No. 2.00

ACCELERATOR TEST FACILITY
SAFETY ASSESSMENT DOCUMENT

Revised October 22, 1999

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Safety Assessment Document

Approvals

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<u>Figures</u>

<u>Appendices</u>

1. INTRODUCTION AND DESCRIPTION OF THE FACILITY

The Accelerator Test Facility (ATF) comprises a 120 MeV electron linear accelerator and an experimental area to study advanced acceleration techniques and to carry out research involving free electron lasers and basic electrodynamics. The linear accelerator is housed in the low bay area of Building 820 as shown in Figure 1 and an experimental area building adjacent to Building 820 shown in Figure 4. Prior to operation of the ATF a Safety Assessment Report was prepared in 1989 and approved by DOE. This Safety Assessment Document (SAD) is a revision of the 1989 document and reflects recent changes in the location of the laser equipment as well as referring to more recent ES&H Standards. It is in compliance with DOE Order 420.2.

1.1 Description of the Facility

The general arrangement of the building shown in Figure 1 provides for an electron gun with a laser excited photocathode, a low energy (~ 5 MeV) beam transport and beam analysis system, two traveling wave linear accelerator sections and a high energy (120 MeV) beam transport and beam shaping system to provide beam appropriate for the experimental program. The experimental hall shown in Figure 4 also houses two of the three lasers for experimental purposes. The experimental area contains three separate beam lines for experimental purposes.

The schematic diagram (Figure 2) shows the system which is designed for the study of advanced accelerator techniques. The photocathode of the r.f. electron gun is illuminated by a 10psec laser pulse, one to three times per second, at a laser frequency close to the photoemission threshold ($\lambda \sim 0.25\mu$m) in order to minimize the transverse emittance. The very high radio frequency electric field strength (~100 MV/m) at the cathode allows us to maintain a very low emittance (~ 10^{-8} rad-m for a bunch charge of 3×10^9 electrons) at the 120 MeV output energy from the linear accelerator. The gun laser gates a high power CO_2 laser which, together with amplifiers to boost the pulsed output power level to 1 terawatt, may be used to excite a plasma to produce a very high accelerating field. The interaction space of the low emittance electron beam with the laser field is approximately 3 mm long and 100 μm in diameter. The light pulses of the two lasers are synchronized with the 2856 MHz r.f. for the electron gun and the accelerating section.

The output energy and spread of the output beam from this experiment is measured in a special spectrometer situated in the experimental building immediately downstream of the plasma accelerator. All of the equipment is carefully supported to minimize the effects of mechanical vibrations. A Life Safety Analysis of the ATF is given in Section 3.3 of this SAD and full descriptions of the laser systems including laser interlocks and search procedures are contained in the ATF Laser Systems Guides: Section 1.3 of the ATF Handbook.

1.2 Worker and Public Safety

In order to protect both workers and the general public, the accelerator and experimental systems are housed in a fully shielded and secured area with appropriate audible and visual signs. There are no exposed electrical systems at voltages greater than 24V and there is no release of radiation or toxic materials that can cause harm to workers or the general public. The high power lasers utilized are also contained in dually interlocked areas requiring key access and are not accessible to the general public. The electron beam is not a source of contamination. There are no routinely generated radiological disposables. However, some quantities of activated copper, aluminum and stainless steel shall be disposed of as part of a decommissioning plan. The total volume of such disposables would be <10 cubic feet.

2. SUMMARY/CONCLUSIONS

The shielding design together with the radiation security interlock search and secure procedures ensure that no personnel are exposed to any levels of radiation that would exceed the BNL untrained, unescorted personnel limit of 25 mrem/yr. due to the operation of the Accelerator Test Facility at the maximum operation levels given in Section 5 of this SAD in the case of a maximum credible accident.

Design and construction of electrical equipment ensures that no exposed high voltages are present anywhere in the facility. High voltage enclosures are either locked or fully interlocked. Normal policy prohibits "working hot" on electrical equipment and any deviation from this requires a permit and working hot procedure. Staff are trained in these policies and in Lock/Out Tag/Out procedures.

Non-hazardous fluids are used for cleaning purposes where possible and all chemical inventories are kept to a minimum. The ATF is not a hazardous waste generator. The building has been designed to conform with the National Fire Protection Association "Life Safety Code" No. 101 and DOE Order 420.1 Facility Safety 10/13/95.

The high power, pulsed, laser beams are contained in interlocked enclosures or rooms and are transported inside opaque beam tubes. Entry into laser areas requires the use of protective eyewear.

The entire facility may be operated at its full potential with minimal risk to the safety and health of staff, users or the general public.

3. SITE FACILITY AND OPERATIONS DESCRIPTION

3.1 Site Location

3.1.1 Introduction

The BNL Accelerator Test Facility (ATF) has been evaluated as mandated in DOE Order 5480.25 "Safety of Accelerator Facilities," against the criteria of DOE Order 6430.1A "General Design Criteria" regarding wind, flood, and earthquake design criteria. DOE Order 5480.28 ANatural Phenomena Hazards Mitigation" (NPH) and its associated standards were used as guidance for this evaluation. Details on site geography, seismology, meteorology, hydrology and demography are contained in "DOE Accelerator Order 5480.25 Implementation Plan for Brookhaven National Laboratory Natural Phenomena Hazards Evaluation" April 25, 1994 by Steve Hoey. It is the consensus of seismologists that no significant quakes are to be expected in the foreseeable future. The ATF Building is a pre-existing structure built in the early 1950's.

The ATF is considered Accelerator Safety Level Low Hazard Class and NPH Performance Class 2 as defined in DOE Order 5480.28. It does not contain significant quantities of radioactive or chemical materials. Should the NPH event cause significant damage the impact would be mission related and not present a hazard to the public.

An Accelerator Readiness Review (ARR) was performed prior to the operation of the Accelerator Test Facility in 1989.

3.1.2 Accelerator Test Facility Location

The ATF is a user facility for accelerator and beam physics. It is operated by the National Synchrotron Light Source and the Center of Accelerator Physics (CAP) to study advanced acceleration techniques and to carry out research involving free electron lasers and basic electrodynamics. This project makes use of a 120 MeV electron linear accelerator utilizing a radio frequency electron gun excited by a NdYag laser giving very short photon microbunches to provide a very bright source of electrons with total charge of 1 nanocoulomb per microbunch. The ATF is under the administrative control of the NSLS Department. The ATF is housed in the west side of Building 820, which was built in 1957; consisting of a steel exterior and frame; and housing a single story with a high-bay area.

3.2. Accelerator Systems Design

3.2.1 Introduction

The linear accelerator (Figures 1 and 2) comprises an electron gun, a low energy beam transport system, two traveling wave accelerator sections and a high energy beam transport and beam shaping system. The klystron amplifiers and cooling systems are situated in the low bay area adjacent to the accelerator components, while the klystron modulator and other power supplies and controls for the beam transport and beam monitoring equipment are situated on a mezzanine above the accelerator. The accelerator and transport system is enclosed in a lead and concrete, or borated polyethylene, shield of sufficient thickness to allow normal occupancy of the adjacent areas of Building 820. A 44" wide aisle is maintained between the mezzanine support columns and the bathrooms and equipment rooms on the west side of the low bay area. Shielded beam stops are provided for both electron gun and total linac operation in the accelerator tunnel in Building 820. The fenced off area next to the electron gun, the experimental hall, the CO_2 laser room (C1, C2) and the optical diagnostic room (C3) are radiologically Controlled Areas but not Radiation Areas.

3.2.2 Design Criteria

All of the accelerator and beam line components have been designed to conform with applicable guides, codes and standards. There are no deviations from DOE current design criteria. Any non-commercial equipment supplied to the ATF is reviewed by the ATF chief electrical or mechanical engineer as appropriate. The evaluation criteria are given in Section 2.06 of the ATF Handbook. A separate safety review of the Accelerator Test Facility mezzanine and jib crane has been carried out and is included as Section 2.08 of the ATF Handbook.

Section 2.04 of the ATF Handbook gives guidelines to be used in the design of electrical equipment which are within those given in BNL ES&H Standard 1.5.0 which conforms to applicable DOE standards.

The interlock system design and search procedures are given in Section 1.3.3 and 1.3.4 of the ATF Handbook. These systems are fully reviewed by NSLS and BNL committees prior to their implementation and are in compliance with ES&H Standard 1.5.3, "Interlocks."

Guidelines for Beam Line Review are provided in Section 2.10 of the ATF Handbook. Experimental Reviews are carried out by an NSLS Experiment Review Coordinator and are in compliance with NSLS SEAPPM 1.3.5a, "Experiment Safety Review."

3.3 Fire Hazard Analysis

3.3.1 Introduction

The purpose of this section is to evaluate the ATF fire protection in regard to compliance with DOE Order 420.1. A detailed "Life Safety Code Analysis" is contained in Appendix I and a Fire Assessment/Fire Analysis Report generated by the BNL fire protection personnel is given as Appendix II.

3.3.2 Summary

The Accelerator Test Facility is housed in the low bay area of Building 820 and in an experimental building attached to the north end of 820 (see Figures 1 and 4).

New building additions added for ATF use have been provided with smoke detection and sprinklers. A sprinkler main has been brought into the building from the street and automatic sprinkler protection is provided in the experimental building. The mezzanine which houses much of the ATF electrical equipment is located in the low bay area of Building 820 and it has been provided with automatic sprinkler protection.

The Fire Assessment/Fire Analysis Report recommendation for the installation of automatic sprinkler protection throughout the unprotected areas of 820 is beyond the scope of the National Synchrotron Light Source Department. However, the recommendation for the automatic sprinkler protection in Building 820 is being added to a proposed line item funded site-wide fire protection improvements project (Phase IV). This project would include the installation of sprinkler systems in the few remaining unprotected areas in Building 820 utilized for ATF operations.

3.3.3 Analysis

The overall occupancy classification of the ATF area of Building 820 for Life Safety Code (LSC) purpose is General Industrial. No high hazard operations are associated with the operation of the ATF in Building 820. The occupancy load is well below 100 sq. ft./person and the doors provide adequate means of egress. Stairs comply with the requirements of Class A or Class B stairs and egress paths are of the required width. Common paths of travel and dead-end corridors are within the maximum allowed. Travel distances to exits are also in compliance with LSC and all exits discharge directly to a public way.

Adequate emergency lighting is provided and the required means of egress are adequately marked.

The ATF area of Building 820 is protected with a combination of automatic sprinklers, fixed temperature/rate of rise heat detectors, smoke detectors and manual fire alarms. Alarms are arranged to annunciate; locally, at BNL Fire/Rescue Headquarters (Building 599), and at BNL Police Headquarters (Building 50)

3.4 Safety Organization

3.4.1 Introduction

From a management viewpoint, safety is represented at a high level at the ATF. One can see from the ATF organization chart (Figs. 3a & 3b) that the Project Director has direct line responsibility for the ATF Safety Program which is administered through the NSLS Department. A member of the ESH/Q Directorate works in liaison with the NSLS Department on safety related matters. The existing NSLS Safety Program serves as the umbrella for the ATF Safety Program. An Emergency Plan has been developed for the ATF together with training programs. The plan is Section 2.01 of the ATF Handbook and training details are given in Section 4.00

3.4.2 Project Safety Committee

The ATF program is administratively part of the NSLS Department and as such is reviewed by the NSLS Environment, Safety and Health Committee for the operation of the accelerator and the NSLS Beam Line Review Committee for experimental facilities. The review is carried out in the same way as the safety and beam line reviews for the NSLS.

