and assisting Departments/Divisions to implement this Standard.
4.Assisting Department Chairs or Division Heads to establish alternate requirements for those situations not covered by this Standard.

BNL Occupational Workers are responsible for complying with this Standard. They shall:

1.Follow the facility's approved interlock procedures.
2.Inform their supervisor of failures of any normal functions or responses of the interlock system.
3.Not defeat/bypass interlocks except as covered under Section V(F) of this Standard.

Non-BNL Occupational Workers are responsible for complying with this Standard. When non-BNL Occupational Workers work at the BNL site, the on-site employer (BNL counterpart) and the non-BNL occupational Worker Employer shall inform each other of their respective safety interlocking logic/designs. The BNL counterpart shall ensure that all personnel comply with the restrictions and prohibitions of the non-BNL employer's energy control procedures, except if the BNL counterpart determines that those procedures do not meet the safety guidelines of OSHA, BNL, or DOE. If the interlock logic is unacceptable, the non-BNL employer must redesign their system, and train their personnel to work in accordance with this Standard.

V. Requirements

A. Design Basis Requirements:

Control of hazardous energy shall require associated interlock systems to be operational before introducing the source of hazardous energy. A temporary exemption to the operational interlock requirement may be granted during testing/commissioning where equivalent protection is provided. Operational controls for the hazardous energy shall be used to enable, and disable the energy source, while the interlock system shall only disable the energy source if the area's safety envelope is violated. The control system for the hazardous energy shall require an operator action, to re-enable the interlock system thereby, re-establishing hazardous energy into the area after the interlock system has disabled the energy source.

The design basis for the interlock system shall be such that:

1. The probability for the interlock system to fail shall be extremely remote, as defined by Hazard Analysis, ES&H; 1.3.3, if Catastrophic hazards exist within the protected boundary.
2. The probability for the interlock to fail shall be remote, as defined by Hazard Analysis, ES&H; 1.3.3, if Critical hazards might exist within the protected boundary.

3. The probability for the interlock system to fail can be classified as occasional, as defined by Hazard Analysis, ES&H; 1.3.3, if Marginal hazards might exist within the protected boundary of the protected system.

B. Technical Design Requirements:

1. The level of protection afforded by interlocks should be appropriate for the level of hazard[1], as follows:

Requirement / Category	Redundant Interlock Protection Systems	Fail Safe	Enforced Sequence Search (Where Appropriate)	Operator Action Required for Restart	Periodic Testing
Catastrophic	Yes	Yes	Yes	Yes	Yes
Critical	No	Yes	Yes	Yes	Yes
Marginal	No	No	No	Yes	Yes

2. The protective functions of the interlock system should render the energy source/system safe during the most likely failure events (e.g., loss of power/pressure, open circuit, short to ground, and single component failures).
3. Redundant circuits should not share cables and should be separated physically on circuit boards and terminal strips. Redundant systems should be configured differently.
4. Cable runs should be made in accordance with good practices and the National Electric Code.
5. Suitable protection shall be provided to preserve the physical integrity of all system components. Components and materials should be resistant to damage from heat, radiation, and water, as appropriate.
6. A configuration management program shall be established to include the interlock system logic and also interfaces to peripheral equipment, such as power supplies for beam control magnets.
7. All interlock lines and components should be labeled and readily identifiable.
8. The interlock system should be modular in design so that the interlocks for different parts of the facility can be serviced independently. If the facility is designed to allow portions to be serviced or modified while the remainder is in operation, such as individual experimental areas, then there shall be a means to reconfigure/disconnect the part of the interlock system which is being serviced from the rest of the system without compromising safety.
9. The design of the interlock system shall provide for complete testing, with the effort and disruption required by such tests within practical limits.

10. There shall be an independent review of the interlock system's design by persons experienced in the design and operation of personnel protection interlock systems. There shall be a record kept of the findings of the review and the response to each finding.
11. A controlled means for reconfiguration and bypassing of components of the interlock system shall be established and documented.
12. A well-designed interlock system for Catastrophic and Critical hazard systems should include sequenced and timed inspection stations, warning lights, audible alarms, and emergency off-switches.
13. Where practicable, indication of the status of the facility interlocks shall be shown on the control console.
14. Interlocks shall not be used as routine shutdown mechanisms. The design shall provide for an orderly means of turning off sources of hazardous energy before access is attempted to an Interlocked Area.
15. Computer-based interlock systems implemented for protection against Catastrophic hazards should be equivalent to relay-based systems and conform to the following additional requirements:
    a. Redundancy shall be provided by independent, dissimilar computer systems with logic software written by different programmers working independently.
    b. Computers for these systems should be dedicated solely for this use, and all external links should be eliminated or strictly controlled.
    c. Where parts of the protection system need to be decommissioned for servicing or modification, it shall be demonstrated that signals from the decommissioned part cannot influence the active part of the interlock system. Breaking software links is not sufficient for isolation.
16. Physical access controls shall not prevent personnel from leaving the area, consistent with requirements of the Life Safety Code (NFPA 101).

3.Interlocked Area Requirements:

A central function of hazardous-energy protection systems is to control personnel access to hazardous areas. Where only hand access is possible, as in control cabinets and power supplies, door locks and/or switches may be sufficient. Areas where personnel entry is possible shall also have provisions for search confirmation, hazard warning, emergency stop, and life safety. The following apply to interlocked areas where personnel entry is possible.

1. Emergency-"Crash"-devices shall be provided, and shall be clearly visible, labeled, and readily accessible. Activation of emergency devices in the Interlocked Area shall re-initialize the system and require a reset at the location of the activated emergency device.
2. Emergency exit shall be possible at all doors in conformance with NFPA 101, Life afety Code. Emergency entry into the area also should be provided.
3. Status signs or clearly labeled status lights should be provided at entry doors.
4. Where personnel entry is possible, Interlocked Areas shall be searched before the nergy source is turned on to insure that there are no people still inside. Where appropriate the following shall apply:

a. Sequential-search confirmation buttons, or check stations, shall be placed to insure that the area is comprehensively searched. These check stations also may be used to set the interlocks on the doors as they are passed. If any door is opened after being set, or any emergency device is activated inside the interlocked area, the system logic shall abort the search.

b. After completing the search, there shall be both audible and visible warnings providing a time interval before enabling of the hazardous energy. Warnings shall be limited to within interlocked areas to avoid de-sensitizing personnel. If the lights are dimmed as the visible warning, then the level of illumination shall remain strong enough for personnel to see clearly to rapidly leave the facility or take action to prevent actuation of the hazardous energy. The duration of the warning interval shall be sufficient for an individual to reach an emergency "crash" device or to leave the area.

c. The search procedures must be rigorous and carefully designed, and shall be tested periodically.

5. A Controlled Entry mode may be provided wherein a few workers are permitted to enter an already searched area to carry out specific tasks. When all personnel leave the area, it may be returned to the "ready" condition without a search. The safety of such entries depends critically on strict controls and well-defined procedures, which may include one or more of the following.

a. A permanent, written record of each Controlled Entry should be made, which shall include the name of each person entering, and the time of entry and exit. This record shall be maintained as a part of the permanent operations record.

b. Each passage, into or out of an entry door, shall be controlled by an operator. The interlock system should require that an operator action permits the door to open without aborting the searched condition of the area. This control may be exercised remotely, from the control room for example, if suitable surveillance is maintained by television or other means.

c. The accounting for each person entering the Interlocked Area under Controlled Entry mode should be by accountable-key-exchange (key-tree)[2], or rigorous login/logout procedure, or an equivalent system where conditions dictate. In new facilities or substantial extensions of existing facilities, key-trees are recommended.

d. Administrative limits should be placed both on the number of people allowed into the area when placed in the Controlled Entry mode and on the maximum elapsed time that the area is kept in the Controlled Entry mode.

e. After a Controlled Entry event is complete, the entry record should be reconciled and a warning interval shall be required before return to the "ready" condition.

6. The interlocked area shall have a device that activates a conspicuous visible and/or audible alarm so that in the event of improper entry, personnel entering the area and the operator are made aware of the entry.

C1. Specific Hardware Requirements for Critical Hazard Areas

An appropriate entry control program shall be established. The fail-safe character of the interlock system is vital. The entry control program shall include at least one of the following. One item alone does not

necessarily constitute an adequate interlock system, therefore Department/Division review is particularly important.

1. The interlock system shall prevent entry[3] to the area when Critical Hazards exist, or upon entry, shall cause the hazard level to be reduced below that level defined as critical; also, it shall prevent restart of the energy source until a manual reset is made.
2. Control devices shall activate a conspicuous visible or audible alarm if the hazard remains, so that the individual entering the Critical Hazard Area through a control device is aware of the energy level and the Area Supervisor or designee are also made aware of the entry. Administrative procedures shall define the required actions of personnel when alarms are activated.
3. Entryways shall be locked during operations, except when access to the area is required. Positive requirements for entry including surveys of hazardous energy levels shall be made for the initial entry, and periodically, as necessary, to assure that safe energy levels are maintained in accordance with administrative procedures.
4. Control devices shall automatically generate audible and/or visible alarm to alert personnel in the area before the use or operation of the energy source. These alarms shall allow sufficient time to evacuate the area, or to activate a secondary control device to prevent the use or operation of the energy source. If the visual indicator should be turning out the lights, levels of illumination shall be high enough so that personnel can rapidly leave the facility or take action to prevent actuation of the hazardous energy.

C2. Specific Hardware Requirements for Catastrophic Hazard Areas

Catastrophic Hazard Areas where personnel access is possible require EACH of the four conditions detailed in the Specific Hardware Requirements for Critical Hazard Areas section (C1), and have the following additional requirements.

1. Access to interlocked areas shall be controlled by locked gates[4], that shall be equipped with two independent interlock devices. Each device shall be capable of deactivating sources of hazardous energies if the area is improperly entered. Improper entry through the gate shall activate an audible and/or visual alarm locally and at a central location, such as a control room.
2. In addition to being fail-safe, the interlock system shall also be redundant, as defined in Section III.

D. Interlock Testing Requirements:

To assure that an installed interlock system is functional and not compromised, periodic testing is mandatory. There is no other way to verify that wiring errors, component failures, or other faults do not compromise the system. A successful testing program depends on a system design that accommodates testing, a well designed series of tests, and the commitment of time and resources to accomplish the tests.

1. A comprehensive functional test shall be performed before an interlock system is placed in service. The test shall require that each logic input is exercised and the appropriate intermediate logic action and protective response(s) is verified. Redundant chains shall be independently exercised. The test should not depend too heavily on system logic for interpreting responses, since

logic configuration also must be tested. Other required functions, such as time delays, status indicators, and warnings, shall also be tested.
2. A functional test shall be performed after modifications or maintenance is completed on an interlock system or any system that might affect the interlocks. The testing shall cover all parts of the system that could be affected by an error or fault in the portion of the system that has been worked on. Maintenance and service actions that are deemed not to require testing shall be declared and justified in auditable maintenance documentation.
3. When the system is reconfigured, it shall be tested before operating the facility to ensure that only the desired function is altered, and that all other parts of the system still function properly.
4. An interlock system should not be used for protection unless a complete functional test has been done within the specified testing interval. The testing interval shall be commensurate with the level of hazard. For Catastrophic and Critical systems, the interval shall be six months. With proper justification, a grace period of up to two months may be approved by departmental configuration management. For all other systems, the interval shall not exceed one year.
5. Tests shall be executed with a prepared checklist, which includes a sign-off by personnel performing the interlock system test and a check-off for each observed input and response. The checklist will ensure a complete and proper test and provide an auditable record.
6. The system's test program shall be independently reviewed. This review should be conducted in concert with the review of the system's design.

5.Documentation Requirements:

1. A written functional description of the interlock system, including:
    a. Hazards protected against;
    b. Means of protection;
    c. Entry and search protocols including announcements, alarms, and emergency responses;
    d. Response of the system in normal operation; and
    E. Responses of the system to fault conditions and foreseeable personnel error, as well as to equipment failure.
2. A record of management approval of the system.
3. Documentation of the physical and electrical configuration of the system, including circuit schematics, logic diagrams, wiring diagrams, and component specifications.
4. A description of configuration management for controlling design, modifications, replacements and maintaining complete and accurate documentation.
5. Written test procedures that specify frequency of tests and their completeness, including prepared checklists to ensure complete functional and auditable records of such tests.