The NSLS ES&H Committee consists of NSLS ES&H and professional staff as well as ESH/Q Directorate members representing Facility Support, Health Physics, and Emergency Services. Guidelines for the NSLS ES&H Committee are listed in NSLS SEAPPM NS 0.0.0.

The NSLS Beam Line Review Committee has been authorized by the NSLS Department Chairman to review the experimental equipment set-up. It includes members of the NSLS ES&H Committee as well as persons with vacuum and mechanical construction experience. Guidelines for Beam Line Review are in Section 2.10 of the ATF Handbook.

3.4.3 Laboratory Environmental Safety and Health (ES&H) Committee

Whenever policy changes not covered by this document or requiring a new SAD are made by the NSLS ES&H Committee they are brought to the Laboratory Environmental, Safety and Health Committee for their review and recommendation for approval by the Director's Office. The policies are not implemented until such a review has taken place and approval has been obtained. In addition to the BNL ES&H Committee Reviews, members of the ESH/Q Directorate act as advisors to the Department in any safety matters. The ESH/Q Facility Representative assists the Department in the implementation of the Laboratory Safety Program and also assists in training NSLS/ATF personnel in safety matters. Operational Readiness Reviews are conducted by a committee appointed by the ESH/Q Directorate prior to operation of the Facility or when there is a major change in equipment layout or operations which require a further review of this and other documentation.

3.4.4 Safety Training

For many of the training areas such as respiratory training, safe crane operation, materials handling and radiation dosimeter usage, the training will be given through the normal regularly scheduled Environment, Safety and Health Services training programs. However, there are a number of topics related to the Accelerator Test Facility which require separate training programs. Topics such as electrical and radiation safety, laser safety and radio frequency radiation safety require such special training. Written procedures for securing radiation areas and for the operation of high voltage equipment are provided and operations staff are trained to carry out these procedures. Laser training and procedures for securing laser areas also are provided for involved personnel. A local Building Area Safety Representative, listed in NSLS SEAPPM NS 0.0.0, has direct responsibility for bringing safety issues to the Safety Coordinator as outlined in NS 0.0.0. Building 820 is included in the regular NSLS Tier I Safety Tour program which covers each area at least every three months. ATF Training Programs and Requirements are given in Section 4.00 and Training course contents in Section 4.01 of the ATF Handbook. All users are required to view the NSLS Safety Video which is certified by ESH Services as equivalent to the GERT Training and read the "General Requirements and Objectives for Accelerator Test Facility Operations" Section 1.1.0 of the ATF Handbook.

3.5. Experimental Operations

3.5.1 Introduction

The experimental hall is divided into two separate regions, the fully interlocked laser equipment rooms and the radiologically controlled experimental area. The arrangement is shown in Figure 4. Detailed layout and shielding studies have been made, as described in Section 4.5.2, and reviewed by the NSLS and BNL ES&H Committees. The high power lasers used for experimental research are housed in the interlocked laser equipment area which is under controlled access as described in Section 4.5.3.2 of this report and in Section 1.3 of the ATF Handbook. This area is shielded from the experimental beam lines so that it may be occupied while the linear accelerator and experimental program are in full operational modes. There are two entry points to the laser equipment area, one through the door located on the east side, through a vestibule, and one from the experimental area on the northwest side of the laser equipment area. The dual interlocked personnel access door from the radiologically controlled experimental area is also used as an emergency exit from the laser area. There are three separate rooms in the laser equipment area. They house the CO_2 laser and the terawatt laser, both of which provide optical radiation for acceleration of electrons in experiments set up in the experimental area, and the FEL experimental room which is used to analyze the light produced by the various FEL experiments. The FEL is equivalent to a Class III(a) laser while the other two lasers are Class IV.

The radiologically controlled experimental area can be entered via a dual interlocked door at the south west corner of the experimental building or by the dual interlocked door from the FEL experiment room. A double entry door is provided for heavy equipment access to the experimental area and this is situated on the west side of the experimental building near to the north end of the building. This door has dual interlocks and no hardware on the outside so it is only available for emergency egress or equipment installation during maintenance periods. Three or more separate experiments may be set up in the experimental area, though only one can operate at any given time. The experimental area is a secured and interlocked radiation area not occupiable during beam operation. Laser interlocks for this area are a separate and independent system.

3.5.2 Experimental Area Operation Modes

Experiments are set up in one of the three beam lines shown in Figure 4. The beam line which first bends to the right after entering the experimental area is a relatively low current beam line operating at less than 10^8 electrons per second and ordinarily poses a relatively low radiation hazard.

The other two beam lines are utilized for high current experiments ($\geq 10^{10}$ electrons/second) and therefore pose more serious radiation hazards. However some experiments carried out on this beam line require a momentum analysis system that may require bending the beam towards the exit door labyrinth. This can give rise to gamma rays being produced by off energy electrons striking the beam pipe upstream of the shielded beam stop. All experiments (or modifications to experiments) are reviewed by the NSLS Beam Line Safety Committee and must be approved. In addition, each experiment (or modification of an experiment) is subject to a radiation survey carried out by a Radiological Control Division representative and ATF Operator. The survey includes fault conditions. If an experiment does not satisfy safe operating conditions at the complete perimeter of the Experiment Hall it is not allowed to run. Shielding calculations must be carried out, and appropriate shielding provided, to ensure that radiation levels outside of the shielded area are in compliance with BNL standards. The review requirements are contained in Section 2-10 of the ATF Handbook. Experimental reviews and approvals are in compliance with NSLS SEAPPM 1.3.5a "Experimental Safety Review."

3.5.3 Radiation Hazards

In 4.5.2 we have estimated that 5 x 10^{19} electron MeV per month will be delivered to the beam stops situated at the north end of the experimental area. This will give rise to copious numbers of bremsstrahlung from electrons stopped in the beam stops and thence photoneutrons requiring concrete shielding. Fault conditions cause the electrons to be lost at other places in the beam transport lines, particularly where bending occurs, so it is necessary to shield the beam lines as well as the beam stops in the experimental area. Lead collars situated at intervals along the beam line are used to stop electrons thus lost and the beam line area is enclosed in a 4 ft. thick concrete enclosure for neutron shielding similar to that used for shielding the linear accelerator sections as shown in Figure 6. Extra concrete shielding up to 6 ft. total thickness is provided for the beam stops. The concrete shield for the north side of the building is placed outside in order to minimize the floor area occupied by shielding. A 1.5 foot thick roof covers the entire experimental area up to the beam stops. Extra concrete shields are also placed above the experimental beam lines as required. During early beam tests and commissioning, area radiation monitors were provided near each operating beam line to monitor fault conditions. Remote read out radiation monitors are located at sites where accidental beam losses may occur and machine operators are trained and have written instructions on the actions required if unusual radiation levels are experienced and alarms are sounded. Figure 4 shows the typical plan layout of shielding in the Experimental Area. Section 4.5.2.2 gives details of the shielding provided for this area.

3.5.4 Electrical Safety

The electrical distribution systems for the Experimental Area and the Laser Equipment Room are similar to that described in Section 3.6.4 and conform to the same codes and conditions. Door interlocks and grounding sticks are provided as necessary.

3.6 Operations Process

3.6.1 Introduction

The accelerator system has a number of different operating modes but for the purposes of this document we will concern ourselves with the mode giving rise to the most serious radiation hazard. In this mode the electron gun is operated in a multipulse laser mode and includes "dark current" electrons, where the beam pulse length is essentially equal to the radio frequency pulse length of up to 3.5 μsec which is the maximum attainable from the hardware utilized in the modulator and klystron tank. Note that, due to the high radio frequency field gradients present in the electron gun, field emission occurs which gives rise to what are called "dark current" electrons. These are accelerated in all directions by the strong electric fields present in the gun and thus produce intense x-rays around the electron gun. If the accelerator sections are misphased with respect to the electron gun, or each other, most of the electrons accelerated from the cathode are lost at energies between 5 MeV and 120 MeV over the whole length of the linac accelerator section and/or the beam transport system. It is also possible to mis-steer the 5 MeV input beam so that essentially a point source at the 5 MeV energy impacts the collimator just before the entrance to the first accelerating section. The radiofrequency gun will accelerate these "dark current" electrons to ≈5 MeV for essentially 180° of each rf cycle and will operate at up to a maximum attainable rate of 6 pulses per second. This can, under some operating conditions, give up to 10^{12} electrons per second from the gun at an energy of 5 MeV and an energy spread of up to 500 keV. A large number, of the order 90%, of these "dark current" electrons will normally be lost in the transport system situated just upstream of the accelerating sections. Others will be lost due to the rf capture process so only 10^{11} electrons per second will be available for acceleration through the two nominally 50 MeV accelerating sections. During low energy operation the electron gun is operated on its own with the beam being stopped in the collimator which can also be used as a beam stop. A maximum power of 10 MW is available for gun operation. At this maximum power level an output energy of up to 7 MeV is possible, assuming that the gun cavity is able to withstand the voltage obtained at this power level. The gun shielding and slit shielding are designed for this eventuality.

Normally the gun is operated with a photocathode where the beam microstructure is better defined and in this mode of operation the beam losses are lower by one to two orders of magnitude over the above situation. However, with the maximum available 100 microbunches each with a charge of 1 nC, there would be 6 x 10^{11} electrons per macropulse or a total of 3.6 x 10^{12} electrons per second for operation at the maximum available repetition rate of 6 Hz. These photo electrons can also be stopped at the low energy collimator so we have conservatively designed the shielding there for 10^{13} electrons per second at a maximum energy of 7 MeV.

Most of the time the high energy beam (up to a maximum of 120 MeV) will be utilized for experiments carried out in one of the three available beam lines in the Experimental Area. The beam will be stopped after the Experimental Region in one of the fully shielded beam stops located at the end of the beamline in use. For tune up purposes and testing of accelerator components such as beam diagnostic equipment the beam may be stopped in a beam stop at the end of the straight ahead line housed in the shielded area of the Linac (see Figure 5). This is provided with the equivalent lead and concrete (and/or borated polyethylene) shielding as the beam stops at the end of the beamlines in the experimental area. A second fully shielded beam stop, after a bending magnet and defining slit in the line directed towards the Experimental Area, is used for tune-up purposes. It is possible to set up equipment in the Experimental Area and Experimental Laser Area while operating in these two modes.

3.6.2 Controlled Entry to the Experimental Area

Entry to the experimental area is via two doors, one at the south and one through the laser areas at the north end of Building 820. Interlocks are provided so that a doubly interlocked beam stop, situated in Building 820 in the transport line, near the junction of Building 820 and the experimental building, is secured in place before entry to the shielded region of the experimental area is allowed. There are common optical paths for the laser light utilized to excite the photocathode in the case of high and low current operation. The low current path includes fixed optical attenuators to limit the optical power so that operation at high current which could damage the experimental grating is not possible. The experimental laser area is separately interlocked and shielded from the experimental beam lines with a door from it to the experimental area having the same interlock provisions as the other door to this area. A double door, situated at the northwest corner of the experimental building which is normally for egress only during non-beam operation allows forklift access to the experimental building for the delivery of large equipment. This door is also dual electrically interlocked. A movable shielded plug door provided for neutron shielding made up of borated polyethylene blocks and situated inside the double entry doors is moved into position and secured in place before a search of the area and operations can commence. Securing this plug door is included in the search and secure procedure given in Section 4.5.3.1.2 of this document and is also described in Section 1.1.2 of the ATF Operations Guide.