F. Administrative Control Requirements:

The high degree of reliability required of an interlock system comes both from the performance of the physical system and the effectiveness of the administrative controls including procedures, training, testing, and control of modification. All work on the interlock system including design, construction, modification

and maintenance shall be performed by personnel designated by the Department Chair/Division Head as "authorized".

1. The configuration control program shall include a definition of the review and approval process required for the design and/or modification of the system's function or logic.
2. Bypassing is defined as the temporary task-specific (e.g., for testing and diagnosis) defeating of a single interlock function or group of functions. When the task is completed, the bypass shall be removed immediately and the interlock system tested before returning t to full operation. All bypassing shall be done in accordance with written, reviewed, and approved procedures.
3. Reconfiguration is defined as modification of the interlock system for routine operation under a changed facility arrangement.
4. When interlock systems are bypassed or reconfigured, an equivalent degree of safety shall be provided. The proposal for either action shall have prior review and approval at the level defined in Section IV, Responsibilities: Department Chairs/Division Heads, of this Standard.

Unauthorized reconfiguration or bypassing of interlock systems is not allowed.

5. Neither bypassing nor reconfiguration of the interlock system shall diminish the level of personnel safety. Both actions require a review of the design and documentation before they are implemented. Alternate means of ensuring personnel protection shall be examined as part of the review.
6. Proper safeguards, for example a locked and tagged beam stop, shall be in place before the interlock is taken out of service. The safeguard shall be external to the system being worked on.
7. There shall be a clear definition of procedures and restrictions on interlock maintenance.
8. The system shall not be returned to service until it has been suitably tested as defined in Section D, Interlock Testing Requirements.

VI. References

1.ANSI Standard Z136.1 *Safe Use of Lasers*
2.DOE Order 5480.10 *Contractor Industrial Hygiene Programs*
3.DOE Order 5480.11 *Radiation Protection for Occupational Workers*
4.DOE Order 5480.25 *Safety of Accelerator Facilities*
5.DOE Title 10 CFR Part 835, *Occupational Radiation Protection*
6.NFPA 101 *Life Safety Code*
7.BNL ES&H; Std. 1.3.3 *Safety Analysis Reports/Safety Assessment Documents*
8.BNL ES&H; Std. 1.5.0 *Electrical Safety*
9.BNL ES&H; Std. 1.5.1 *Lockout/Tagout Requirements*
10.BNL ES&H; Std. 1.5.2 *Design Criteria for Electrical Equipment*
11.BNL ES&H; Std. 2.3.1 *Lasers*
12.BNL ES&H; Std. 2.3.2 *RF and Microwaves*
13.BNL *Radiological Control Manual*

[1] Hazard levels include Hazard Dose Rates, e.g., a whole body exposure to 50 rem in an hour is considered a Catastrophic Hazard.
[2] A "key-tree" system requires anyone making a "controlled access" to have a specified key in their possession during access. All such keys must be returned to the key-tree, where they are captured, before the facility can resume operation.
[3] In conformance with ANSI Z136.1-1993, Safe Use of Lasers, class 3b lasers are exempt from this requirement.

[4] Facilities being used as patient irradiation facilities may be exempt from this requirement for locked entryways if the design is consistent with AAPM/FDA.

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Attachment N

N - DCPM SOP 105.9 - Office Machines Maintenance and Repair

Dept. of Contracts and Property Management
SOP 105.9, Office Machines Maintenance and Repair, Rev. 5
Select "Supply and Materiel Group S.O.P. Manual" at
<https://sbms.bnl.gov/ppm/BNL_ONLY/Manual.htm>

I. Purpose
To establish the procedure for the maintenance and repair of office machines.

II. Definitions
Preventative Maintenance - Periodic lubricating, cleaning or minor adjustments.
Repair - Work performed on equipment to restore it to normal operating efficiency.

III. General
The Laboratory has an on-site repair service capability for the minor repair or adjustment of normal business machines which include photo copiers, calculators, time-date machines or typewriters.

IV. Procedure

Department/Division:
Requests for repair or adjustment should be processed through the Office Machine Repair Section located in Building 87, Ext. 2898.

S&M Personnel:
Schedules office machine mechanic to perform requested service.
Office mechanic inspects equipment to determine if repairs can be made in the field or whether the machine must be brought back to the shop.
Performs repairs at the location or determines that outside services are needed. If the machine must be removed from service, provides loaner from the pool when available.
If outside services are needed, contacts appropriate service contract.

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Attachment O

O - Interlock Systems Self-Assessment Questionnaire

Interlock Systems Self-Assessment Questionnaire

March - June, 2003

Interlock Systems

Interlocks are engineered systems which function automatically to prevent the use, or operation, of a potentially hazardous system or device in a manner that might endanger personnel. Interlocked Areas are any zones into which entry is restricted by positive means, so that personnel are protected from exposure to potentially hazardous conditions. Hazards which may require appropriate interlocks for personnel protection include those associated with pressure, thermal, mechanical, and chemical systems.
The high degree of reliability required of an interlock system comes both from the performance of the physical system and the effectiveness of the administrative controls including procedures, training, testing, and control of modification.

Deployment of Interlock Systems

All energy sources, systems or devices that have the potential to cause a fatality or severe injury to personnel shall be analyzed to determine whether an interlock system is necessary. (Emergency systems, such as fire protection and detection, are not included in this material.) Interlock systems shall be operational before introducing the source of hazardous energy, except that a temporary exemption may be granted during testing/commissioning if equivalent protection is provided.

1. Are interlock systems required in satisfaction of a Safety Analysis Document (SAD), or Safety Analysis Report (SAR)?

2. Are the interlock systems part of a laser installation, or to establish a controlled area for a particle accelerator?

3. Do you have machinery or other energy sources for which interlock systems are used to protect workers?

4. Are interlock systems furnished as part of commercial equipment? Has the system been altered, or connected to other systems, or made part of a more extensive system?

Design of System

5. Is primary safety provided through proper operating controls and procedures with the interlock system used as a backup, or do operators depend on operation of the interlock system to assure safety?

6. Is status of the interlock system displayed on a control console?

7. Is the system designed to require operator action for re-start after the interlock system has disabled the energy source?

8. Is the interlock system fail-safe? How is this feature implemented? How will the system fail during the most likely failure events (e.g., loss of power/pressure, open circuit, short to ground, and single component failure)?

9. Are access-control interlock systems arranged so they do not prevent personnel from leaving the area?

10. If the level of hazard is "Catastrophic," is the interlock system redundant? How is this feature implemented? [Redundant circuits should not share cables and should be separated physically on circuit boards and terminal strips. Redundant systems should be configured differently.]

11. For Critical hazards, is failure probability of the interlock system remote? For Catastrophic hazards, is the failure probability for the interlock system extremely remote?

12. For Critical and Catastrophic hazard interlock systems, have sequenced and timed inspection stations, warning lights, audible alarms, and emergency off- switches been provided.

13. Does the interlock system design provide for complete testing, with minimum effort and disruption?

Review of System

14. Is there an independent review of the interlock system design by persons experienced in the design and operation of personnel protection interlock systems? Is a record kept of the findings of the review, and the response to each finding?

15. Are there additional reviews to ensure that modifications or additions do not compromise the integrity of the interlock system.

16. Is the Laboratory Electrical Safety Officer included in the review and documentation process?

Documentation of System, and Configuration Management

A configuration management program shall be established to include the interlock system logic and also interfaces to peripheral equipment. Configuration Control includes the provision of physical security and labeling of the components of an interlock system, as well as the hierarchy of approvals and procedures required to modify an interlock system installed for personnel protection.

17. Is there a written description of the configuration management system for controlling design, modifications, reviews and approvals, replacements, and maintaining complete and accurate documentation?

18. Is there a written functional description of the interlock system, including:
    - Hazards protected against;
    - Means of protection;
    - Entry and search protocols including announcements, alarms, and emergency responses;
    - Response of the system in normal operation;
    - Responses of the system to fault conditions and foreseeable personnel error;
    - Responses of the system to equipment failure.
    - A record of management approval of the system?

19. Is there documentation of the physical and electrical configuration of the system, including circuit schematics, logic diagrams, wiring diagrams, and component specifications?

20. Are written test procedures and completed checklists retained as system documentation?

Installation and Maintenance of Interlock System

All work on the interlock system including design, construction, modification and maintenance shall be performed by personnel designated by the Department Chair/Division Head as "authorized". There shall be a clear definition of procedures and restrictions on interlock maintenance.

21. Are only employees authorized in accordance with approved configuration control procedures permitted to install, modify, test, or maintain the interlock system?

Testing of Interlock System

A comprehensive functional test must be performed before an interlock system is placed in service. In addition, an interlock system should not be used for protection unless a complete functional test has been done within a specified testing interval. The testing interval shall be commensurate with the level of hazard. For Catastrophic and Critical systems, the interval shall be six months. With proper justification, a grace period of up to two months may be approved by departmental configuration management. For all other systems, the interval shall not exceed one year.

22. Are test procedures for the interlock system based on a prepared checklist, which includes a check-off for each observed input and response, and a sign-off by personnel performing the interlock system test?

23. Are the tests arranged to require that each appropriate logic input is exercised and the appropriate intermediate logic action and protective response is verified? Are redundant chains independently tested? Is the test functionally arranged so that operation of logic inputs (switches, for example) leads directly to the required output action? Are associated functions such as time delays, status indicators, and warnings, included in the test?

24. Are the checklists retained to provide an auditable record?

25. Were the test procedures independently reviewed?

26. Was the system tested upon installation and periodically afterward, as required?

27. Are functional tests performed after modifications or maintenance of the interlock system, covering all parts of the system that could be affected by an error or fault in the portion of the system that has been worked on?

Bypassing and Reconfiguration

Bypassing *is defined as the temporary task-specific (e.g., for testing and diagnosis) defeating of a single interlock function or group of functions.* ***Reconfiguration*** *is defined as modification of the interlock system for routine operation under a changed facility arrangement. Neither bypassing nor reconfiguration of the interlock system shall diminish the level of personnel safety.*

28. Do all proposals for bypassing or reconfiguration have prior review and approval at the Department Chairs/Division Head organizational level?

29. Has a controlled means been established and documented for reconfiguration and bypassing of components of the interlock system , and is all bypassing or reconfiguration done in accordance with these written, reviewed, and approved procedures?

30. *An equivalent degree of safety is required when interlock systems are bypassed or reconfigured. Proper safeguards, for example a locked and tagged beam stop, shall be in place before the interlock is taken out of service. The alternative safeguard must be external to the system being worked on.* Are alternate means of ensuring personnel protection part of the process of bypassing or reconfiguration?

31. After the interlock system is reconfigured, is it tested before operating the facility to ensure that only the desired function is altered and that all other parts of the system still function properly?

32. After the interlock system is bypassed for a task, are bypasses removed promptly upon completion of the task and the interlock system tested before returning it to full operation?

Operation of System

33. Have all in the organization received instruction and training in safety interlock procedures consistent with the extent of their exposure to potentially hazardous systems or devices?

34. Do instructions and training include the precaution that interlocks shall not be defeated or bypassed except through special procedures?

35. Do instructions and training require workers to inform their supervisor of failures of any normal functions or responses of the interlock system?

36. Are guests and/or contractors are trained to, and comply with, the organization's interlock policy before beginning work with or near hazardous systems or devices?

Attachment A: Requirements for Interlocked Areas

A central function of hazardous-energy protection systems is to control personnel access to hazardous areas. Where only hand access is possible, as in control cabinets and power supplies, door locks and/or switches may be sufficient. Areas where personnel entry is possible shall also have provisions for search confirmation, hazard warning, emergency stop, and life safety.