The laser equipment area security system which allows controlled entry into the laser area, while both the electron and laser beams are in operation, is described in Section 4.5.3.2.1 of this document.

There are no special requirements with regard to general building entry since all radiation areas and laser operation areas are separately controlled. Since the building is shared by other BNL Departments, external doors have locks which are part of the Collider/Accelerator Department keying system (CA1).

3.6.3 Fire Hazard and Control

Building 820 is one of the older buildings on the BNL site; as such it does not contain a full building sprinkler system. Smoke and heat detectors are provided and there is an annunciator and signal system tied to the Site fire alarm system. Portable Halon 1211 fire extinguishers (UL rated 3A:80BC) are located throughout the ATF. The maximum travel distance to a fire extinguisher is 75 feet. Individual laboratories have their own fire extinguishers and smoke detection equipment.

The trailers, experimental area (experimental hall, terawatt & CO_2 laser rooms, FEL optical room - see Fig. 4) and the equipment mezzanine in Building 820 are provided with automatic sprinkler protection. Smoke detection is provided in the experimental area, the mezzanine, the Control Room, the offices, the machine room and the YAG laser area. All other areas of the ATF are provided with heat detectors. Exiting for fire emergencies complies with the Life Safety Code NFPA101, 1994 (see Section 3.3 of this SAD).

The total value of the equipment located in the control room will not exceed $250,000.00 and all of it could be replaced within a six month period. Backup magnetic tapes for the main operating system are stored in a metal file cabinet in another area of the building so the programmatic loss due to a fire would be minimal. Most of the high cost equipment in the ATF is directly associated with the accelerator itself, is made from copper, and is under a lead and concrete shield where it is protected from an external fire. The power equipment such as the modulator and power supplies for bending magnets, etc. are situated on the sprinklered mezzanine above the accelerators. The major cost items are the modulators and power supplies for the klystrons each of which cost $200,000.00. The two klystron amplifiers required for final operation were obtained from SLAC for shipping cost only and four replacement tubes are available.

Spares for the main components of these systems are available so they could be reconstructed over a 3 to 6 month period depending on the severity of any fire damage.

3.6.4 Electrical Safety Issues

The electrical power to operate the accelerator is distributed to the equipment at 208 or 480 volts, three phase, or 115 volts single phase, each with a separate ground connection. The installation of the distribution equipment is according to standard industrial practice for equipment of this type and conforms to applicable ANSI National Safety Codes and the National Electric Code. In order to prevent the electric shock hazard all control and instrumentation systems are well insulated, with dead front cabinets, and operate at voltages less than 24 volts rms. They are within guidelines set forth in ANSI Spec. #39.5 (Electrical and Electrical Measuring and Controlling Instrument Safety Requirements) and DOE/EV-0051/1 (Electrical Safety Criteria for Research and Development Activities). Voltages above this 24 volt rms level for both AC power distribution as well as DC and AC equipment are either lock or interlock protected or behind bolted panels and covers according to the serviceability of the equipment. The klystron modulator and power supply cabinet which houses high voltage equipment has the entry doors electrically interlocked so that the high voltage is turned off when the door is opened. In addition, grounding sticks are provided within this enclosure. Unauthorized entry into the experimental hall will cause the Linac modulator to be turned off via a dual electrical interlock with this door and will cause a beam stop to be inserted in the high energy beam transport line. All the main circuit breakers for the power distribution system have lock out capability. The ATF Electrical Standards are given in Section 2.04 of the ATF Handbook.

3.6.5 Occupational Health Issues

3.6.5.1 Non-ionizing Radiation

The klystrons which provide the radio frequency power for the accelerator utilize a permanent magnet (5 gauss @ 1.4 meters) for beam focusing and provide high radio frequency power at an operating frequency of 2856 MHz . This power is transmitted from the klystrons to the accelerating sections and electron gun via vacuum waveguide.

3.6.5.2 Laser Issues

High power lasers (Class IV) are utilized to irradiate the cathode of the radio frequency electron gun and to accelerate electrons in the Experimental Program. The laser beams are transported in enclosed pipes or inside interlocked enclosures for personnel protection.

3.7 Safety Design Procedures

3.7.1 Introduction

Worker safety is an integral part of the design process for the ATF equipment. Electrical, radiation (ionizing and non-ionizing) and general safety are considered and preventative measures such as interlocked enclosures with controlled entry and adequate shielding are provided.

3.7.2 Normal Building Access and Egress

Normal access to the buildings is from the north access road off Railroad Street. A large roll up door provides access to the high bay area of Building 820 and a fork lift is used to move equipment from the high bay to the low bay area. A platform off the existing mezzanine allows for transfer of light electrical equipment from a crane in the high bay area to the mezzanine. A small jib crane mounted on one of the vertical support columns for the high bay area allows the klystrons to be set in place. This crane installation has been reviewed by Plant Engineering and ESH/Q Directorate(see Section 2.08 of the ATF Handbook). There is also a jib crane in the Terawatt laser room. The jib cranes are inspected annually by PE and prior to each use by the operator as per ESH Standard 1.6.0 "Material Handling."

Personnel access to Building 820 is also available on the North, South and West walls of this building. Two stairways provide for personnel access to the mezzanine. Entrance to the new experimental building is provided by a door on the east side from outside the building, through a vestibule into the laser equipment room area. There is also a personnel entry door with a vestibule through the west side into the experimental area. A double door situated at the bottom of a ramp on the west wall at the north end allows fork lift access in order to place shielding blocks or large equipment in place before the final neutron shielding is completed in that area.

Figure 1 shows the equipment layout in Building 820 and Figure 4 the new experimental building. The floor plan and entries to the Experimental Building are shown there. In Building 820 an aisle at least 3'6" wide is provided along the west side of the linear accelerator adjacent to the existing pump room and equipment rooms. Egress is also available through the control room on the west side of Building 820. Nowhere in the ATF complex is a person more than 60 feet from an exit.

3.7.3 Radiation Shielding and ALARA

In the process of designing the radiation shielding described in Section 4.5.2 ALARA concepts were utilized so that as far as workers at the Accelerator Test Facility are concerned there is minimal risk of exposure to ionizing radiation.

3.7.4 Occupational Health Hazards

Both the klystrons powering the linear accelerator and the lasers used for gun excitation and the experimental program pose potential occupational health hazards which are considered in Section 4.3 of this document.

3.8 Worker Safety Controls

3.8.1 Introduction

Worker safety controls used at the Accelerator Test Facility include "fully" interlocked and controlled enclosures for radiation, laser and electrical safety as well as radiation monitoring and protective equipment.

3.8.2 Radiation Monitoring

Everyone working at the ATF is provided with a personal dosimeter that is collected and read monthly. In addition Area TLD's are located at appropriate locations around the facility, outside the shielded area. These are read and recorded on a bi-monthly basis and a data base is maintained. Also a number of "CHIPMUNK" radiation monitors are used where accidental or unusual operations conditions could give rise to some radiation. They are read out and alarmed locally and in the Control Room.

3.8.3 Occupational Health Controls

The klystrons which utilize permanent magnets developing fields of the order of 5 gauss at 1.4 meters are situated in an elevated location not normally accessible to workers or the general public. Warning signs are posted in the area of high magnetic field.

Safety goggles are provided for those workers who need to enter the interlocked laser areas in order to make adjustments while the lasers are operating. Eye examinations are required and only trained and authorized personnel may work in the laser areas.

4. SAFETY ANALYSIS

4.1 Radiation Safety Hazards

4.1.1 Prompt Radiation Hazards

Both the electron gun, when operated at its maximum energy, and the linear accelerator, are producers of copious numbers of bremsstrahlung. In addition, the "dark current" electrons also produce copious numbers of x-rays. Losses occur due to electron capture and/or equipment malfunction or missetting. The linear accelerator also gives rise to neutrons. Thus, we require both lead and concrete or borated polyethylene shielding to protect personnel from the radiation hazard. Normal electron losses will occur in the following locations and at the maximum energy and charge levels given below, for two modes of operation, i.e. for gun operation only and for full linac operation.

A. Operating Electron Gun Only

Under certain operating conditions of the electron gun**,** up to 100 μA of peak current electrons are produced as "dark current" by field emission from all surfaces of the electron gun where high electric field gradients are present. Some fraction of these electrons are accelerated axially, in the forward direction up to the maximum energy of the electron gun (~ 7 MeV) for a fraction of each rf cycle during the 3 μsec rf pulse. They are also accelerated in the reverse direction, to lower than maximum energy (~ 3 MeV) during the reverse part of each rf cycle. These "dark current" electrons produce copious amounts of x-rays around the electron gun region and require lead shielding.

In addition, at 100 microbunch operation at 1nC per microbunch from a photocathode including "dark current" electrons, potential losses occur at the following locations:

1. At a collimator/faraday cup situated before the linear accelerator sections, $\approx 3.6 \times 10^{12}$ electrons per second of up to 7 MeV energy. This is essentially a point source.
2. Missetting of the transport line solenoid magnets or trim dipoles. This would give rise to a loss of beam over a line source downstream of the mis-set device which would result in an estimated electron loss of up to 2×10^{12} electrons per second over a length of ≈ 50 cm at an energy of up to 7 MeV.

B. Full Linac Operation at up to 1 nanocoulomb per 100 microbunches in 6 macropulses per second can give rise to losses at the following locations.

1. The above potential loss modes are also included in this mode of operation.
2. During the capture process of electrons in the first accelerating section, electrons may be lost along the length of both accelerator sections and at the first bend magnet of the high energy beam transport system**;** 10^{12} electrons per second at energies between 7 MeV and 120 MeV
3. In the high energy beam transport momentum selection system or after any mis-set bending magnet in this line, up to 10^{12} electrons per second of energies between 7 MeV and 120 MeV may be lost**.**
4. At final beam stops in the experimental hall, 3.6×10^{12} electrons/sec at 120 MeV energy are stopped.5. At the Linac beamstop.

Clearly the worst case conditions are at the low energy collimator or other point sources of loss in the low energy beam transport system, where 4.6×10^{12} electrons per second from both dark current and photo current electrons can be lost at an energy of 7 MeV, and in the high energy beam transport system where a point source loss of 10^{12} electrons per second of 120 MeV electrons are possible. All beam stops are provided with extra local shielding and therefore do not represent a worst case hazard.

4.1.2 Activation Hazards

During normal operation, no air activation of any sort will occur since;

(a) The beam is not exposed to air.

(b) No ozone is produced.

(c) No radionucleides are produced.

Most of the electron losses occur during the capture process in the first accelerating section, at energies below 15 MeV, which is the typical threshold energy for activation by electrons. Thus, the only possibility for air activation is in the case of a failure of a magnet power supply causing the high energy (>15 MeV) electron beam to exit through the vacuum chamber, or activation of the electron beam dump. We calculate below the activation products for these situations.

Even without forced ventilation a complete air change usually occurs a few times per hour. Therefore, it is not possible to reach saturation levels for ^{3}H or ^{7}Be or approach the Derived Air Concentration (DAC) values for these isotopes and the only nuclides that need be considered for air activation are ^{13}N and ^{15}O. Saturation activities for these nuclides are 14000 and 1500 $\mu Ci m^{-1}$ kW^{-1} respectively where m is the path length for bremsstrahlung in air in meters and the kW applies to the electron beam power. Note that γ-rays are mainly responsible for the air activation since the cross sections for electrons are much lower. In our case, two factors help to minimize air activation; first, we place lead close to the accelerator section or beam pipe where accidental electron losses and hence γ production occurs and second, most of our electron losses will normally occur at energies below 7 MeV where activation is not a problem. If we assume, conservatively, that 10% of our electron beam losses occur at energies >7 MeV and that the air gap between the accelerator and the lead shielding is 5 cm, then the electron beam power is 8 watts and the saturation activities for ^{13}N and ^{15}O are 5.6 μCi and 0.6 μCi, respectively. For a room volume of 400 x 10^6 ml this will give a total air activation of 1.55 x 10^{-8} μCi/ml which is 0.4% of the DAC value of 4 x 10^{-6} μCi/ml. In practice the beam loss will be detected by the remote read out radiation monitors located at sites where beam loss is likely to occur and the duty operator will take action to correct the fault in this accidental loss mode so saturation activities will not be attained.

All of the accelerator sections and beam line components are water cooled by closed loop, low conductivity water systems, each of which utilizes a small makeup water tank. In no case will the electron beam strike the water pipe directly, so water activation can only occur due to bremsstrahlung produced when electrons strike the copper discs of the accelerating structure or the stainless steel or aluminum beam pipe. Again, for normal operation, electron losses will occur at or near the injection energy so the γ-ray flux will be relatively low making activation of the machine components and the cooling water negligible. This is consistent with the observed results on the 120 MeV electron linac for the NSLS which operates at about the same average beam current as the ATF linac and where the only activation that can be measured is in the momentum defining slits in the transport line where more than 50% of the electron beam is stopped. Levels of a few mR/hr can be measured at this location immediately after turning off the electron beam.

Activation of a copper beam stop utilized to stop the full electron beam are calculated from data in the report by W.P. Swanson. For 100 microbunches, 1nC/bunch at 6 pps, 120 MeV electron beam (average power 72 watts) we obtain saturation activities for Cu-61, Cu-62 and Cu-64 of 0.06, 1.08 and 0.36 Ci. This will give rise to a radiation field of 600 mR/hr at 1 m from the target immediately on beam turn-off without shielding and assuming no self shielding in the target. After about 1 hr this would decay to about 15 mR/hr. A lead shield around the target will readily reduce the radiation levels to acceptable values.

Under normal operation the electron beam does not pass through air so there is no possibility for ozone production. For the accidental case described above we calculate that without any air change we would reach a saturation level of 0.005 ppm for 8 hrs. This is well below the ACGIH TLV for static fields of:

- Heavy Work 0.05 ppm
- Moderate Work 0.08 ppm
- Light Work 0.10 ppm
- Heavy, Moderate, or Light Work ≤ (2 hours) 0.20 ppm

A NESHAPS permit has been issued for ATF operations but is not applicable (see Appendix III). The application was made for the air activation values given above and was based on the maximum capability of the accelerator in terms of its maximum output and worst case condition for passage through air. It is therefore unlikely, if not impossible, to exceed the permitted limits. In the unlikely event that these limits are exceeded, the proper notifications will be made as specified in the approval letter from the EPA dated October 19, 1989.

4.2 Electrical Hazards

In addition to the normal electric shock hazards present in the operation of electrical equipment operating off the building electrical distribution service at 115 volts single phase, there are a number of systems at the ATF that operate off 208 or 480 volts three phase. All cabinets housing these voltages are either secured by bolts or screws that can only be accessed internally, interlocked or covered with appropriate insulating material. The high pulse voltages up to 40 KV found in the modulators driving the klystron amplifiers which provide the radio frequency power to drive the linear accelerator are all contained in cabinets with interlocked doors and automatic grounding of the high voltage, both mechanically and electrically, when an entry door is opened. In addition grounding sticks are available to manually ground the high voltage points within the modular enclosure prior to working on the system.

All ATF controls and instrumentation systems are well insulated with dead front cabinets and operate at voltages less than 24V rms.

Warning signs indicating high voltage hazards are posted.

4.3. Occupational Health Hazards

4.3.1 Non-ionizing Radiation Hazard

The radio frequency system for the linear accelerator utilizes two 25 MW peak power klystrons operating at a frequency of 2856 MHz. All of the high power rf is contained within the vacuum waveguide or accelerating cavities and poses no health hazard.

Magnetic fields of the order of 5 gauss at 1.4 meters developed by a large permanent magnet used for focusing the electron beam in the klystron and 5 gauss @ 0.2 meters by electromagnets used to bend the electron beam from the gun into the linear accelerator will be present. Signs warning of this hazard are posted near the klystron magnets and on the entry doors to the linear accelerator area where the electromagnets are housed..

4.3.2 Laser Hazard

A 3 mJoule per pulse, with up to 300 pulses per second, 1 GW peak power, NdYag, laser used to excite the electron gun cathode is also a potential hazard. However, stability and timing requirements necessitate the laser light being enclosed in a vacuum pipe with temperature control for the normal operational mode. There may be times during setup when the light will not be enclosed and at these times only trained laser users wearing protective clothing and eyewear may be inside the special interlocked enclosures used to contain the laser light. This is effectively a Class IV laser as defined in Section 2.3.1 of the BNL ES&H Standard and is operated as required by that guide and as described in the ATF Laser Systems Guide, Section 1.3 of the ATF Handbook. Similar precautions are taken for the CO_2 laser, also a Class IV laser, used for the Experimental Program and also the light from the FEL experiments which is equivalent to a Class IIIa laser. There is a pulsed, high terawatt power laser which will be used to accelerate electrons in specially designed accelerator devices housed in the

Experimental Area. It poses laser hazards similar to the Nd:YAG system and is treated in the same way.

4.4 Accident Assessments

4.4.1 Accident Assessment for the Linear Accelerator Systems

Extremely high levels of radiation, mainly in the form of bremsstrahlung and neutrons exist inside the linac shield so the potential for a serious radiation accident exists if the shielding is removed. Warning signs and a search procedure prior to start up will preclude any accident due to radiation. In order to assure shielding configuration control the moving of any shielding material must be reviewed and documented by the NSLS Safety Officer using the "Permit for Work on NSLS Injector Storage Ring Safety Systems."

There is also the potential for an accident due to electric shock. Preparation for this eventuality includes regular electrical safety training and training in the BNL ES&H Standard #1.5.1 (Lock-out/Tag-out) for all electronic technicians and others working with high voltage. Detailed training requirements are given in Section 4.0 of the ATF Handbook. The equipment is designed with the appropriate interlocks to prevent the electric shock happening. LOTO is the policy at NSLS and any working hot is not permitted unless covered by a "hot work permit." Specific LOTO procedures are given in Section 2.02 of this Handbook. Detailed layout and shielding studies have been made and reviewed by the NSLS ES&H Committee. The shielding configuration for the entire accelerator housed in Building 820 low bay area is shown in Figures 5 and 6.

4.4.2 Accident Assessment for the Experimental Area

The electron beam striking any part of the beam pipe or lead shield in the beam line system produces very high levels of bremsstrahlung and neutrons. The protection systems described above are designed to prevent personnel from exposure to these levels. For an accident to occur, all of the following systems or procedures must fail.

1. The operations personnel would have to fail to carry out the prescribed search procedures.

2. The dual electrical interlocks on the entry door which automatically turn off power to the linac r.f. and magnet systems must have failed.

3. The dual electrical interlock that is activated when any entry door is opened and which automatically inserts the transport line beam stop must have failed..

All of the above procedures rely upon a proper search being carried out by the operations personnel. The only backup to this are the emergency off buttons which exist in all potential radiation areas and which will inhibit beam operation and revoke the interlock state.

4.4.3 Risk Assessment

ATF Risk Assessments have been carried out and are presented below:

SAD RISK ASSESSMENT

FACILITY: Accelerator Test Facility
SYSTEM: Electrical distribution system and electrical equipment
HAZARD: Possible contact with high voltage

Hazard Impact: Possible loss of life or serious injury to personnel

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Risk Assessment prior to mitigation:

Severity : I (x) Catastrophic II ( ) Critical III ( ) Marginal IV ( ) Negligible
Probability : A( ) Frequent B( ) Probable C(x)Occasional D( ) Remote
E( )Extremely Remote F( ) Impossible
Risk Category: I(x) High Risk II( ) Moderate III( ) Low Risk IV( ) Routine

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Mitigating Factors: All power supplies are protected with physical barriers wherever there is a possibility of exposure to voltages exceeding 24 volts. In situations where extremely high voltages are present, such as the klystron modulators, door interlocks and automatic and manual grounding is provided. Working hot is discouraged and requires special training and approved procedures. High voltage and, or high current equipment is only accessed using BNL standard Lock-out Tag-out procedures. All affected personnel are trained to follow these procedures.

Risk Level following mitigation:

Severity : I(x) Catastrophic II( ) Critical III( ) Marginal IV ( ) Negligible
Probability : A( ) Frequent B( ) Probable C( ) Occasional D( ) Remote
E(x) Extremely Remote F( ) Impossible
Risk Category : I( ) High Risk II( ) Moderate III(x) Low Risk IV( ) Routine

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SAD RISK ASSESSMENT

FACILITY: Accelerator Test Facility
SYSTEM: Accelerator, Beam Transport and Experimental Area
HAZARD: Fire

Hazard Impact: Possible threat to personnel safety or equipment loss

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Risk Assessment prior to mitigation:

Severity : I ( ) Catastrophic II ( ) Critical III (x) Marginal IV ( ) Negligible
Probability : A( ) Frequent B( ) Probable C( ) Occasional D(x) Remote
E( )Extremely Remote F( ) Impossible
Risk Category: I( ) High Risk II( ) Moderate III(x) Low Risk IV( ) Routine

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Mitigating Factors: Most of the equipment associated with the accelerator and beam transport systems is metallic and is under a lead shield where it is somewhat protected from an external fire. Smoke and heat detectors are provided in all areas and there is an annunciator and signal system tied to the Site fire alarm system. Portable CO_2 and Halon 1211 fire extinguishers (UL rated 3A:ABC) are located throughout the area. The maximum travel distance to a fire extinguisher is 75 ft.

The Experimental Area is protected by a sprinkler system as well as having smoke and heat detectors.

All ATF personnel are trained in BNL Emergency Response Procedures.

Risk Level following mitigation:

Severity : I( ) Catastrophic II( ) Critical III(x) Marginal IV ( ) Negligible
Probability : A( ) Frequent B( ) Probable C( ) Occasional D( ) Remote
E(x) Extremely Remote F( ) Impossible
Risk Category : I( ) High Risk II( ) Moderate III( ) Low Risk IV(x) Routine

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SAD RISK ASSESSMENT

FACILITY: Accelerator Test Facility
SYSTEM: Control Room
HAZARD: Fire

Hazard Impact: Possible threat to personnel safety, equipment loss and program downtime.