The following apply to interlocked areas where personnel entry is possible.

a. Emergency-"Crash"-devices shall be provided, and shall be clearly visible, labeled, and readily accessible. Activation of emergency devices in the Interlocked Area shall re-initialize the system and require a reset at the location of the activated emergency device.

b. Emergency exit shall be possible at all doors in conformance with NFPA 101, Life Safety Code. Emergency entry into the area also should be provided.

c. Status signs or clearly labeled status lights should be provided at entry doors.

d. Where personnel entry is possible, Interlocked Areas shall be searched before the energy source is turned on to insure that there are no people still inside. Where appropriate the following shall apply.

   i. Sequential-search confirmation buttons, or check stations, shall be placed to insure that the area is comprehensively searched. These check stations also may be used to set the interlocks on the doors as they are passed. If any door is opened after being set, or any emergency device is activated inside the interlocked area, the system logic shall abort the search.

   ii. After completing the search, there shall be both audible and visible warnings providing a time interval before enabling of the hazardous energy. Warnings shall be limited to within interlocked areas to avoid de-sensitizing personnel. If the lights are dimmed as the visible warning, then the level of illumination shall remain strong enough for personnel to see clearly to rapidly leave the facility or take action to prevent actuation of the hazardous energy. The duration of the warning interval shall be sufficient for an individual to reach an emergency "crash" device or to leave the area.

   iii. The search procedures must be rigorous and carefully designed, and shall be tested periodically.

e. A Controlled Entry mode may be provided wherein a few workers are permitted to enter an already searched area to carry out specific tasks. When all personnel leave the area, it may be returned to the "ready" condition without a search. The safety of such entries

depends critically on strict controls and well-defined procedures, which may include one or more of the following.

- A permanent, written record of each Controlled Entry should be made, which shall include the name of each person entering, and the time of entry and exit. This record shall be maintained as a part of the permanent operations record.

- Each passage, into or out of an entry door, shall be controlled by an operator. The interlock system should require that an operator action permits the door to open without aborting the searched condition of the area. This control may be exercised remotely, from the control room for example, if suitable surveillance is maintained by television or other means.

- The accounting for each person entering the Interlocked Area under Controlled Entry mode should be by accountable-key-exchange (key-tree)[2], or rigorous login/logout procedure, or an equivalent system where conditions dictate. In new facilities or substantial extensions of existing facilities, key-trees are recommended.

- Administrative limits should be placed both on the number of people allowed into the area when placed in the Controlled Entry mode and on the maximum elapsed time that the area is kept in the Controlled Entry mode.

- After a Controlled Entry event is complete, the entry record should be reconciled and a warning interval shall be required before return to the "ready" condition.

f. The interlocked area shall have a device that activates a conspicuous visible and/or audible alarm so that in the event of improper entry, personnel entering the area and the operator are made aware of the entry.

Specific Hardware Requirements for Critical Hazard Areas

An appropriate entry control program shall be established. The fail-safe character of the interlock system is vital. The entry control program shall include at least one of the following. One item alone does not necessarily constitute an adequate interlock system, therefore Department/Division review is particularly important.

The interlock system shall prevent entry[3] to the area when Critical Hazards exist, or upon entry, shall cause the hazard level to be reduced below that level defined as critical; also, it shall prevent restart of the energy source until a manual reset is made.

Control devices shall activate a conspicuous visible or audible alarm if the hazard remains, so that the individual entering the Critical Hazard Area through a control device is aware of the energy level and the

Area Supervisor or designee are also made aware of the entry. Administrative procedures shall define the required actions of personnel when alarms are activated.

Entryways shall be locked during operations, except when access to the area is required. Positive requirements for entry including surveys of hazardous energy levels shall be made for the initial entry, and periodically, as necessary, to assure that safe energy levels are maintained in accordance with administrative procedures.

Control devices shall automatically generate audible and/or visible alarm to alert personnel in the area before the use or operation of the energy source. These alarms shall allow sufficient time to evacuate the area, or to activate a secondary control device to prevent the use or operation of the energy source. If the visual indicator should be turning out the lights, levels of illumination shall be high enough so that personnel can rapidly leave the facility or take action to prevent actuation of the hazardous energy.

Specific Hardware Requirements for Catastrophic Hazard Areas
Catastrophic Hazard Areas where personnel access is possible require EACH of the four conditions detailed in the Specific Hardware Requirements for Critical Hazard Areas, and have the following additional requirements.

Access to interlocked areas shall be controlled by locked gates, that shall be equipped with two independent interlock devices. Each device shall be capable of deactivating sources of hazardous energies if the area is improperly entered. Improper entry through the gate shall activate an audible and/or visual alarm locally and at a central location, such as a control room.

In addition to being fail-safe, the interlock system shall also be redundant.

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Attachment B: Requirements for Computer-Based Interlock Systems

Computer-based interlock systems implemented for protection against Catastrophic hazards should be equivalent to relay-based systems and conform to the following additional requirements:

a. Redundancy shall be provided by independent, dissimilar computer systems with logic software written by different programmers working independently.

b. Computers for these systems should be dedicated solely for this use, and all external links should be eliminated or strictly controlled.

c. Where parts of the protection system need to be decommissioned for servicing or modification, it shall be demonstrated that signals from the decommissioned part cannot influence the active part of the interlock system. Breaking software links is not sufficient for isolation.

P - Organizations Interviewed

Organizations Interviewed

Code	Organization	Date
AD	Collider-Accelerator Department	
AM	Magnet Division	
BO MO	Life Sciences Directorate - Biology Department - Medical Department	
CO	Chemistry Department	
DA	Energy, Environment & National Security Directorate -	
EP	Plant Engineering Division - Maintenance Management - Operations & Environment	
IO	Instrumentation Division	
LS	National Synchrotron Light Source	
PG	Photography & Graphic Arts Division	
PO	Physics Department	
RP	Radiological Control Division	
SC	Central Shops Division	
SE	Safeguards & Security Division	
SS	Staff Services	
WM	Waste Management Division	

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Q - Interview Notes

Collider-Accelerator		June 5, 2003
Site Personnel	Asher Etkin Jon Sandberg Tom Nehring	ES&H Coordinator Chief Electrical Engineer Electrical Engineer
Survey Personnel	Joe Curtiss John DiNicola Steve Waski, Jr. Al Boerner, Jr. Pete Kelley	Lab Electrical Safety Officer Electrical Safety Committee, Chair Electrical Safety Committee Electrical Safety Committee DOE

The Collider-Accelerator Department operates the Tandem and 200-MeV Linacs as injectors, a Booster ring, the Alternating Gradient Synchrotron, and the Relativistic Heavy-Ion Collider.

The Collider-Accelerator facilities' access control system is required Safety Analysis Documents. The assessment team was told that the system is rigorously engineered and maintained, and is based on a combination of Kirk keys, relay systems, and programmable controllers designed to be fail-safe and include reachback circuits to trip upstream devices if a Power supply does not trip when it should. Radiation sources have redundant interlock chains. Status displays were reported to be provided both locally and in the main control room.

Each major facility has an individual interlock system arranged for protection of all associated areas. Operator action is required to restart after the interlock system disables an energy source. Beams from the Tandem to the Booster and the Linac to the Booster are disabled by beam stops; other mechanisms are employed beyond the Booster, such as systems which interfere with beam extraction. In addition, RHIC has a shutter at the 12:00 o'clock position which disrupts beam, as a backup to non-QA-1 extraction interlocks. All facilities have a system of Crash Buttons. Interlocked radiation areas are generally arranged so as not to impede exit in an emergency, however such areas exist and C-A depends upon sweep procedures and crash buttons.

The team was told the following. Only authorized employees are permitted to install, modify, test, or maintain the interlock system. All interlock boxes are labeled. The system is functionally tested using written procedures and check-off lists which require that each appropriate logic input is exercised and the appropriate intermediate logic action and protective response is verified. Testing of the entire system is performed annually, and local tests are performed after modifications or maintenance. Electronic technicians work on power supplies, and a dedicated group works only on interlock systems. Each group informs the other if changes are made to equipment or operating procedures. The interlock system design

is reviewed by the head of that group, followed by a review by the C-A Chief Electrical Engineer for adequacy and redundancy. The material is then reviewed by the ES&H Coordinator, then QA, and then the Department Chair, upon which they are controlled documents. All bypassing or reconfiguration has prior review and approval by the Chair of the Radiation Safety Committee. Test procedures are generated by the interlock system staff, reviewed by the ES&H Coordinator, and signed by the Department Chair. While the interlock system design is constantly refined, there is also a three-year cycle wherein all drawings are reviewed. The system was originally tested every six months, which has been extended to annually due to demonstrated reliability of the system

C-A has a formal configuration management system for controlling design, modifications, reviews and approvals, and maintaining accurate documentation. All equipment is documented on engineering drawings and all prints are reviewed. Functional descriptions, and documentation of the physical and electrical configuration of systems, is being entered into C-A's records for all new equipment, and the intention is to assure that all systems are so documented. As a collection of legacy facilities, some information still resides in the desk of individual engineers and only a small percent of older information is in the record system.

Construction and alteration activities are controlled through work permits. Experimenters, and even BNL personnel, must be trained in order to obtain unrestricted access to C-A areas, and there is an Experimental Safety Review form for each experiment.

Department procedures provide for certain devices to be worked on while energized. They include lighting in the Main Control Room, certain ventilation systems, and the UPS which includes a battery and the battery-powered Siemens control system.

The Siemens MG set and the Westinghouse MG set are operated at 13.8 kV. All associated doors, cabinets, and switchgear are locked, and room access is locked. There are physical barriers on areas with exposed hazards, like rotating shafts. The Siemens lockout procedure starts with the line crew opening the 13.8 kV feed at location 603 which is under their exclusive control. (No Kirk lock is used at this point, although Lockout/Tagout is applied through use of a lock box.) Then, the Siemens staff cranks out the first circuit breaker, which is unpowered, and applies a Kirk padlock to prevent the device from being re-inserted. In addition, there is a captive Kirk key on the secondary side of the Siemens generator. The AGS rf and vacuum system, located in a building adjacent to the Siemens building, are protected by Kirk key lockout.

Power supplies and similar equipment are controlled during service and maintenance by lockout/tagout. Some power supplies and similar equipment have switches on side panels, but C-A takes no credit for this safety feature. C-A asks that door and panel interlocks and capability for locking be provided by vendors for larger power supplies, and while they are not required for small supplies the vendors generally supply them. Wired panel interlocks are always factory- and acceptance-tested. Lockout and barriers are the means that C-A uses to protect workers, however the additional panel switches are free and redundant. All 480-volt power supplies, all magnet power supplies, the RF system, and all high-voltage equipment have Kirk keys on their main disconnect, usually located on the main door. A screwdriver or socket wrench is required to remove side panels. Note that the Kirk-controlled device does not necessarily turn off control

power, which is generally in a separate compartment. Equipment that is fed from two sources is always labeled. Some power supplies are wired with water mats in the control circuit, however these devices are not interlocks but simply trip the power supply. Capacitor banks in cages, typically used as a pulse-forming-network (PFN), resemble power supplies in that they are devices totally secured behind locked doors. Some of these banks, specifically the PFN's, have door switches arranged to de-energize a relay which shorts the output of the capacitor bank. Others have Kirk locks and mechanically-arranged shorting bars.

Use of interlocks discouraged on experimental equipment

There are two experimental lasers in the Linac, completely enclosed and in laser-controlled areas with interlocks on the doors. The interlocks are functionally tested at appropriate intervals using a written test procedure reviewed by Weilandics. There are three lasers at STAR, in cabinets bolted shut. There is one laser at PHENIX, owned by the Physics Department, which has interlocks and a test procedure for the interlocks executed by Physics.

Oxygen Deficiency Hazard (ODH) detectors are deployed in the RHIC tunnel, used to turn on the RHIC tunnel ventilation system, and is also wired into the access control system. The vent fans are tested every six months by Plant Engineering, through the Preventative Maintenance system. Flammable gas is used in both STAR and PHENIX, and several gas detectors are used to mitigate this hazard. The flammable gas detectors are calibrated for the major gas in the gas mixtures used in the detectors. At PHENIX, an ODH will turn off all gas supply, while detection of flammable gas in the experimental hall will start the exhaust fan system, operate a local alarm, and annunciate for further action under experimental control. At STAR, the same is true except that there is no ODH sensor. All detectors and the associated controls are tested once each year.

The Department has four diesel generators at the AGS, which are tested monthly into a load bank. There are eight diesel generators at RHIC, which are started monthly with no load and tested with the existing emergency loads during shutdowns. The ODH fans are also tested with the RHIC generators as the only source.