Risk Assessment prior to mitigation:

Severity : I ( ) Catastrophic II ( ) Critical III (x) Marginal IV ( ) Negligible
Probability : A( ) Frequent B( ) Probable C( ) Occasional D(x) Remote
E( )Extremely Remote F( ) Impossible
Risk Category: I( ) High Risk II( ) Moderate III(x) Low Risk IV( ) Routine

---

Mitigating Factors: Smoke and heat detectors are situated in the Control Room and adjacent areas. Activation of any fire detection sensor automatically sounds local alarms and transmits an alarm to the BNL Fire and Rescue Group. Portable CO_2 and Halon fire extinguishers are located in the Control Room and adjacent area. There are two exits fromthe Control Room.

The total value of equipment situated in the Control Room Does not exceed $250,000 and all of it could be replaced within a six month period.

All ATF personnel are trained in BNL Emergency Response Procedures.

Risk Level following mitigation:

Severity : I( ) Catastrophic II( ) Critical III(x) Marginal IV ( ) Negligible
Probability : A( ) Frequent B( ) Probable C( ) Occasional D( ) Remote
E(x) Extremely Remote F( ) Impossible
Risk Category : I( ) High Risk II( ) Moderate III( ) Low Risk IV(x) Routine

---

SAD RISK ASSESSMENT

FACILITY: Accelerator Test Facility
SYSTEM: Laser Equipment Areas
HAZARD: Personnel exposure to radiation from Class IV lasers

Hazard Impact: Eye or skin exposure to laser light

Risk Assessment prior to mitigation:

Severity : I ( ) Catastrophic II (x) Critical III ( ) Marginal IV ( ) Negligible
Probability : A( ) Frequent B( ) Probable C(x) Occasional D( ) Remote
E( )Extremely Remote F( ) Impossible
Risk Category: I( ) High Risk II(x) Moderate III() Low Risk IV( ) Routine

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Mitigating Factors: All personnel entering or working in laser equipment areas are required to wear protective eyewear. They are also protected from accidental exposure to laser radiation by transmitting the laser beams inside opaque enclosures and by providing interlocked areas to house the lasers. The laser safety and access control system is designed to be failsafe. Unauthorized entry into these secured areas will automatically cause a beam stop to block the beam so that the hazard is removed.

All laser operators undergo "Laser Safety Awareness" training and undergo an eye exam. As part of their training and certification, all personnel at the ATF must demonstrate an understanding of the procedures.

Risk Level following mitigation:

Severity : I( ) Catastrophic II(x) Critical III() Marginal IV ( ) Negligible
Probability : A( ) Frequent B( ) Probable C( ) Occasional D() Remote
E(x) Extremely Remote F( ) Impossible
Risk Category : I( ) High Risk II( ) Moderate III( ) Low Risk IV(x) Routine

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SAD RISK ASSESSMENT

FACILITY: Accelerator Test Facility
SYSTEM: Electrical equipment, Laboratories and Laser Systems
HAZARD: Fire

Hazard Impact: Possible threat to personnel safety, equipment loss and program downtime.

Risk Assessment prior to mitigation:

Severity : I ( ) Catastrophic II ( ) Critical III(x) Marginal IV ( ) Negligible
Probability : A( ) Frequent B( ) Probable C( ) Occasional D(x) Remote
E( )Extremely Remote F( ) Impossible
Risk Category: I( ) High Risk II( ) Moderate III(x) Low Risk IV( ) Routine

---

Mitigating Factors: The trailers, the gun laser area and the equipment mezzanine are provided with smoke detection and also fire protection via a sprinkler system. Portable CO_2 and Halon 1211 fire extinguishers (UL rated 3A:ABC) are located throughout the area and the maximum travel distance to a fire extinguisher is 75 ft.

Gun and Linac modulators have been equipped with crash buttons to remove all sources of electrical power. Microphones are located inside each modulator cabinet and connected to the ATF PA systems to alert personnel to capacitor failures.

All ATF personnel are trained in BNL Emergency Response Procedures.

Exiting for fire emergencies is in compliance with the Life Safety Code NFPA101, 1994.

Activation of any fire detection sensor or alarm automatically sounds local alarms and transmits an alarm to the BNL Fire and Rescue Group.

Risk Level following mitigation:

Severity : I( ) Catastrophic II( ) Critical III(x) Marginal IV ( ) Negligible
Probability : A( ) Frequent B( ) Probable C( ) Occasional D( ) Remote
E(x) Extremely Remote F( ) Impossible
Risk Category : I( ) High Risk II( ) Moderate III( ) Low Risk IV(x) Routin

4.5. Worker Safety Controls

4.5.1 Introduction

All of the safety hazards at the Accelerator Test Facility are treated in essentially similar ways with regard to personal safety barriers such as shielding for radiation hazards and covered closed areas for electrical or laser safety. Entry to radiation or laser areas is controlled by locks, interlocks and securing procedures.

4.5.2 Radiation Shielding

4.5.2.1 Gun, Linac and Transport Line Shielding

Here we are concerned with the problem of shielding to attenuate radiation produced by any of the loss modes described in Section 4.1.1 above. The shielding is designed to stop electrons and the resulting bremsstrahlung and x-rays in lead and then to absorb the neutrons thus produced in concrete or equivalent shielding. We estimate the shielding requirements for worst case operation modes. Figure 5 shows the lead and concrete shielding for the linear accelerator and beam transport areas, and Figure 6 a cross-section of the linac and shielding.

We assume that the Linac testing and alignment operation with "dark current" and photo electrons will be carried out for 100 hours per month in a combination of the modes described in section 4.3.1. However, monitoring of radiation levels and magnet currents should preclude operation at some of these loss levels for long periods of time. Faults which create unusual radiation loss will be detected by Chipmunk radiation monitors which are located at sites where such losses may occur. These are read out and alarmed in the Control Room and machine operators are given written instructions and are trained to take actions appropriate to the level recorded by these monitors. High loss levels will result in the beam being turned off while the reason for that loss is determined. Thus accidental losses will not be sustained for more than a few minutes. For shielding calculations these accidental losses may be neglected when compared with normal operational losses detailed below.

For normal operation of 250 hours per month at the low energy end, losses of 1.3×10^{19} electron-MeV/ month occur at the collimator in the low energy transport line just upstream of the accelerating sections at an energy of up to 7 MeV. This assumes conservatively that 20% of the electrons are stopped at the collimator with the rest passing through it to be accelerated to higher energies. In addition, an estimated 10^{16} electron-MeV/month of electron losses occur in the electron gun itself, due to "dark current" electrons, at energies up to 7 MeV. This requires shielding of the electron gun region as well as the transport line slit region. Losses of up to 5×10^{19} electron-MeV/month also occur at the beam dumps in the experimental hall assuming 50% of the operating time, or 100 hours per month is at the maximum energy and charge.

The "dark current" electrons which are emitted from all copper surfaces of the electron gun where fields in excess of 50 MV/m to 100MV/m are present, produce x-rays when they strike the walls of the gun cavity. Since these electrons have energy < 7 MeV they are stopped by the copper walls and produce x-rays locally. The electrons are accelerated in all directions by the electromagnetic fields in the radio frequency cavity of the electron gun and receive energy gains which vary from 0 to 7 MeV. The 7 MeV electrons are only obtained by synchronous acceleration from the cathode surface at which they are emitted by field emission, across the 1.5 cells of the electron gun essentially along, or parallel to, the gun axis. Electrons are also produced at the exit aperture by field emissions there and they are accelerated towards the cathode, though not synchronously, thus gaining energies of up to about 3 MeV, again essentially along or parallel to the gun axis in this reverse direction. These reverse electrons are stopped by the copper cathode and a large Pb plug.

The electrons which travel synchronously along or near the axis will exit from the gun in the normal way, will be focused by the beam transport solenoids and are measured on the collimator faraday cup used to measure the normal electron beam. The measured peak "dark current" at 4.2 MeV/c in a test on the facility was 8 μA for 1 μsec. These forward electrons are only a small fraction of the beam of electrons which are accelerated from the photocathode which suffer from the same, or similar, loss modes. Shielding for the normal electron current will, therefore, take care of any "dark current" electrons emitted in the forward direction. "Dark current" electrons traveling in all other directions will, however, require proper shielding.

We assume that up to 8 μA peak "dark current" electrons are accelerated towards the cathode to an average energy of 3 MeV for a period of 1 μsec, 6 times per second and calculate the x-rays produced and shielding required for this case. According to NCRP Report No. 51 the shielding transmission ratio for x-rays produced by these electrons is given by:

$$B_x = 1.67 \times 10^{-5} \left[\frac{H_M d^2}{D_{1o} T} \right]$$

where D_{lo} is the absorbed dose index rate (rads m^2 min^{-1}) at a standard reference distance of 1 m from the source. H_m is the maximum permissible dose-equivalent or dose limit rate (mremh^{-1}), d is the distance between the X-Ray source and the reference point (meters), T is the occupancy factor. If we assume conservatively 2000 hrs/year of gun operation and a 20% occupancy factor for the gun area we need to reduce the dose rate limit to 0.25 mremh^{-1} in order to obtain the 100 mrem per year dose limit for nonradiation workers as well as meeting the BNL administrative dose limit of 25 mrem/year for non-radiation workers. Substituting these values in the above equation gives $B_x = 2 \times 10^{-3}$ for a lead shield starting 15 cm and ending 30 cm from the source. This would require 5" of lead in the forward direction. X-Ray radiation in the sideways (90° direction) is down by a factor of 4 compared to the (0°) case so 4" of lead is sufficient in that direction. In practice, only a small fraction of the "dark current" electrons reach the full 3 MeV energy at the cathode and the shield distance from the cathode is 30 cm rather than the 15 cm for the sideways (90°) direction so 4" of lead is an adequate shield in all directions.

The neutron yield per unit beam power, mainly arising from giant resonance neutrons, is nearly independent of electron energy at energies above 20 MeV and is taken from the calculations of W.P. Swanson (Health Physics 37 (1979) pages 347-358) as 2.1×10^{12} neutron/k Joule for the full Linac operational loss mode. For 7 MeV operation we are below the threshold for neutron production so no neutrons are produced. For the experimental hall beam dump:

$$\phi = \frac{5 \times 10^{19} \dfrac{MeV}{month} \times \dfrac{12\ month}{year} \times 2.1 \times 10^{12} \dfrac{neutrons}{kJoule} \times 1.6 \times 10^{-16} \dfrac{kJoule}{MeV}}{4\pi (200cm)^2}$$

$$= 4x\,10^{11}\ neutron/\ cm^2\ year$$

We will assume that ordinary concrete is used to shield the neutrons thus produced and use the formulation of NCRP Report #51 to calculate the shielding thickness required to reduce the dose level at normally occupied areas of Building 820 and the Experimental Hall to 100 mRem per year. To reach this number a conversion factor of 2.5 x 10^{-13} rem cm^2 must be applied to the fluence at the Linac beam stops. This gives a value of 350 g/cm^2 or 148 cm of concrete for the beam stop regions. The appropriate shielding is provided for these areas as described in Section 4.5.2.2 of this document and the procedure for securing the Linear Accelerator Area is in Section 4.5.3.1.2.