A great deal of personal lifting devices (PLD's) are used within C-A, from pallet lifters to man lifts, aerial lifts, very large fork lifts, and mobile cranes. Some belong to Plant Engineering, but the majority are C-A property. Plant Engineering maintains their own equipment under their PM program, and some (but not all) of the C-A equipment is also maintained by Plant Engineering. All overhead cranes are maintained by Plant Engineering. All operators of this equipment are trained. There is a rigging crew assigned to C-A, who operate under Plant Engineering supervision.

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Magnet Division		May 7, 2003
Site Personnel	John McNeil Paul Phillipsberg Mike Gaffney	Equipment Calibration Control Room Operator ES&H Coordinator, Safety Engineering, SHSD
Survey Personnel	Joe Curtiss John DiNicola Steve Waski, Jr. Emil Zitvogel Pete Kelley	Lab Electrical Safety Officer Electrical Safety Committee, Chair Electrical Safety Committee Electrical Safety Committee DOE

The Magnet Division manufactures and tests beam transport magnets, both room-temperature and cryogenic. John McNeil is in charge of calibration and documentation for the Division.

Interlock systems are used on equipment used to manufacture and to test magnets, as well as on material-handling equipment. There is much legacy equipment, dating from SSC days, with existing interlocks and associated procedures. As the mission for a piece of equipment changes, new interlock test procedures are prepared.

There is a procedure for all work done in the Division. The only valid procedures are those posted as Adobe files on the Division's web site, accessed at <bnl.gov/magnets/>, followed by selecting QA & Manufacturing Documentation/Operations Procedures Manual/. All workers involved with the machines have access to a bank of computers and a printer located outside the manager's office, and use of the machines were demonstrated to the assessment team. There are about fifty operations procedures, and each are reviewed at least every three years. A header on each page of each procedure requires the user to verify they have the most current version of the procedure. Each procedure requires the operator to verify that interlocks have been tested within the past six months. (Likewise, all overcurrent protection is calibrated every six months.) As a noteworthy practice, a copy of the Safety Interlock Test Approval form is posted in a plastic holder at each machine, in a manner similar to use of a calibration sticker.

Interlock test procedures are controlled by the Division's Operating Procedure Manual (OPM). Interlock test procedures are reviewed by the cognizant scientist, then the chief electrical engineer, then QA, training, and the ES&H Coordinator. Only after final review and approval by the Division Manger does the procedure get an OPM number, placed on the Division's web site (only the approved version is posted) and is authorized for use.

Most equipment with significant hazards is protected by Kirk Key interlocks. Such interlocks are used, for example, in the short sample test facility where one magnet power supply is wired to three interlocked bays, enabling testing to proceed in one bay while hands-on work can proceed in the remaining two. Interlocks based on switches are functionally tested at zero power settings by opening doors or unbolting (but not removing) side panels. Devices are tested dead-front, if possible. Switches found to hang up,

generally due to dust or dirt in the switch mechanism, are repaired on-the-spot using lubricant sprays followed by operating the switch 4-5 times, or they are replaced.

For equipment used routinely a simple ACCESS database is used to trigger testing of interlock systems. In the event that a test is in progress, equipment may be operated outside its calibration/test date with approval by the cognizant engineer. (Smaller power supplies and similar equipment are not tested.) In all cases, the interlock systems are designed so that operator action is required for restart. Interlock strings are fail-safe, are generally low-voltage, generally 12 volts, and are not located near live components. They are seldom configured for redundancy, although in some cases there are double switches. Crash buttons, cords, and bars are considered to be part of the interlock string. Interlock and crash systems do not prevent personnel from leaving an area. Bypassing is sometimes necessary, to work in a low-voltage area, but is controlled through a work planning "green sheet" which is subject to the same reviews as the procedures. Requirements of NFPA 70E are accommodated by work planning.

Guests are sometimes associated with work of the Magnet Division. They do no "wrench-turning," but are generally present from CERN or other labs to witness testing.

There is an over-temperature device used as an interlock, on the curing press in Bldg. 924. The device is tested every six months using an Omega Thermocouple Simulator, and all readings are sent to a LabView program. In some applications, cable temperature is monitored as an operator aid, and the equipment is administratively shut down for temperatures greater than 170F.

A tour of the Division's site followed.

The division operates two electric pallet lifters, numbers 905EP-038597 and 902EP-114658, each of which have stop switches at the end of the operating handle. Plant Engineering maintains these items. [Follow-up telephone inquiry to Pete Palamidis, x2462: Regarding the two electric pallet lifters in the Magnet Division, Pete reported that maintenance includes "check hand controls for proper operation and labeling." The last pallet lifter we saw, 902EP-114658 (Big Joe), is being checked every six months. The next-to-last pallet lifter, 905EP-038597, was last seen on 10/17/00, over two-and-a-half years ago. Pete's record shows that Tom Dilgen (Magnet Division) declared at that time that the lifter was in poor condition and should no longer receive preventative maintenance.

As stated earlier regarding requirements for operators to ensure they are using the most current version of a procedure, the team noted that a hydraulic press in Bldg. 905, identified as a magnet collaring device, did not have a current interlock sign-off sheet at the control panel. Subsequent to the on-site review, the magnet collaring device interlocks were verified as operational on May 13, 2003.

The Bldg. 903 machine shop contains only one lathe with an interlocked guard.

Medical & Biology		May 23, 2003
Site Personnel	Bob Colichio Deana Buckallew Jim Bullis	ES&H Manager, Life Sciences Directorate FSS, Radiological Control Division R&RR Group ESH Coordinator
Survey Personnel	Joe Curtiss Emil Zitvogel Tom Nehring Pete Kelley	Lab Electrical Safety Officer Electrical Safety Committee Electrical Safety Committee DOE

The Medical and Biology Departments are located adjacent to one another along Bell Avenue. The Medical Department has a standby generator, maintained by Plant Engineering. A few circuits are extended to Biology, for example, to CERF. As a result of the May 2003 water main break in the Biology building, a few more circuits are expected to be added to the electrical panel.

Medical - Bldg 490

Veterinary Services operates a Buxton Cage Washer, a room-size device operating with 185F water. The are two interlocked access panels in front of the machine, each about four ft high by three ft wide. There are two trained operators; a group that has not changed in a long time, and training is by OJT. The interlocks are tested on six-month intervals.

In an access-controlled room, Medical operates a Phillips RT-100 x-ray machine for research in the effects of x-rays on rats and tissue samples. A radiation survey determined that there was only one point of vulnerability, directly above the x-ray tube, and so additional lead shielding was added to the roof. There is a crash button in the test chamber, along with a check station to assure proper clearing of the room. There are two position switches on each door for the redundant access control circuit. A red lamp is located over the door, and lamp removal was reported to the survey team as part of the interlock test procedure. The system is tested at appropriate intervals, and our team examined the test record. The cabinet containing the relay-based interlock system has the circuit diagram on the inside of the door, however there is no indication that the lamp current is monitored. Subsequent discussions with Chris Weilandics revealed that the lamp is not interlocked, and that as a result of a recent review of the device it was deemed to be in compliance with two ANSI standards governing Radiation Generating Devices.

BNL and Stony Brook operate an Electron Accelerator (Bremstrahlung) which has an individual SAD, must follow SBNY procedures, and must conform to the NYS Sanitary Code 16, which is similar to 10CFR835. The device is operated by Stony Brook University Hospital, and patients receive medical treatments. Interlocks are tested every six months. About four years ago, an interlock was discovered to be bypassed through securing the switch with duct tape. The incident resulted in an Occurrence Report.

Biology - Bldg 463

The Controlled Environment Radiation Facility (CERF) is located in the basement of Bldg. 463. CERF contains a 5000 Curie cesium source (in room B12) used to irradiate biological specimens. This facility has a separate Safety Analysis Report and recently completed an Occupancy Readiness Evaluation. The red lamps over the irradiation chamber door have a current monitor and are interlocked with the control system.

Room B-237 contains a Machlatt/Picker x-ray machine. This table-top device has the operating procedure posted to the side of the machine, with interlock system checks as the initial steps. The red lamp on top of the device is not equipped with a current monitor. There is a Geiger counter that provides audio indication that the machine is running, along with additional visual information.

Room B-237 also contains a Sorval RC2-B centrifuge, an older machine that was factory-supplied without interlocks. On the other hand, Room B-228 contains a Sorval RC3BP ultracentrafuge with a factory-equipped interlock.

General: The team asked if there were other interlocks in the building. The facility personnel responded that there were additional washers with door switches, but they were not routinely tested because they are too small to present a hazard. There are two glass washers in Medical and six in Biology, and in addition there is a rack washer in Veterinary Services.

Building 801 - Hot Cells

The building has a vent system for the hot cells and fume hoods, arranged to discharge into Bldg 802 and then to the stack. There are multiple forced-draft blowers in Bldg 801, and dual induced-draft blowers at the other end of the connecting duct in Bldg 802. The forced-draft blowers could potentially over-pressure the duct, so an interlock was installed such that the induced-draft blowers must be operating for the forced-draft blowers to operate. The decision was made recently that failure of this arrangement could affect personnel safety, and therefore the interlock was declared a safety interlock. The interlock is now tested quarterly.

Bldg. 801 also contains an ICP-OES device having an rf cavity wherein a plasma is developed using argon gas. The plasma is fully enclosed behind a hinged doors equipped with an interlock, however performance-based testing of the interlock could cause the spread of radioactive contamination which presents a greater hazard than malfunction of the door interlock. After a detailed review of the unit, a hasp and padlock were installed to prevent opening of the hinged doors except as controlled by the operator of the device, who is custodian of combination lock.

There is a motorized roll-up door in the building, and a portable lift device (pallet lifter, bar code 099649), both maintained by Plant Engineering.

Brookhaven Linac Isotope Producer (BLIP) - Bldg 931

The team did not visit BLIP, but discussed the facility with Jim Bullis. BLIP has a number of interlocks but few are safety-related. The facility has a Safety Analysis Report; however, the current version was

prepared in 1996 and the document is now being revised and updated. The new version will clarify the purpose of the various interlocks as operational versus safety-related. Procedures for operations and interlock testing are generated by Henry Schnakenberg, reviewed by Jim Bullis, and approved by Leonard Mausner.

BLIP has roll-up doors that are manual and without interlocks.

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Chemistry Department		June 17 & 18, 2003
Site Personnel	Diane Cabelli Connie Koehler Dave Schlyer Mike Schueller	ES&H Coordinator, Operations Coordinator Bldg. Manager, Work Control Coordinator Cyclotron Facility Manager Cyclotron Operator
Survey Personnel	Joe Curtiss John DiNicola Tom Nehring Emil Zitvogel Al Boerner, Jr. Pete Kelley Larry Hinchliffe	Lab Electrical Safety Officer Electrical Safety Committee, Chair Electrical Safety Committee Electrical Safety Committee Electrical Safety Committee DOE DOE

The Chemistry Department operates a number of facilities and experiments on site. The facilities each have safety analysis documents and have reviews appropriate to their size and complexity. All such documentation is scheduled for periodic review.

There are nine laser labs in the Chemistry Building. All lasers are commercial and are housed in cabinets that come with interlocks. Researchers do not test the machines or the cabinet interlocks, which are maintained by the laser vendors. Laser lab interlocks are limited to door switch arrangements that will disable the lasers if a lab door is opened without operating the temporary (few seconds) entry-control pushbutton. The arrangement in each lab is reviewed by the Laboratory Laser Officer. There is a single written, functional test procedure used within the building for all laser labs, and they are tested every six months.

Chemistry operates a 52 year old Van de Graff in compliance with a Safety Analysis Document. The machine is in a room by itself. The assessment team did not visit the device, however a laminated copy of the interlock test procedure is fastened to the door of the Van de Graff room as well as the test log record which dates back several years.

The Laser-Electron Accelerator Facility (LEAF) is located in a basement space in Bldg. 555. The facility houses both high-power lasers and an electron gun. The facility has a Safety Analysis Document (SAD), and experienced an Accelerator Readiness Review (ARR). The interlock system design is redundant and fail safe, and performing the functional test procedure every six months takes 45 minutes. During the visit the team noted that the six-month test was overdue. The Department immediately tested the system, and changed the procedure for testing to include both posting a testing requirement calendar and assigning specific individuals to test the system on the specific dates on the calendar.

Designs for all equipment within the Chemistry Bldg. remain with the originator, with copies retained by the Bldg. Manager. Test records for lasers are maintained in a binder within each laser lab, while for other facilities both the written functional test procedure and the testing sign-off sheet is posted the at door to the controlled area.

Three cyclotrons, used to make radiopharmaceuticals for use in the PET machine, are located in Bldg. 901. The Japan Steelworks (JSW) 41-inch machine is in current use, although it is becoming less reliable and in need of attention. In 1949, BNL put together a 60-inch machine, using a driver by Collins Radio. This variable-energy machine can accelerate four different particle types, and to higher energies than the JSW machine. The machine has problems, which Chemistry is looking for funding to correct. An EBCO cyclotron, a commercial unit intended to supplant the JSW, was recently purchased and installed in Bldg. 901 and is currently being commissioned.

Each of these stand-alone machines is in a room by itself, and their interlock systems are individual but similar. Each system includes inspection stations: there are two for the JSW, three for the 60", and three for the EBCO. The interlock system and crash buttons are in a fail-safe design, and all have status displayed on a control console and are arranged to require operator action to re-start in the event of a trip. The machines are not operated beyond six months after their interlock system is tested. The test procedures are functional, and written records are kept of the testing. Diagrams of the interlock system are maintained in an office in Bldg. 901. There are four qualified operators for the cyclotrons.

A UPS is used for the EBCO programmable logic controller (PLC), but there is no standby generator. A manual overhead crane and pallet lifter are associated with cyclotron activities; these devices are all maintained by Plant Engineering.

The Radiopharmaceutical Lab in Bldg. 901 is used to process the product of the cyclotrons for use in the PET machine. All radiopharmaceuticals are short-lived sources, the longest being two hours, and all processing is done in a sealed system. . There is a radiation alarm in the lab. The lab has a fume hood which is alarmed on loss of air flow, and there is an annual flow test on the hood. There are no interlocks in the lab.

The PET Facility is located in Bldg. 906. UPS's are used with the scanners, but there is no standby generator. There are no interlocks in the PET Facility.

The MRI Facility in located in Bldg. 560, which is fenced and has locked doors due to pacemaker issues. The equipment operates continuously, and although a crash button is installed, it is impossible to test because it would quench the magnet which would likely be accompanied by severe damage to the MRI machine. The assessment team noted that the system could be engineered to allow testing of a crash system without actually crashing the machine during the test. Other than the crash button, there are no interlocks in the MRI facility.

NSLS hosts two current Chemistry Department experiments. The NSLS assumes responsibility for safety review of the experiments conducted at their facility, and the Chemistry Department has minimal involvement.

In the Chemistry Building there is a standby generator used to power the fire alarm system and emergency lights. The generator is maintained by Plant Engineering. There is an electric fork lift, which is not maintained by Plant Engineering. Rather, Chemistry does their own preventive maintenance in an informal, periodic, undocumented manner. Checks include operation of deadman switches, checking the battery, and examining the hydraulic lines, but not pre-use checks of the safety switch. During all the time Chemistry owned the forklift there have been two problems, corrected by calls to Plant Engineering. Chemistry also has pallet lifters, an engine lift, and a chain hoist above the chuck of a large lathe.

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Energy, Environment, and National Security		May 22, 2003
Site Personnel	John Boccio Ron Webster	Manager, EENS Research Operations Office EENS Staff, Alternate Bldg Manager
Survey Personnel	Joe Curtiss John DiNicola Emil Zitvogel Tom Nehring Pete Kelley	Lab Electrical Safety Officer Electrical Safety Committee, Chair Electrical Safety Committee Electrical Safety Committee DOE

The Department of Energy, Environment, and National Security is spread across a number of buildings on site and is involved in a number of small experiments, utilizing a significant amount of commercial legacy equipment.

Building 526

Rm. 115 contains an 18 year old Electron Spectrometer manufactured by VG Scientific, Sussex, England, used to detect electron-thin films on metal. There are two rear doors with interlock switches on each door. The operators do not know what drops off if the doors are open since there they have no reason to go inside and essentially never go in. The unit is powered through a three-phase, 208 V line cord which can be unplugged to implement lockout/tagout. The device is not serviced by the experimenters, but maintained by the vendor.

In the same lab is a 7 year old Perkin Elmer 1600 series FT/R, labeled as a Class II laser.

On a balcony in the same building there is a system of insulated ducts used for research in residential heating. The 4 kW heater is wired through an on/off switch mounted in the door of the enclosure, which includes a mechanical interlock similar to those on commercial equipment.

Building 830

Lab 1 (Room 12-107) contains a Varian “Liberty 100" Inductively Coupled Plasma Emission Spectrometer, a commercial unit used to measure metals in liquid samples. Maintenance is performed by the manufacturer.

In the Hi-Bay, there is an DuPont Instruments/Sorvall model RC-5 Superspeed Refrigerated Centrifuge (20,000 rpm ultracentrifuge). The cover is interlocked to open only when power is on and the rotor is stopped. The interlock is not routinely tested. The unit is maintained by the vendor, Long Island Scientific in Port Jefferson.

Lab 4 contains a Jordan Valley model EX-6600 X-ray fluorescence unit, which handles solid samples. The device is serviced by the vendor. The unit is a "radiation generating device" and interlocks are tested every six months by following a written procedure. The procedure includes verifying that unplugging the red warning lamp will disable the device. An operator aid was posted on the front of the unit, which documented that the "Next Interlock Test 12/11/03."

Building 815

Lab D-7 contains an X-ray device which is out of service. An ORE would be needed to restore the unit to service.

The Raptor experiment was moved from the Bldg. 939 Experimental Hall to Lab D-8 in Building 815. Administrative control is exercised during experiments, rather than the area interlocks used when the device was in Bldg. 939.

Room I-21A contains a small machine Shop. Much of the equipment will restart on restoration of power.

General: Building 815 has space in the basement. Personnel access is by an interior stairway, while a fenced opening with an industrial gantry crane provides for handling of large equipment. The crane is maintained by Plant Engineering. There is also a gas-operated forklift in the building.

Building 490A (Medical Research Center)

Asbestos-related research was performed in Bldg. 490A. The research was completed several years ago and the labs used to conduct the program were cleaned out and decommissioned in 2001. Room 12-107A contains a Liberty model 150 Inductively Coupled Plasma (ICP) emission spectrometer. Room 12-107F contains a Sorval centrifuge, model RC26 Plus.

General

EENS does not have any standby emergency generators.

Plant Engineering Maintenance		June 12, 2003
Site Personnel	John Hynan Mike Curtis Pete Palamidis Nick Houvener	BNL Hoisting & Rigging Inspector Heavy Equipment Supervisor Preventive Maintenance Coordinator Safety Professional
Survey Personnel	Joe Curtiss John DiNicola Steve Waski, Jr. Al Boerner, Jr. Tom Nehring Emil Zitvogel Pete Kelley	Lab Electrical Safety Officer Electrical Safety Committee, Chair Electrical Safety Committee Electrical Safety Committee Electrical Safety Committee Electrical Safety Committee DOE

Plant Engineering is responsible for maintaining all major non-programmatic operating machinery on site. The Maintenance Management Center (MMC) uses a Computerized Maintenance Management System (CMMS) computer program to track when scheduled maintenance is required and when it is performed. Equipment-specific checklists and procedures are available on Plant Engineering's web site. Some equipment is "owned" by Plant Engineering while other equipment is "owned" by other organizations and these organizations are charged (by rate per craft) for maintenance of the equipment. The organizations can arrange for periodic maintenance by Plant Engineering, through their posting the equipment on the PM list, or the Building Manager (who is responsible for programmatic equipment) can generate a Maintenance Management request when preventive or corrective maintenance is required.

Information below was provided during a meeting. For brevity, the assertions below are recorded as fact although there was no follow-up examination of records.

All building cranes are maintained by Plant Engineering. Cranes are maintained periodically, depending on how much they are used; a typical 30-40 ton crane will be maintained quarterly. Inspections of all cranes are performed at least annually; John Hynan maintains an Inspector's Certificate, through an bi-annual (every two years) re-certification process, for cranes and aerial lifts. Inspections include all limits, crane travel, inspection of the hook (including measuring the opening), examining wire rope with measurements for wear, components, controllers, gear boxes, and the like. The inspections are performed with the aid of a checklist. Safety during maintenance is implemented through lockout/tagout. New overhead cranes are tested at 100 to 125 percent of capacity, and re-tested at this load after major repair. The three cranes in the Bldg. 326 Maintenance Shop on Princeton Avenue are "owned" by Plant Engineering, while all other building cranes on site are associated with programs. All overhead building overhead cranes are furnished by Plant Engineering with a laminated "Preoperational Checklist."

Passenger elevators are "owned" by Plant Engineering, while freight elevators are "owned" by facilities. All elevators are serviced and inspected monthly, and twice each year all elevators are inspected by an outside, qualified elevator inspector. New elevators are tested at 100 percent of capacity, and re-tested at this load after any modifications and every five years after the last load test.

All standby generators are tested periodically, generally monthly or semi-annually.
The generators at Bldg. 449 (Telephone Switch Room), Bldg. 599 (Fire House), and Bldg. 50 (Safeguards & Security) are tested monthly, with the Bldg. 50 generator under a 2.5 hour load. The routine tests include responding to loss of line power, and annually the generators undergo a 2.5 hour load test. Standby generators in the buildings listed above, and in buildings 423, 452, 488, 55, 575, 580, 801, and a few others, are "owned" by Plant Engineering, while other generators on site are associated with programs.

Overhead doors are maintained by the BNL carpenters. Scheduled maintenance is performed by an outside vendor under contract with Plant Engineering. The routine maintenance intervals for the doors depends on use, with some doors checked annually and others every two years. Checks include the drive motors and their overload mechanisms, travel limits, and the safety switch on the bottom of many overhead doors. Building managers can contact Maintenance Management if an overhead door is malfunctioning. Overhead doors in Bldg. 100 (Receiving), along with the loading docks and mechanisms which lock trucks to the dock, are "owned" by Plant Engineering, while all other overhead doors on site are associated with programs.

Heavy equipment, including both the rigger's heavy lift equipment, and earth moving equipment (bulldozers, payloaders and backhoes) is maintained by Plant Engineering under the PM program. Most of this equipment is "owned" by Plant Engineering, but some is jointly owned, for example, as a shared item with the AGS.

Powered Industrial Trucks, defined by OSHA as "any mobile power-propelled truck used to carry, push, pull, lift, stack or tier materials," whether ridden or controlled by a walking operator, are maintained by Plant Engineering. Machine-type checklists, by type of machine, are used during maintenance. A typical machine checklist states: "Check all controls,"or "Check all interlocks," thus testing procedures are not always directly related to a particular piece of machinery. Specifically for fork lift maintenance, all those on Plant Engineering's PM list are visually checked every six months and they are serviced annually. All limits are checked, including the seat interlock and the neutral safety switch. Plant Engineering also depends on BNL requirements that all forklift operators be trained. This training includes the necessity to check a forklift (or any powered industrial truck) before operating, however the team believes this is not always done. Fork lifts are not furnished by Plant Engineering with a laminated "Preoperational Checklist." The preventive maintenance described is performed as agreed to, and funded by, operating groups. For equipment not under such agreements, individual Building Managers know they must generate maintenance requests.

All man lifts are maintained by Plant Engineering, including those owned by operating groups. All man lifts are furnished by Plant Engineering with a laminated "Preoperational Checklist."

Lawn mowers, weedwackers, and similar grounds maintenance equipment are "owned" by, and maintained by, Plant Engineering. BNL owns sixteen Toro lawnmowers and three Jacobsen lawn mowers, each on scheduled maintenance. The required preventive maintenance is once per year, however it is usually performed 3-4 times per year due to heavy usage. The normal machinery checks of all operating switches and controls performed under maintenance are supplemented by daily operator checks.

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Plant Engineering Operations		June 12, 2003
Site Personnel	Bill Chaloupka Pattie Bender A. Soma	Assistant Manger Operations & Environment ES&H Coordinator Superintendent, Crafts Maintenance
Survey Personnel	Joe Curtiss John DiNicola Steve Waski, Jr. Emil Zitvogel	Lab Electrical Safety Officer Electrical Safety Committee, Chair Electrical Safety Committee Electrical Safety Committee

Plant Engineering Operations Group is responsible for operating the Central Steam Facility, Central Chilled Water Facility, Water Treatment Facility and Sewage Treatment Facility, and for the Site Electrical Distribution System.