4.5.2.2 Beam Transport Lines and Experimental Area

4.5.2.2.1 Introduction

An overview of the neutron, bremsstrahlung and x-ray shielding for the Accelerator Test Facility is given in Section 4.5.2. This section expands on that information giving details of lead and concrete shielding configurations for the experimental hall and the linac transport area of Building 820. Source terms and shielding calculations are also presented.

4.5.2.2.2. Operating Parameters

The linear accelerator is approved to operate at energies up to 120 MeV with a maximum pulse repetition frequency of 6 Hz and a maximum charge of 1.0 nC in each of 100 microbunches contained in a 3.5 μsec macrobunch. Therefore, the maximum number of electrons accelerated to 120 MeV is 3.6 x 10^{12} per second. Under normal operating conditions, almost all of these electrons reach the beam dumps situated in the experimental hall or at the end of the transport lines in the Building 820 high energy beam transport region (see Figures 1 and 2). Under certain conditions, some beam is lost at points along the beam line, such as near quadrupoles, or dipole bending magnets, or at collimators utilized to clean up the tails of the electron beam. We shall assume that up to 5% of the electron beam is lost at a single point in any of the above locations in any part of the beam transport system and calculate the shielding required to reduce the radiation levels to less than 100 mrem for the year. We shall further assume that the facility operates for 2400 hours per year with 1200 hours of operation at levels where the radiation levels are insignificant, i.e. less than 10^7 electrons per second accelerated to full energy.

4.5.2.2.3. Shielding Estimates

The primary lead shielding is for bremsstrahlung γ-rays produced by electrons striking the stainless steel of the beam transport pipe or the copper of the linac structure. Lead shields are placed at locations where such electron losses may occur. In essence, the primary γ-ray source is the lead shield itself since the energetic electrons easily pass through the beam pipe with little loss in energy.

The 2" to 4" thick lead shield also gives rise to the production of photo neutrons which are then shielded by concrete enclosures around the lead. Any γ-rays which pass through the primary lead shield are readily stopped in this concrete shield wall so we will concentrate on the neutron shielding calculations.

The calculations presented in the Section 4.5.2.1 for the beam stops in the experimental area, and in the linac tunnel in Building 820, estimated that, after the electrons were stopped there, for the above operating conditions, slightly less than 5 ft. of ordinary concrete is required to reduce the levels outside the shield to 100 mrem per year. If 5% of the beam can be lost at any point along the transport line this requires 3.5 ft. of ordinary concrete to reduce the radiation levels outside the shield to 100 mrem/year. In the beam transport area of Building 820, there is a mezzanine above this line which contains accelerator equipment. The shield above this line must also be 3 2 ft. thick. In the experimental hall, the roof thickness must be sufficient to handle "skyshine" so we will use the methods presented in NCRP Report #51 to calculate the required shielding. (Here, we assume that the beam stops in this area are shielded by a full five foot of ordinary concrete or equivalent in all directions.)

4.5.2.2.4 Shielding for Skyshine of Neutrons

If we assume a steady 5% beam loss near a quadrupole or dipole bending magnet in either of the high current transport lines utilized for FEL or IFEL studies in the experimental area, and assume that this electron loss occurs in the lead shield, we can obtain the total neutron yield from Appendix F.3 of NCRP Report #51 as 2 x 10^{11} neutrons sec^{-1} μA^{-1}. The total number of electrons lost per second is 5% of 3.60 x 10^{12} or 1.8 x 10^{11} which is equivalent to an electron current of 1.8 x 10^{11} / 6x10^{12}, or approximately 3 x 10^{-2} μA. Then the neutron yield for all directions is Y = 2 x 10^{9} neutrons per second.

From Appendix F.4 we obtain the neutron fluence rate is $\varphi = Y_{sr-1} \times 10^{-4} / d^2$ where d is the distance from the source in meters. Also from F.4 we see that $Y_{sr-1,90}/Y_{sr-1,0} = 2$ so we obtain the neutron fluence φ_o at 90° as:

$$\phi_o = \frac{2x2x\,10^9\,x\,10^{-4}}{4\pi\, d^2}\ neutrons\ m^2\, cm^{-2}\sec^{-1}$$

Since the experimental area roof is 1.4 m above the beam line, or source of neutrons, this gives φ_o = 1.6 x 10^4 neutrons m^2 cm^{-2} sec^{-1}.

Section 4.5.2 gives the roof shielding neutron transmission ratio, B_{ns}, for skyshine up to 20m from the source as:

$$B_{ns} = 3.3\ x\ 10^{-3}\left[\frac{\dot{H}_M\, d_i^2}{\phi_o \Omega}\right]$$

Where $\dot{H}_m$ is the maximum allowable dose rate limit in $mremhr^{-1}$ and d_i is the distance between the source and 2 meters above the roof shield, Ω is the solid angle in steradians subtended by the neutron source and the shielding walls. We shall conservatively assume this angle to be 2π so that for $\dot{H}_m$ =100 mrem/1200 hrs we obtain:

$$B_{ns} = 3.3 \times 10^{-3} \left[\frac{\frac{100}{1200}(3.5)^2}{2 \times 10^4 \, 2\pi} \right] = 2.7 \times 10^{-8} \, rem \, cm^2$$

If we apply this to Appendix F.8 we obtain a concrete slab thickness of 50 gcm^{-2} or 22 cm of concrete. These shielding thicknesses for neutrons are more than adequate shielding for γ-rays which are primarily shielded by the lead near the beam line. For structural purposes the roof concrete thickness provided for the Experimental Area is 1.25 ft. or greater.

4.5.2.2.5 Entry Mazes

In order to enter the experimental area it is necessary to pass through a maze. Both the laser equipment area and the entrance foyer adjacent to the entrance from the Control Room area are considered to be controlled areas, while the experimental area is a high radiation area. The nearest source of neutrons in the experimental area to either exit aperture is about 3 meters so the neutron fluence rate at the maze inner aperture is less than 10^3 neutrons cm^{-2} sec^{-1}. Both mazes are double legged and have a width of 3 ft. and a height of 7.5 ft. Section 4.4.2 gives the neutron transmission ratio through ducts, B_{nm}, as:

$$B_{nm} \leq \frac{270 \, \dot{H}_m}{K \, \phi_m} \quad where \; \dot{H}_m \; is \leq 5 \; mrem/hr.$$

and where K = 8 for a two-legged maze. Thus for our case, we obtain:

$$B_{nm} \leq \frac{270 \times 5}{8 \times 10^3} \quad i.e. \; B_{nm} \leq 0.17$$

From Appendix F.11 we obtain a center line distance of $2\sqrt{3x7.5}$ or 9 ft. in order to provide acceptable levels at the entry doors to the experimental area.

4.5.2.2.6 Shielding Design and Equipment Access

4.5.2.2.6.1 High Energy Beam Transport in Building 820

The shielding layout for the linac and low energy beam transport systems is given in Section 4.5.2.1 The shielding for the high energy beam transport system is shown in Figures 1, 5 and 6. In order to align the transport elements with the shielding in place, it is necessary to provide a narrow accessway alongside the beam lines which is entered by removing a plug door situated under the stairs to the equipment mezzanine. This plug door is on rollers with a winch and cable arrangement for opening it. The door is electrically interlocked so that the rf system modulator cannot be turned on while the door is removed unless two independent interlock circuits which interrupt the modulator power supply are satisfied. It can be seen from Figs. 1, 5 and 6 that local lead shielding is provided near quadrupole and dipole magnets and around collimating slits. At least 3.5 ft. of light concrete or heavy concrete equivalent is provided as required by Section 3 of this document and 5 ft. equivalent thickness is provided for the two beam stops as calculated Section 4.5.2.1.

Because the accessway is potentially a high radiation area, a search and secure procedure and emergency stop buttons are provided for this area (see ATF Handbook Section 1.1.2). Regular and emergency lighting and a telephone extension (x3875) have been provided for the accessway.

4.5.2.2.6.2 Experimental Hall Shielding

The shielding for this area is shown in Figure 4. Local lead γ-ray shielding is provided near quadrupole and dipole bending magnets and beam line collimators. A minimum of 3.5 ft. of concrete or equivalent is provided in the forward, backward and sideways directions for all loss points. A roof thickness of 1.25 ft. or greater of concrete is provided over the whole experimental area and entry mazes of greater than 9 ft. in length are provided at both entry points. All entry doors have dual safety interlocks. A search and secure procedure is described in Section 1.1.2 of the ATF Handbook.

Sprinklers, emergency and regular lighting and air conditioning are provided for this area. Beam stop shielding is provided as detailed in Section 4.5.2.1. The beam stops are entirely in vacuum so no air activation from primary electrons is possible.

4.5.3 Accelerator Interlocks and Security

4.5.3.1 Radiation Security

4.5.3.1.1 Securing the Linac Gun Area

Since the electron gun area is a controlled area and has the potential of becoming a high radiation area if certain lead shielding is removed, it is a fenced and locked area. Removal of lead requires a safety permit, a copy of which is given as Appendix IV. The entry door to the gun laser hutch is electrically interlocked so that entry to this area causes the laser shutter to be inserted, thus turning off the Nd:YAG laser beam and hence the laser induced electron beam.

The gun laser hutch is secured using one of the procedures described in the ATF Lasers Systems Guide, Section 1.4 of the ATF Handbook. Completion of the search culminates by depressing of a button on a control box adjacent to the last exit door either inside or outside the gun hutch. If anyone for any reason wishes to stop operation of the laser they may do so by depressing any of a number of emergency stop buttons situated at convenient and clearly marked locations at the laser hutch, the Nd:YAG hutch and in the experimental area. The hutch door is provided with standard door hardware to allow for fast exit in an emergency.

If the gun hutch entry door is opened while the search is being carried out, the search is aborted and has to be restarted. Entry to the gun laser hutch only, does not require another search of the fenced area around the electron gun.

4.5.3.1.2 Securing the Experimental Area

Since this is a primary radiation area it is protected by stopping the electron beam in either a fixed or movable beam stop situated in the high energy beam transport line just at the conjunction of Building 820 and the new experimental building (see Fig. 5). Any attempt to enter the experimental area will cause the movable beam stop to be inserted and will also automatically turn off the contactor providing power to the klystron modulators. Dual electrical interlocks are provided on both the electron beam stop and the entry doors to the experimental area. Each electrical circuit operates an independent set of power contactors in the supplies to the modulators. One of the electrical circuits also inserts a beam stop situated downstream of the linac.

Before startup of the accelerator a search is made of the experimental area. In order to insure a proper search, reset buttons are provided which require the person carrying out the search to cover all regions of the experimental area. These have to be reset in a prescribed sequence, and in a prescribed time. The person carrying out the search exits through the entry door situated at the northeast corner of the experimental area. After exiting and locking the door, a reset button must be pressed which sets off an annunciator in the experimental area which sounds for 15 seconds. If anyone for any reason wishes to stop operation they may do so by depressing any of a number of emergency stop buttons situated at convenient and clearly marked locations within both the Linac and experimental buildings. Both entry doors are interlocked and keyed in the same way and both are provided with an emergency panic release system to allow fast exit in an emergency. If either of the entry doors is opened while the search procedure is in progress the search is automatically aborted and has to be restarted. The detailed procedure for securing the ATF Experimental Area is given in Section 1.1.2 of the ATF Handbook.