Access to facility areas such as electrical substations, wells and adjoining chemical treatment rooms, and water and waste treatment facilities, are locked and hazards to personnel are guarded. As a result, there are no electrical interlocks for protection of personnel deployed within this operating section. There are a few mechanical interlocks on hypochlorite chemical systems, implemented by “banjo” valves, to assure that one ball valve is in a particular position before another can be operated.

The section is supervised by Bill Chaloupka, a Registered Professional Engineer. All workers have extensive experience in their areas of activity. Senior Stationary Engineers (ten, plus supervisor) working in the Central Steam Facility have backgrounds in marine engineering with more than ten years experience, or are ex-Navy with more than twenty years experience. Central Chilled Water Facility personnel (ten, plus four supervisors) typically have more than ten years experience. Water and Sewage Engineers (eight, plus supervisor) have between five to ten years experience, and have New York State Certification in water and sewage. Site Electrical Distribution Towerline workers (five, plus two supervisors) have a minimum of ten years of direct experience, typically twenty years, and the supervisor has thirty years experience.

There are standby generators at the Central Steam Facility, the Sewage Treatment Facility, Bldg. 580 for Lab outflow monitoring, and in Bldg. 452 to support the maintenance shops. The wells are equipped with “auxiliary power units,” propane or diesel engines which can be engaged directly with the pump shafts. All these devices are maintained by Plant Engineering’s maintenance section.

The Utility Operations has one fork lift at the Water Plant.

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Instrumentation		May 21, 2003
Site Personnel	Bob DiNardo T. Srinivasan-Rao M. Montemagno N. Schaknowski	ES&H Coordinator Laser Experimenter Technician Engineer
Survey Personnel	Joe Curtiss Al Boerner, Jr. Pete Kelley	Lab Electrical Safety Officer Electrical Safety Committee DOE Area Office

Instrumentation is located in Building 535.

Room B-148 was a laser lab with an interlocked door, which is now used as a storage area for detector work. The switches are not used, but they have not been removed because of the possibility of laser work in the room in the future. A sign is posted outside the door, indicating that the interlock system is not used.

Room B-156A contains an e-beam unit, used for evaporating metal for coating other materials. The device is powered by an 11 kV power supply and is thus capable of generating x-rays; however, the x-rays are contained by the metal enclosure and lead glass viewing ports. The device is examined for x-rays every six months. Two red lamps are illuminated when the device is operating; one on the Veeco electron gun power supply panel, and one external. These indicators are not interlocked. A vacuum interlock assures that power will not be available while the vacuum is inadequate, because the e-beam filament will burn out if energized while the chamber is not under vacuum. The unit is reviewed by Chris Weilandics, and a radiation survey is performed every six months.

Room B-102A contains four Class IV lasers, each one equipped with a spring-loaded fail-safe outlet shutter. All three doors to the laser room are interlocked with the shutter system. The laser room is entered through an anteroom, to which only four persons with laser training have keys. The anteroom leads into the laser room through a door equipped with a button-operated pass-through system requiring that the second button be pressed within a set time delay or the system will shut down. The system has been in use for 15 years. The survey team reviewed the interlock test record, which showed a gap in the six-month testing requirement between January 2000 and October 2001. Tests of the interlock system were always successful. The system is reviewed by Chris Weilandics, who in discussions subsequent to the survey recalls that the system was being redesigned in the recent past, which period may correspond to the period of the gap noted above.

Room B-114B, the Printed Circuit Lab, contains a circuit board router and an oven. The router is fully enclosed, and has a slide-up plexiglass cover. Opening the sliding cover requires two hands, one to operate the cover and the other to hold open a spring-loaded pressure-pad brake. The brake was added in response to a Tier I inspection report, that also resulted in posting a sign that reads “Warning, Door Closes Automatically.” The intention is to prevent accidents, rather than provide an interlock.

Room B-118 contains an oven manufactured by Precision Quincy Corp., used for drying circuit boards at 150F and for curing circuit board coatings at 180F and 300F. The oven is typically used for five minutes for drying, and for curing circuit board coatings the oven would be loaded late in the afternoon and opened the next morning. The oven has a recirculating fan and an exhaust fan. The oven is equipped with what was described by the user as an "OSHA Package," which included a switch on the door which interrupts the recirculating fan. The comment was that this switch was installed in order to not subject a person to a blast of hot air; however the switch could equally have been installed to protect the product from a sudden inflow of cooler air. The switch is not tested, but operators rely on the switch and would take corrective action if it should not function properly. The instruction manual requires an operating sequence test of all components every six months.

Room B-139 (Lab 7) contains an x-ray machine in a rectangular enclosure constructed of lead-loaded plexiglass. This machine is a Radiation-Generating Device, and is tested for radiation leakage with a counter. The last check was performed by Jim Durnan on January 2, 2003. The enclosure is provided with magnetic switches on the door, interlocked lamps, and a two-hand reset upon closing the front plexiglass door. A red folder kept local to the machine contains the interlock test procedure along with the sign-off sheet. The RGD requires testing every six months, and the operators report that the machine is "hard to turn on,"meaning that the interlock system is effective.

Room B-124 contains an X-Y Location laser, used for scribing silicon, and operated by the machine shop. The bench-top device is a turn-key commercial unit from U.S. Laser Corp, and contains a Class IV laser with an interlock on the nine-by-nine inch hinged door. This is a self-contained system, and there is no training or test procedure associated with the equipment. The system was reviewed by Chris Weilandics.

General. Instrumentation has no standby generation

National Synchrotron Light Source		June 3, 2003
Site Personnel	Nick Gmur Scott Buda Mike Buckley Al Boerner, Jr.	ES&H Coordinator Interlock Engineer QA and Conduct of Operations Representative Electrical
Survey Personnel	Joe Curtiss Steve Waski, Jr. Tom Nehring Jim Wright Pete Kelley Mohammad Ali	Lab Electrical Safety Officer Electrical Safety Committee Electrical Safety Committee Electrical Safety Committee DOE DOE

The National Synchrotron Light Source (NSLS) operates many beam lines simultaneously, using an extensive access control system to provide for individual control over each experimental area. The NSLS is operated under a Safety Assessment Document (SAD), which includes an Accelerator Safety Envelope.

The NSLS also operates a development facility for high power lasers, the Deep Ultraviolet Free Electron Laser Source Development Laboratory (DUV SDL). Until recently, NSLS operated the ATF, a linear accelerator development facility which was transferred to the Physics Department about a year ago.

The NSLS access control system is required by a Safety Analysis Document, describing the Accelerator Safety Envelope. The system is rigorously engineered and maintained, and is based on a combination of Kirk keys and electronic modules designed to be fail-safe and include reachback. Radiation sources have redundant interlock chains, while lasers generally have a single chain, with requirements in the Radcom manual having precedence. Status displays are provided both locally and in the main control room. A key locker in the control room, accessible by three persons, contains beam line lockout Kirk keys used by the NSLS operations coordinator to enable each of the beam lines.

Each beam-line hutch is connected to an interlock system of a single, modular design, including the Kirk key enable mechanism. Operator action is required to restart after the interlock system disables an energy source. Each hutch contains a Crash Button. Some, but not all, hutches have their Kirk Key strike fastened through retainer removable from inside the hutch. The Laboratory Fire Safety Officer determined that life safety is not compromised even in the absence of this device, since there is minimal fire loading in the hutches, they are of metal construction and inherently fireproof, and there is a permanently-installed sprinkler system above each hutch providing external fire suppression.

Individual interlock systems are reviewed by the NSLS interlock working group for simple designs. For more complicated systems or equipment, reviews are expanded to include electrical engineers and others.

The reviews are recorded on a review form, and records are kept of more extensive meetings. The documents are placed in the NSLS central file system, which also includes all drawings, test procedures, and engineering change notices (ECN's). This rigorous procedure applies in a formal program to beamline reviews, conducted now in the planning stage to allow time for experimental and alara reviews. The beamlines are reviewed upon construction or significant change, and every two years, and the review is conducted in a uniform format and against a safety checklist. Testing is triggered through the NSLS "MARTI" maintenance program, which tracks preventative maintenance due dates, issues notices, and maintains a record of completed maintenance. All radiation and laser devices are included in the database.

Construction and alteration activities are controlled through work permits issued by the Building Manager. Experimenters must be trained in order to obtain access to the NSLS, and there is an Experimental Safety Review form for each experiment. New this past year is a continuous review by a Beam-line Inspection Group, who visit beam lines very much like Tier I inspections by mostly concentrating on electrical safety hazards.

The interlock system is QA category A2. All interlock system boxes are locked, and all cables are numbered and identified as part of the interlock system. Interlock equipment is posted with an NSLS-designed pictograph warning against tampering (see attached). Disconnected interlock cables are locked and tagged, as witnessed during the tour of the NSLS experimental floor.

The modular design allows for testing by logical blocks such as a single hutch, or a single beam line. Testing is through use of a single-design test plug, as an engineered replacement eliminating use of older test techniques using jumper wires. This assures that no test jumpers are inadvertently left in place following the test. Any changes, even to one wire, triggers a re-test of the associated interlock system. Bypassing of the interlock system is not permitted. Lockout, for example on laser safety shutters, is used during recofiguration. (There was one occasion wherein an experimenter who bypassed a laser interlock switch was suspended and lost NSLS privileges for six months.) Upon completion of testing for all radiation and laser systems, the interlock group affixes a sticker both to the equipment and to the operating console, showing that the system successfully passed the test and listing the due date for the next test. The operations manager is responsible for reviewing the information on the sticker before releasing the beamline for operation.

There are a number of laser systems in the NSLS Bldg. For Class 3b and 4, the NSLS interlock group reviews the schematics and interlock arrangement supplied by the vendors, and then applies their own interlocks. They report that they have seen some vendor interlocks which they considered were not reliable. The current process is to equip each laser system with a spring-loaded mechanical "universal shutter," available in two sizes, designed by an NSLS mechanical engineer. Newer systems are so arranged, and the NSLS is in the process of equipping existing systems with the shutters. There are a number of lasers in the Bldg 729 Source Development Laboratory, all in a single clean room and all equipped with the NSLS standard shutters.

There is a single Radiation Generating Device (RGD) at the NSLS. The device has an interlocked red lamp which, on failure of the lamp, shuts off the power supply and closes the shutter. The procedure, and

interlock and safety checks were reviewed by Chris Weilandics.

Power supplies and similar equipment are controlled during service and maintenance by lockout/tagout. Some power supplies and similar equipment have switches on side panels, which are tested when equipment is maintained but the testing is not documented. All 480-volt power supplies, all magnet power supplies, the RF system, and all high-voltage equipment have Kirk keys on their main disconnect, usually located on the main door. A screwdriver or socket wrench is required to remove side panels.

Miscellaneous Equipment

The cryogenic lab in room 1-169 is equipped with an oxygen deficiency system which can automatically start a large purge fan. At the receiving area, where dewars may be located, there is an oxygen deficiency detector interlocked with the roll-up door.

The NSLS has a machine shop, but there are no interlocked equipment guards. All drill presses are equipped with Safe Start devices which prevent automatic startup on restoration of power after a power interruption. There is one high-speed centrifuge, at the X-9 beam line. The device is a DuPont Instruments, Sorval RC-5B Refrigerated Superspeed Centrifuge, and the interlocks are not tested.

The NSLS has five roll-up doors in the building, and one at the Bldg. 729 Source Development Lab. Employees use their identification card to enable the door control system, and must hold the push button to raise or lower the door. This arrangement ensures that a person is at the door and eliminates the need to have a sensor strip at the bottom of the door.

The NSLS has one forklift, operated by trained personnel. Pallet lifters are hydraulic and do not have interlocks. There are two overhead cranes. This equipment is all maintained by Plant Engineering.

NSLS has a single standby diesel generator. The 150 kW device is maintained and load tested monthly by Plant Engineering during Bldg. 725's maintenance periods, and also to 75% capacity twice each year during substation maintenance.