In order to carry out beam studies in the straight ahead or 20 degree beam line by stopping the beam within the existing building it is necessary to insert the movable beam stop. Entry to this area is via a dual electrically interlocked movable concrete door. Section 1.1.2 of the ATF operations manual describes the procedures for entering and securing this area. When the movable beam stop is inserted and the plug door is in place with the interlock complete it is possible to operate the modular and low energy beam transport systems in order to carry out beam diagnostic studies at >5 MeV while the experimental area is open. The procedures given in Section 1.1.2 of this Manual must be followed in order to operate in this Mode. All ATF Radiation Interlock Systems have been reviewed and approved by the BNL Interlock Review Committee (see the ATF Interlock Manual).

4.5.3.2 Securing the Laser Equipment Rooms

The lasers housed in the laser equipment rooms are classified as Class IIIa or Class IV lasers as per ANSI Z136.1. Therefore, all entry doors to the laser equipment rooms are electrically interlocked so that an unauthorized entry will cause a beam stop to be inserted in the laser beam path. Section 1.3 of the ATF Laser Systems Guide describes the procedure for securing the laser system. In addition, persons working in this area are required to wear protective eyewear whenever the lasers are capable of emission. They are also required to undergo training as specified in Sections 4.00 and 4.01 of the ATF Handbook. Furthermore, the beam path is enclosed, with interlocks being provided for the enclosures. The ATF Handbook Laser Systems Guide gives an overall description of the lasers to be used in the experimental program at the ATF and Section 1.3 of this Guide gives search patterns and procedures for securing the Laser areas.

5. ACCELERATOR SAFETY ENVELOPE

Section 5 of this SAD has been superceded by the Accelerator Test Facility, Accelerator Safety Envelope dated 08/08/2001 and approved by DOE-BAO-09/25/2001.

5.1 Electron Gun

The electron gun shielding has been designed to allow for operation at up to 7 MeV energy with a total charge of 1 nC per bunch in a total of 100 microbunches per 3.5 μsec macropulse at a repetition rate of 6 Hz. These shall be considered the operational limits for electron gun operation.

All of the required equipment such as modulators, klystrons, magnet power supplies or laser systems are capable of operating at these levels without violating any design limits.

The shielding designs presented in Section 4 above allow for operation at these maximum achievable levels of operation and for a maximum credible accident without exceeding the control level of 25 mrem to any personnel.

5.2 Accelerating Sections

The allowable operating limits for beam energy and power are 120 MeV and 3.6 MW respectively.

Shielding calculations for the accelerator tunnel and the Experimental Area are based on the maximum energy capability with the electron gun operating at the maximum levels given in Section 5.1 above. This, therefore, is the Operational Safety Limit for accelerating section operation.

Note: On January 24, 1995, the DOE Area Office gave permission for “Operation of the Accelerator Test Facility (ATF) up to 120MeV,” see Appendix III.

5.3 Safety Controls

The interlock systems used for radiation protection shall be tested every six months using the test procedures described in Section 1.1.3 of the ATF Handbook. The laser interlocks shall be tested every 6 months by using the test procedure described in Section 1.3.5 of the ATF Handbook.

The high voltage electrical interlocks shall be tested every 6 months using the ATF test procedure for electrical interlocks. Shielding shall be utilized to achieve an annual exposure level to personnel of no greater than 100 mrem in a year.

5.4 Staffing and Training

Only trained personnel are permitted to operate the accelerator or run an experiment at the Accelerator Test Facility. Each experiment has a person assigned to it who has direct responsibility for safe operation of the equipment involved. An operations log is maintained by machine operations staff and is kept in the Control Room at all times. Keys to important security areas are under the control of the operator and are in a locked key-box in the Control Room. At all times during operations at least one person qualified as per the ATF Handbook shall be present.

Detailed training requirements are given in Section 4 of the ATF Handbook. Operations staffing and responsibilities are given in Section 1.1.0 of the ATF Handbook AGeneral Requirements and Objectives for ATF Operations." Key personnel with their responsibilities are listed below:

5.4.1 Accelerator Operator

The Accelerator Operator, who is one of the engineers or technicians responsible for the design and/or construction of the ATF, has overall responsibility for machine operation. He/she is responsible for carrying out all operations procedures and check lists (though trained laser operators may also conduct laser procedures). The Accelerator Operator has singular responsibility for control of the master key at all times and maintains operations, key and other operation log books.

5.4.2 Laser Operator

The Laser Operator is responsible for all laser local operations and for demonstrating proper laser conditions at the electron gun photo-cathode and at the experiment in progress. This person may carry out search and secure procedures in the gun hutch, laser rooms or experimental area. The persons assigned this responsibility are skilled in the design and operation of high power laser systems.

5.4.3 Lead Experimenter

The Lead Experimenter is a knowledgeable accelerator or beam physicist who is responsible for the safe conduct of an ATF experiment. It is this person's responsibility to ensure that only trained authorized users are involved in work in the Experimental Area.

5.4.4 Experimental Operator

The Experimental Operator is generally a graduate student familiar with the experiment currently under study and trained in the safe operation of the experiment and in Experimental Area Radiation and Laser Security Checks.

This person may adjust beam energy, intensity, and profile using the ATF computer system either in the Control Room or in a remote location such as the FEL Room. He/she may work on experimental equipment on which he/she is trained and knowledgeable.

An Experimental Operator may not work on accelerator equipment such as modulators, klystrons, magnet power supplies, etc. Only persons trained on that equipment may work on it. However, Experimental Operators may turn off such equipment at the end of an Experimental shift or an emergency and are trained for this eventuality.

5.5 Exceeding Safety Envelope Limits

Permission to exceed ASE limits must be obtained through review and approval of written plans by the NSLS and BNL ES&H Committees as well at DOE prior to exceeding operational or administrative limits. If any limits are exceeded without prior approval, these must be documented through the Occurrence Reporting System, and reported to the appropriate BNL and DOE/BHG offices. DOE authorization to recommence operations will then be required. Appropriate ATF/NSLS staff and management will review each incident in a timely manner, and introduce corrective actions so as to prevent future occurrences.

6. QUALITY ASSURANCE

The ATF project is part of the National Synchrotron Light Source (NSLS). The NSLS Quality Assurance Program applies to the work performed on the project. The ATF management is responsible for the quality of construction, the operation of the equipment and the work processes in the facility. Responsibility for quality is delegated through the line staff positions and they are responsible for the quality of their own work. ATF accelerator components are evaluated for quality assurance categories A-1 through A-4 as per BNL QAC-301. The ATF shall comply with the required QA elements of DOE Order 414.1.

7. DECOMMISSIONING AND DECONTAMINATION PLAN

At the appropriate time a full decommissioning and decontamination plan will be developed based on the requirements outlined in the AChecklist for a Decommissioning Plan@ contained in NSLS SEAPPM 1.3.0 AFacility Design and New Program Review.@

8. ASSOCIATED DOCUMENTATION

1. BNL Environment, Safety & Health Standards.
2. BNL Operations Manual
3. BNL Quality Assurance Manual
4. BNL Implementation Plan for DOE Accelerator Order 5480.25.
5. NSLS Safety and Environmental Administrative Policies and Procedures Manual
6. NSLS Quality Assurance Manual