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Photography & Graphic Arts		May 13, 2003
Site Personnel	Bruce Style Rick Backofen Cornelius Jackson	Division Head Printing Supervisor Senior Operating Mechanic
Survey Personnel	Joe Curtiss John DiNicola Tom Nehring Emil Zitvogel Pete Kelley	Lab Electrical Safety Officer Electrical Safety Committee, Chair Electrical Safety Committee Electrical Safety Committee DOE

Photography & Graphic Arts does all the printing for BNL, including operating Quick Copy. Cornelius (Neil) Jackson is trained in Lockout/Tagout, he performs maintenance and adjustments to the printing machinery, and he operates the PG&A machinery along with others.

All machinery in P&GA having interlocked guards and emergency stop devices come so equipped from the factory, or have been added by factory personnel. There is no formal program to test the interlocks every six months. In practice, machine setup and operation exercises all interlocks so that malfunctioning interlocks would be rapidly identified. Neil Jackson performs all maintenance and most setup operations on the printing machinery. He does so without using Lockout/Tagout, because it is necessary to jog the equipment during lubrication, adjustments, and setup. Neil is very aware of the pinch-point and other hazards, and it appears that no guards are removed or interlocks bypassed during maintenance or setup operations.

(Note that 10CFR1910.147, *The control of hazardous energy (lockout/tagout)*, provides that servicing and/or maintenance which takes place during normal production operations is covered by this standard only if (a) an employee is required to remove or bypass a guard or other safety device; or (b) an employee is required to place any part of his or her body into an area on a machine or piece of equipment where work is actually performed upon the material being processed (point of operation) or where an associated danger zone exists during a machine operating cycle. Minor tool changes and adjustments, and other minor servicing activities, which take place during normal production operations, are not covered by the OSHA standard if they are routine, repetitive, and integral to the use of the equipment for production, provided that the work is performed using alternative measures which provide effective protection.")

Horizon Book Binder BQ-240. This machine has a hot glue pot, and a powered shuttle device which is loaded by hand for each set of pages to be bound. There are two covers, only one of which is interlocked. There is a red emergency stop button, which is used routinely in the event of a jam. Setup adjustments are performed with the machine off, and "tweaked" with an open cover. There is a single operating button, not a two-hand control device. The machine may lie idle for up to two months, then be used two or three times in a month. Setup and operation exercise all the interlocks. The machine is connected to power through a plug-and-cord.

AB Dick Printing Press. The machine is plug-and-cord connected, and has a number of cylinder and roller pinch points. They are all protected by an elaborate system of interlocked open-wire guards (called "safety gates"), except for one area where paper is picked up and delivered into the machine. Maintenance and setup are as described above.

Komori Printing Press. The machine is similar to the AB Dick, except it is much larger. Power is supplied to this machine through a fused disconnect, which is appropriately labeled. Lockout/Tagout is only applied when the machine may be serviced by the manufacturer's representative. Otherwise, maintenance and setup are performed using red-handled and lighted buttons placed at the front and rear of the machine, allowing the operator to jog the mechanism. The system of interlocked guards is extensive, and coverage of moving parts is nearly complete except for the paper pickup point. The team observed that the stop buttons are depressed and twisted slightly to keep them in the off position, which is not the most reliable type of switch to assure the machine does not start. While use of these switches may be acceptable during minor adjustments, the team believes it would be hazardous to rely on these interlocks when it is necessary to go into the "guts" of the machine to repair/clean/replace some piece that goes beyond the term "adjustment." The function of the red buttons is also not clear: do they stop the machine from operating or do they remove power from the entire machine? The team believes that a Lockout/Tagout hazard analysis should be performed for the type of work to be performed within the machine.

Challenge 420 Paper Cutter. Some time ago a worker cut his finger while using this machine. As a result, P&GA added a safety shield in front of the blade, as an addition to guards which are factory-installed. The operating area in front of the machine is indicated by a red floor covering, and personnel are emphatic about no one being on the red area when the machine is in use. The machine is operated by a two-hand control. When it is necessary to change the blade, Neil removes a key from the machine's control panel and keeps it in his pocket. When major service is necessary, for the hydraulic system or for other reasons, P&GA calls in the manufacturer's mechanics and lockout/tagout is used at the fused disconnect switch.

Bell & Howell Inserter. This is an old machine with a lot of moving parts, used to stuff envelopes. It was factory-equipped with a crash bar, and P&GA had the manufacturer add a light-curtain interlock in front of the paper-handling mechanism. There are several stations in the machine, and each station is controlled by an individual toggle switch. In addition, the toggle switch panel has a separate switch for machine setup. P&GA personnel view this machine as the worst hazard in their area.

Xerox Docu Tech Copier. This nine-year old machine is the major work-horse of P&GA. A new front end and rear end will be installed this summer. The equipment access doors are interlocked, similar to any desktop printer. The machine is generally reliable, and any maintenance is performed by the manufacturer. Two P&GA operators have taken "Advanced Customer Training" by Xerox, so they can perform routine maintenance functions.

Xerox 2060 Color Copier. This machine is similar to the Docu Tech Copier, and runs about one-half the speed.

Physics Department		June 5, 2003
Site Personnel	Mike Zarcone	ES&H Coordinator
Survey Personnel	Joe Curtiss Al Borener, Jr.	Lab Electrical Safety Officer Electrical Safety Committee

The Physics Department is responsible for the RHIC Data Storage Silos in Bldg. 515, and the Accelerator Test Facility in Bldg. 820. They also operate small-scale experiments in the Physics Bldg. 510, in the Reactor Bldg 703, and small development facilities in the Atlas Bldg. 832.

Access to the RHIC Data Storage Silos in Bldg 515, is administratively limited to vendor-authorized StorageTek service personnel; all others must lockout/tagout all power to the silo.

The Accelerator Test Facility (ATF) is configured as described in a Safety Analysis Document. Administration of the accelerator was recently transferred from the NSLS to the Physics Department. The original NSLS designed-and-installed access control system is now maintained by the Collider-Accelerator interlock group. In addition to controls on the main level, the mezzanine supports two rf modulators containing hazardous voltages. The normally-locked modulator doors also operate interlocks. The ATF houses a high-power YAG laser and a high-power CO2 lasers, each in rooms with the doors interlocked with the laser. For all the above, status of the interlock system is displayed, there are reviews of the designs, configuration control is implemented, there are written and approved functional interlock test procedures, the interlocks are tested every six months, and records are maintained of the testing. Experimenters are required to take an ALF awareness training course, which includes a tour and explanation of the ALF systems. Control of all experiments is simpler than at the NSLS, since the facility does not operate around the clock. All experiments are reviewed.

The Physics Department operates a Rigaku Rotaflex Rotating Anode x-ray machine in two interconnected hutches in Bldg. 510, room 1-219. This unit is a commercial device that has been extensively altered and customized. The control system of this Radiation Generating Device (RGD) includes interlocked red lamps in each of the two hutches. In addition, there is a yellow rotating beacon to alert users that the system is in use. The interlock system is functionally tested every six months using a written, functional procedure. Only three persons typically use the device, although occasionally others may be trained to use it, and checking for successful test of the interlock system within the past six months is part of the procedure.

There is a smaller commercial bench-top Rigaku x-ray machine used in Bldg. 703; however, this machine does not require that the red lamp be monitored as part of its interlock system.

There is a new group within Physics that has a centrifuge, which has not been reviewed. There is an oven in Bldg. 832 which may contain interlocks; however the device is not in use and is currently in storage.

There is no equipment in the Physics Department machine shops that are equipped with interlocks. None of the smaller devices, like drill presses and sanders, have been equipped with Safe-Start modules to prevent starting upon restoration of power without manual action.

The Physics Department has no standby generators.

There is one electrically-powered portable lifting device in the Physics building, and one fork lift in Bldg. 832. The devices are all maintained by Plant Engineering, and all the operators are trained. There is an overhead crane in the ALF, which is maintained by Plant Engineering.

Building 510 has two roll-up doors without bottom-edge safety switches; however both doors require an operator to keep the control button depressed upon lowering the door. There are two roll-up doors at the ALF, Bldg. 820, one of which is currently broken and does not open; both are maintained by Plant Engineering.

Radiological Control Division		May 20, 2003
Site Personnel	Kay Conkling Paul Zahra George Hughes	ES&H Coordinator Calibration Manager Supervisor
Survey Personnel	Joe Curtiss Emil Zitvogel	Lab Electrical Safety Officer Electrical Safety Committee, Chair

The Radiological Control Division (RCD) periodically calibrates detectors used in personnel frisking and area surveys, and operates the Radiation Calibration Facility in Bldg. Xxx to support this activity.

Simple calibrations are performed in a Box Calibrator, a lead box containing two Cesium-137 sources totaling 180 Curies. The sources are secured with a padlock when the calibrator is not in use; the padlock key is in another box accessible only to trained, qualified operators. After removing the padlock, two hands are required to open the cover with one hand holding the button which operates a solenoid releasing a catch. When the device under calibration is inserted into the box, and the cover is closed, the radiation source is manually raised which disables the release solenoid circuit interlocking the box closed. The system is tested every six months using an written, functional test procedure, the testing is documented, and records of the tests are retained.

The Radiation Calibration Facility Annex (RCFA) provides a source of low-scatter radiation for neutron and photon calibrations. In the center of the irradiation chamber is a shielded box, a commercial device, that containing a number of different sources including Cs-137, Co-60, and Pu-238 Be. The irradiation room is searched prior to the sources being exposed while the interlock system electronically monitors the doors to ensure access control. The interlock system is redundant, hard-wired, and interlocked with the source. The control system uses a programmable logic controller (PLC) to enforce the search logic sequence. The control system incorporates crash buttons. The interlock system is tested every six months using a written, functional test procedure, which takes about a half-day to perform. Records are maintained of the interlock testing.

There is no standby generator at the Radiation Calibration building.

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Central Shops		June 4, 2003
Site Personnel	Tom Lambertson Jim Durnan Fred Wahlert	Central Shops Supervisor Facility Support Rep. Supervisor, Heavy Shop
Survey Personnel	Joe Curtiss John DiNicola Steve Waski, Jr. Pete Kelley Jerald Bond	Lab Electrical Safety Officer Electrical Safety Committee, Chair Electrical Safety Committee DOE DOE

Central Shops operates a large number of machine tools, some relatively simple and others very sophisticated including some equipped with computerized numerical control (CNC). Central Shops employs about twenty machinists, long-term employees of BNL who are not simply operators but tool and instrument makers. Central Shops also employs one CNC operator, who is a temp. Central Shops is not a production facility, and items they produce are generally one-of-a-kind or short-run. Most work consists of operations where the machinists must have access to the point of contact where the tool meets the work, and most machines in Central Shops do not have interlocks.

Central Shops stated they have a vertical turret lathe, two production lathes, and a vertical bridge mill in the Bldg. 479 “Heavy Shop” that have factory-equipped interlocks. They also have an x-ray machine with appropriate “Radiation Generating Device” (RGD) interlocks, including an interlocked red indicating lamp. A new off-the-shelf enclosure was recently purchased for the x-ray machine. Standard Operating Procedure 4.8.0, available on the Central Shops web site (<http://www.sc.bnl.gov>) addresses “Machine Tool Interlocks,”and contains the following text:

> Interlocks are installed on the doors of some machining centers produced today. The purpose of the interlock is to provide point of operation guarding and shielding from coolant spray and chips. This is usually accomplished by preventing the machine tool spindle from operating when the door is open. The most modern machine controls enable functionality of the machine tool with the door open when the control is in the setup mode. This mode allows the craft person to set up, observe and test the first part in a production run.
>
> Central Shops’ has 2 machines that do not have controls with a setup mode. Central Shops has installed a switch in the AWEA circuitry, and a mechanical door simulator on the CINTURN to allow this function. Many of the jobs in Central Shops are one off or short run. Use of the setup mode while performing setups and other functions is described in this SOP.
>
> Setup Mode can be used when setting up a machine, any operation where the craft person is required to put their hands into the machining area (example: deburring/polishing a part), first piece run etc. It is not to be used for production runs.

The ESTEC/Bullard vertical turret lathe is a numerically-controlled tool with doors that are locked during operation. A machinist must put a significant part of his body into the operating area of the machine to set the tool. The vendor provided a code that allows the machinist to jog the tool during setup. It is necessary to keep the button depressed in order to jog. An envelope on the machine's control station listed interlock inspection dates as 10/8/01, 8/27/02, and 4/22/03. The larger-than-six-month gaps were explained by the fact that the lathe is not used all the time, and the shop does not turn on the machine only to test interlocks. All required safety interlock tests had been performed and associated documentation and records were up-to-date and complete.

The Cincinnati CNC Lathe is a machine designed for production runs, and has an interlocked sliding door with a magnetic switch covering the tool point. A conventional padlock hasp has been mounted near the magnetic switch, and setup mode is entered by rotated the hasp on its hinge to position the flat surface on top of the magnetic switch. There is no indication on the machine of this function, and the assessment team suggested the hinge be highlighted (painted red?) and appropriately labeled. An envelope on the machine's control station listed interlock inspection dates as 2/21/02, 8/23/02, and 4/22/03. The larger-than-six-month gaps were explained by the fact that the lathe is not used all the time, and the shop does not turn on the machine only to test interlocks. The Cincinnati is currently out of service, is expensive to repair, and is not needed at this time. Central Shops noted that the machine cannot be placed in service unless testing of the interlock has occurred within six months of the machine being used.

The Wasino CNC Lathe is positioned directly opposite the Cincinnati so they share an operator workspace, and conditions are similar to the Cincinnati lath except that there is an actual toggle switch used to enter the setup mode. This machine has been tested semi-annually. All required safety interlock tests had been performed and associated documentation and records were up-to-date and complete.

The Awea Vertical Bridge Mill is large enough that a setup machinist must stand on the 240-inch movable bed to make adjustments. There is an interlocked sliding gate at the operator's station. All required safety interlock tests had been performed and associated documentation and records were up-to-date and complete.

Central Shops emphasized that setup mode is necessary to permit a machinist to examine and adjust the point-of-contact with the work, to set the tool with the spindle turning, for the first piece. This procedure depends for safety on the "skill of the craft" of their experienced staff, as opposed to production work for which the machines come equipped with interlocks. Central Shops has their own machine maintenance group, and employs a dedicated electrician.

As a good work practice, and to further ensure interlock test compliance, the assessment team suggested that a sign be posted on each machines stating "Do not use machine if interlocks have not successfully passed a test within past six months." Also, since test logs are maintained only at each machine and there is no "tickler file" indicating the need to re-test interlocks, the assessment team suggested that the machines be entered into Plant Engineering's PM program, which could then generate a tickler to test stop switches or "crash buttons" and interlocks, and the program would also keep a central record. (The team understands that ultimate responsibility to ensure tests are completed properly, in a timely manner, and

proper records are maintained, must remain with individual organizations, in this case with Central Shops.)

The HAAS Horizontal Machining Center (HMC) is a new machine installed in Bldg 478 during the summer of 2002. It was stated by Central Shops supervision that the U.S.-manufactured machine has no interlocks, however the team noted that the door of the tool changer, a closet-sized cage, is equipped with a switch which would disable the machine, and thus is an interlock. The team suggested that an Operational Readiness Evaluation (ORE) should be performed on significant additions to the Shop. Since the extent of having equipment installed without proper reviews is unknown, the team considers this to be a site-wide finding that goes beyond interlocks, and should include receipt inspection of equipment, etc.

There are a number of belt sanders and similar machinery in Bldg 479 that will restart upon restoration of power. The team suggested that they be retrofitted with safe-start devices.

Two trip-type metal brakes, and one hydraulic shear, are located in Bldg. 462. These are large pieces of machinery. Central Shops initiated a purchase order for installation of light curtain interlocks across the operating area of the machines, in compliance with current OSHA requirements. Central Shops reported that the high-bidder would have provided devices affording protection throughout the entire operating cycle, but the lab awarded the contract to the low bidder and the machines are only protected for one-half their cycle. Central Shops intended to use Activity Data Sheet (ADS) funding to correct the situation, but funding was subsequently removed and they were told to use their own “capital” money. When the assessment team visited the machines, all light curtains had been removed because the work in progress at each machine could not be done with the protective device in place. Central Shops pointed out that these machines are operated by very experienced, qualified personnel, and there has never been an accident on the brakes or shear. (Safety Awareness Day 2002 brought Bill Robbins to BNL, a very experienced, qualified person who never had an accident until the one in which he lost both arms.) While the team understands the need to remove the safety device, they pointed out that there need to be procedures for such actions, including appropriate reviews and sign-offs, and that these could be rapid and convenient. Removal of the interlocks on these machines is a non-compliance, and therefore a finding during this interlock self-assessment.

Central Shops has one forklift in each building, and three hydraulic pallet lifters. All operators (machinists, welders, sheet metal workers) were reported by Central Shops to be trained, with the practical examination administered by Training and Qualifications, although the team did not verify this. They have four motorized bridge cranes and one manual bridge crane in Bldg. 473, one unused crane in the Hot Shop, and a manual monorail crane in Bldg. 462. There are a number of motorized doors with interlock strips at the bottom. All these devices are maintained by Plant Engineering.

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Safeguards & Security Division		May 19, 2003
Site Personnel	Joe Musorrafiti Frank Raynor, Jr.	Technical/Physical Security Specialist "A" Electrician
Survey Personnel	Joe Curtiss John DiNicola Steve Waski, Jr. Al Boerner, Jr. Pete Kelley	Lab Electrical Safety Officer Electrical Safety Committee, Chair Electrical Safety Committee Electrical Safety Committee DOE

The High Flux Beam Reactor (Bldg 750) had two x-ray machines for use in examining packages at the Medical Reactor. When this program ended at BNL, one machine was given to another organization and the other to Safeguards and Security (S&S). This machine was installed in a room-sized container located at the southeast corner of Receiving, Building 100. Each day, officers in the BNL Protective Force operate the x-ray machine to examine random packages.

The x-ray machine is a "Radiation-Generating Device" requiring red lamps which annunciate that the device is active. Two such lamps are provided on the machine; one at the inlet port and one at the outlet. The lamps are interlocked with the machine, so that the machine will not operate if one or both lamps are not operating. The lamps are unplugged individually for testing the interlock system, along with tests on the emergency stop buttons located adjacent to each lamp and on the control panel. These tests are performed quarterly.

The team observed that the building has no label, and there is no green safety placard. A member of the assessment team visited the location on June 16, 2003, nearly a month later, and the green placard had still not been placed on the building.

Safeguards and Security also has a portable x-ray device. There are no interlocks on the unit, which is operated by setting a timer, pressing a start button, and leaving the area.

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Staff Services		May 19, 2003
Site Personnel	Ken Mohring Henry Hauptman	Division Manager, ES&H Coordinator Automotive Fleet Supervisor
Survey Personnel	Joe Curtiss John DiNicola Steve Waski, Jr. Al Boerner, Jr. Jerald Bond Pete Kelley	Lab Electrical Safety Officer Electrical Safety Committee, Chair Electrical Safety Committee Electrical Safety Committee DOE Area Office DOE Area Office

Staff Services is in charge of vehicles on site, and their maintenance.

Compressed Natural Gas (CNG) vehicles are refueled at the recently-constructed CNG Fueling Facility located on Brookhaven Avenue opposite the ballfield. The facility was constructed by Air & Gas Technology. Vehicles are fueled at two "pumps," one operating at 3000 psi and the other at 3600 psi. On the end of each refueling hose are interlocked mechanical fittings which are used to couple to the vehicles. The fittings must be made up to the vehicles or refueling cannot occur, and the fittings for the two different pressures are non-interchangeable. The facility is in Plant Engineering's Preventive Maintenance program. The facility has five crash buttons which are tested by Plant Engineering every three months, and a single methane detector which they test every six months. Pressure relief valves are removed and tested every five years. The assessment team accepted the statements and did not check any records.

Staff Services is also in charge of the commercial service station on site. There are identical vehicle lifts in three of the service station bays. They consist of an inverted "U" frame with columns on either side of the vehicle, with two rotatable arms on each column which are positioned under a car and then raised by a cable system. The frames are securely mounted six inches into 4000-lb concrete. During initial tests, the frames supported a 9000 lb load for one hour. Operation of a deadman device is required to lower a car, and each support column is fitted with a cog device so that the car will be locked at in place if a cable should snap. Each of the four lifting mechanism arms is fitted with a unique mechanical interlock, consisting of gear teeth located at the pivot point. A non-rotatable matching gear is supported above the gear on the arm, by a pin in contact with the floor. As the lift rises, the arm gear meshes with the fixed gear, which then rises along with the arm, thus preventing the arm from rotating if it is more than about two inches off the floor. Recently, the original square-cut non-rotatable gear was replaced with a similar gear having a rounded profile, which ensures that the gears will mesh. An outside contractor examines the lift devices every six months.

The BNL Garage on Brookhaven Avenue, just east of the Lab's main entrance, contains a single heavy-lift bay and four auto lift bays. All lifts are hydraulic and operate with environmentally-safe vegetable oil. One of the auto bays has two hydraulic cylinders, one on each side of the bay, with swing arms similar to the commercial garage. The three remaining auto bays have center-post lift systems, and the heavy lift bay has

two hydraulic cylinders, one for the front axle and one for the rear. All cylinders are equipped with mechanical interlocks consisting of a ratchet device which automatically engages and which will release only without load. An outside contractor examines the lift every six months.

BNL contracts with an outside vendor for the services of a Certified Lift Mechanic to examine the lifts, including "operation of positive stops and lift locks," in accordance with an ANSI standard prepared by the American Lift Institute (ALI). The lifts are examined every six months, in January and July. The contract and the bills for service that support that this work were examined by the assessment team; however, no written report of the service was provided to BNL.

The garage supervisor stated that there is a safety interlock at the gas pumps, which is maintained by an outside contractor. The assessment team did not pursue this issue or examine any records.

The BNL Garage has a standby generator, serviced by Plant Engineering, that is used to pump gas in an emergency.

Waste Management		May 20, 2003
Site Personnel	Doug Warren Warren Voegelin	ES&H Coordinator Maintenance Manager/Work Controls Coordinator
Survey Personnel	Joe Curtiss Emil Zitvogel Pete Kelley	Lab Electrical Safety Officer Electrical Safety Committee DOE Area Office

Waste Management operates several buildings along Fifth Avenue, all within a fenced complex. There are safety devices on the bottom edge of the overhead doors in Bldg. 810 (one door), Bldg. 855 (four doors), Bldg. 860 (four doors), Bldg. 865 (eight doors), and Bldg. 870 (three doors). In addition, there are safety devices on the motorized gate providing vehicle access to the complex. These doors and gates are routinely tested during Tier I inspections, and all of these devices are maintained by Plant Engineering. The assessment team did not examine any records regarding this issue.

There were safety interlocks on three devices which have since been removed from Waste Management. The devices included a shredder, a cutter, and a lead melter.

The single remaining programmatic machine in Waste Management which has safety interlocks, as reported to the assessment team, is the B-1000 Supercompaction System. Waste Management Division personnel and documents they provided for examination describe this device as consisting of a man-sized chamber with a front-loading door, above which are two vertically-mounted hydraulic cylinders which drive a ram into the closed compartment. The device was recently used to crush 55-gallon drums. The loading door to the chamber is equipped with door switches and a solenoid-operated pin which secures the doors closed during operation. Preventive maintenance, including testing operating controls and interlock switches, is performed by Plant Engineering, based on running hours. It is unclear whether or not Plant Engineering communicates to Waste Management that the maintenance and interlock system tests were performed, and the assessment team did not pursue checking records. There is no bar code on the compactor.

Regarding powered lift devices (PLD), Waste Management has the following forklift devices: one electric, two propane, one gas-powered barrel lifter, and one diesel. All operators take the classroom portion of BNL forklift training every three years. Warren Voegelin is a “designated examiner”for the practical portion of the training, both for forklifts and operation of overhead cranes. This was noted on Warren’s PLD card, as seen by the assessment team. Warren administers no practical exams unless the operator attended the class. This arrangement has been in place since 1996, and there have been no failures. Operation of the forklift is preceded by checks of the device, in accordance with training, except that the team understands that safety switches are not checked. Operation of the overhead cranes are preceded by following a checklist.

There is no standby generation at Waste Management.