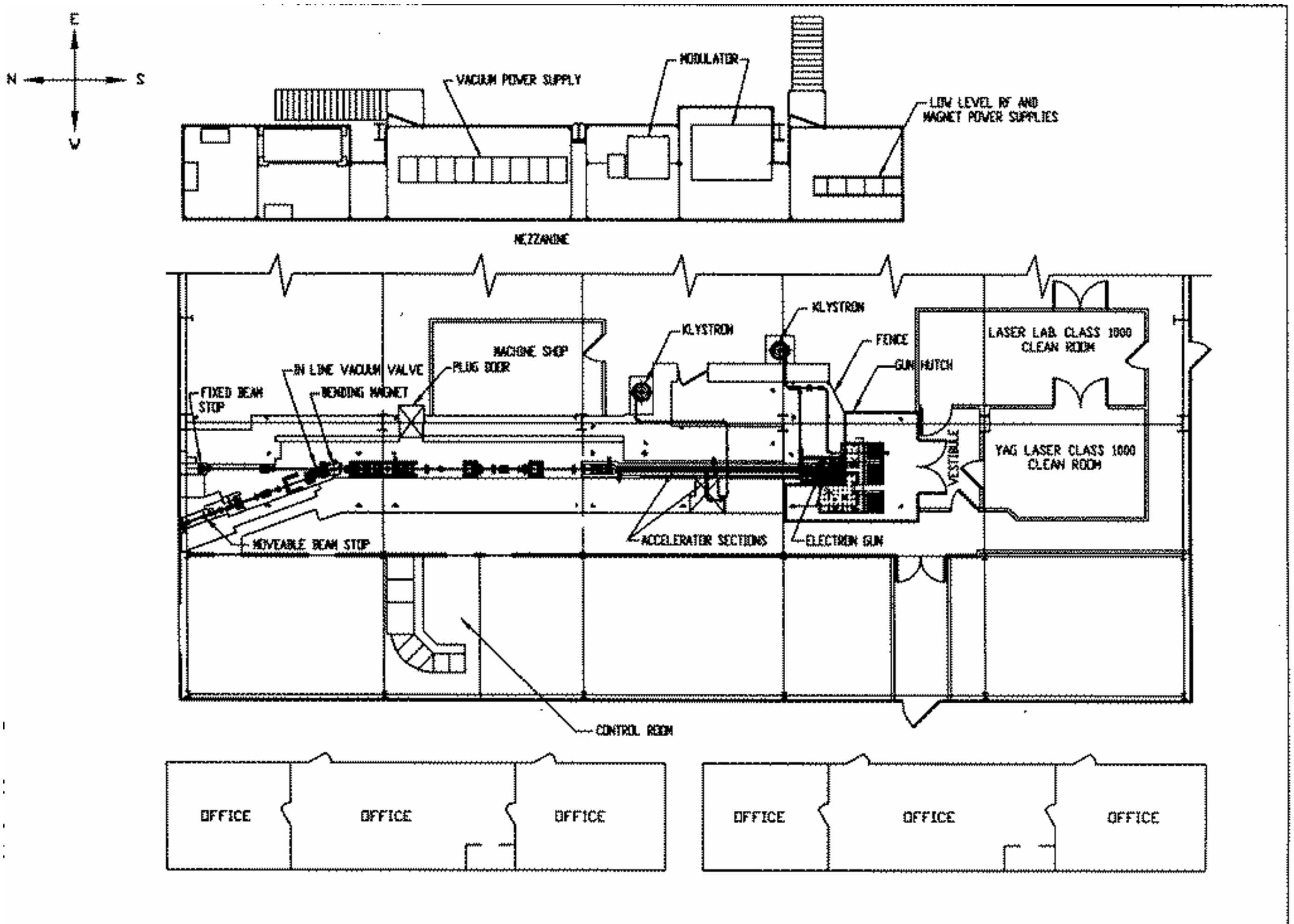

FIGURE 1
ACCELERATOR TEST FACILITY LAYOUT/ BUILDING 820

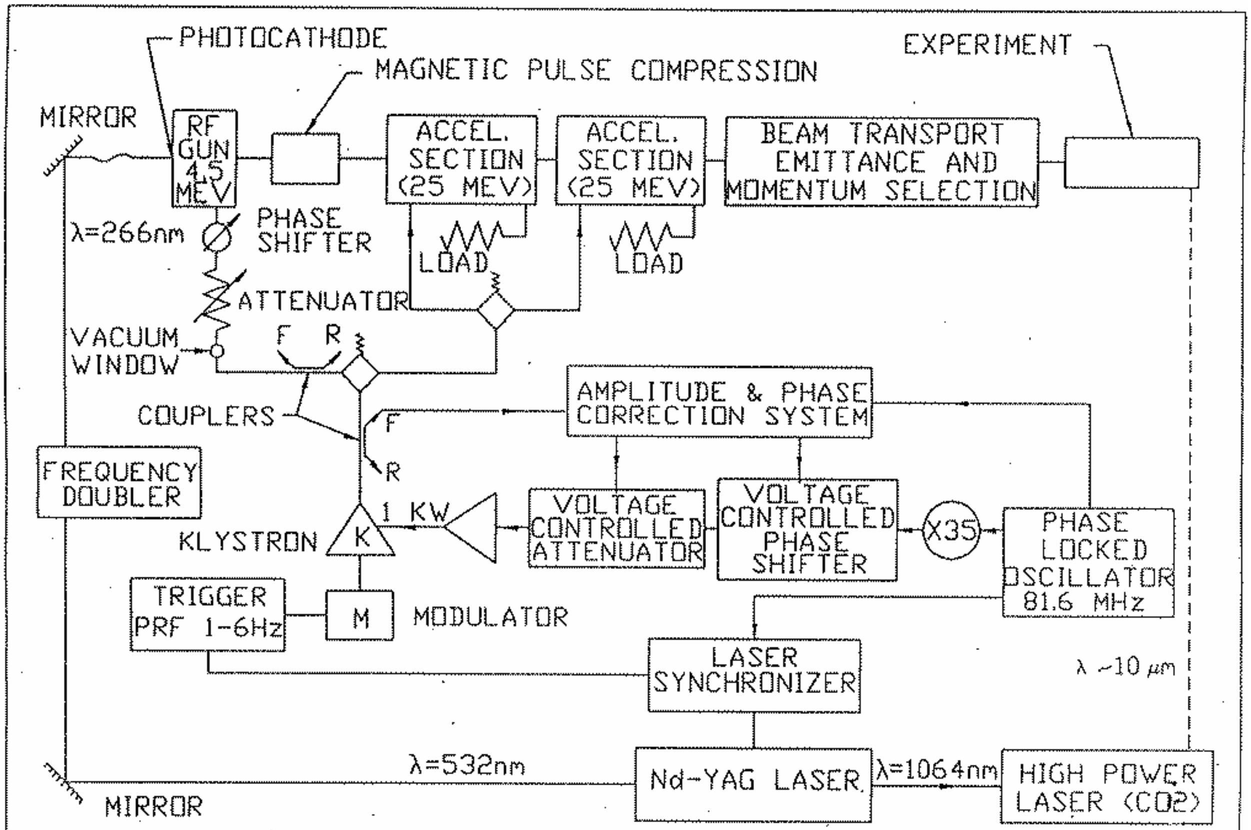

FIGURE 2
SCHEMATIC DIAGRAM OF
ACCELERATOR TEST FACILITY

Figure 3a: ATF Organization Chart

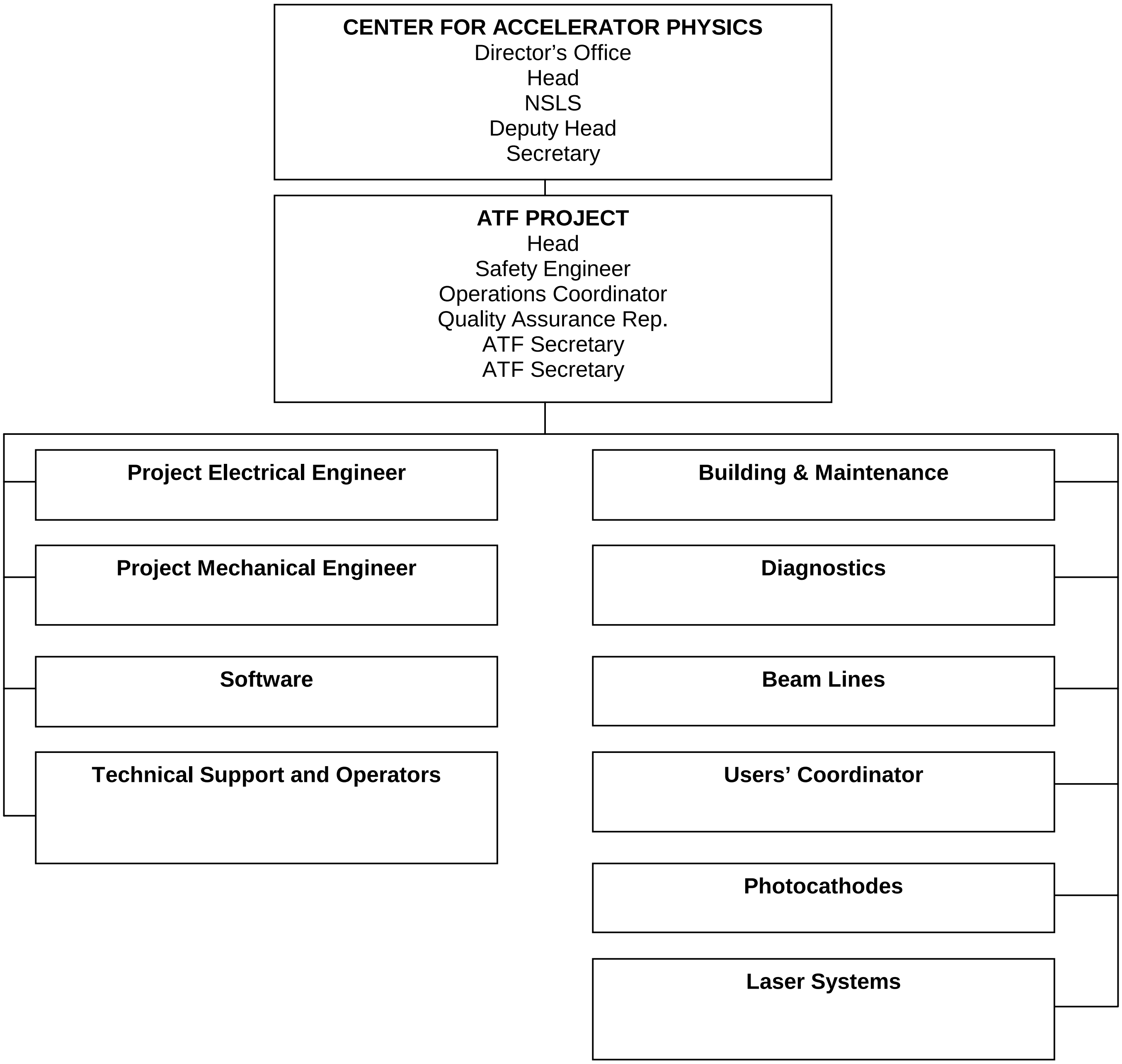

Figure 3b: Safety Organization Chart
Accelerator Test Facility

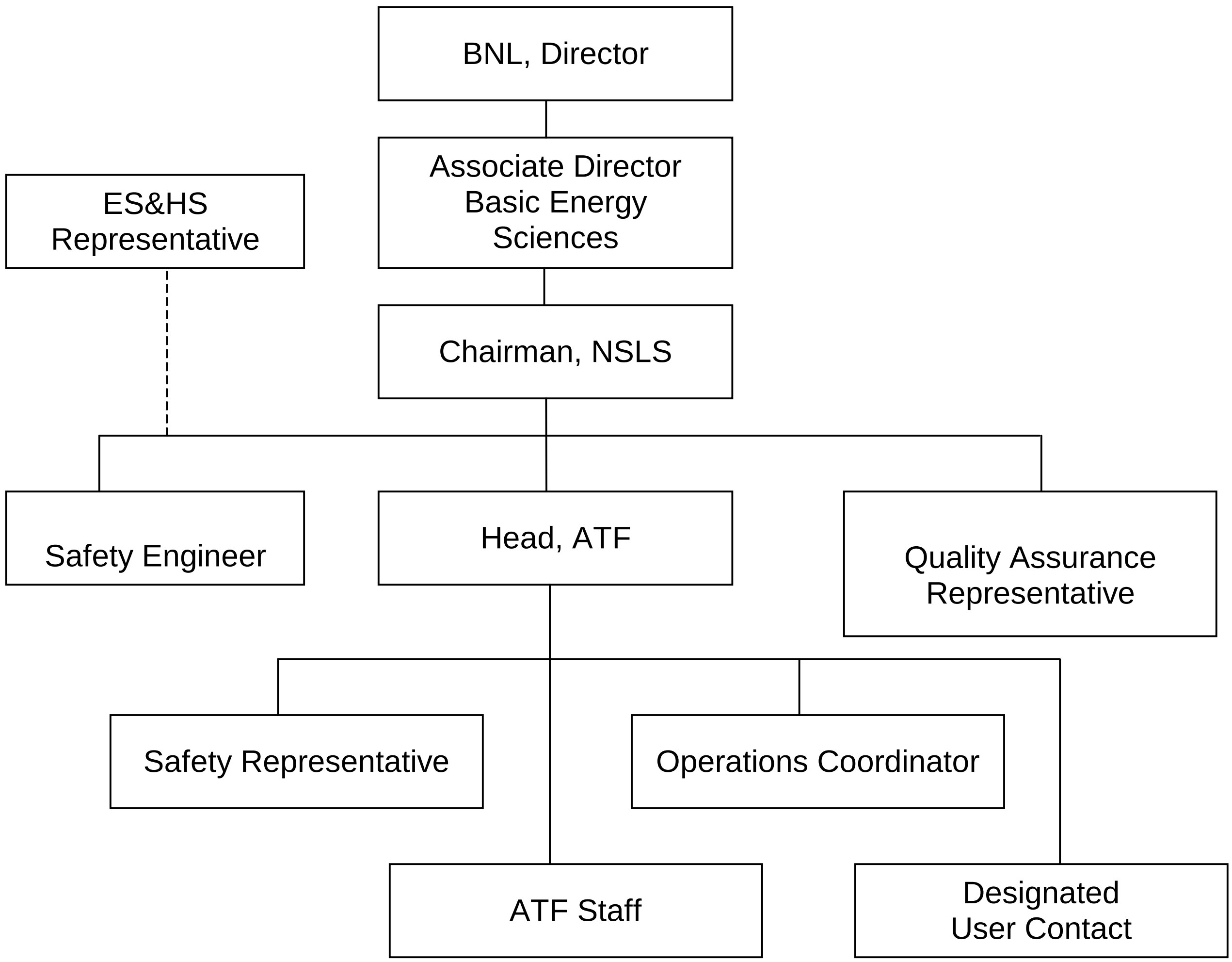

Figure 4 is pdf file to be inserted after Word file is converted to pdf.

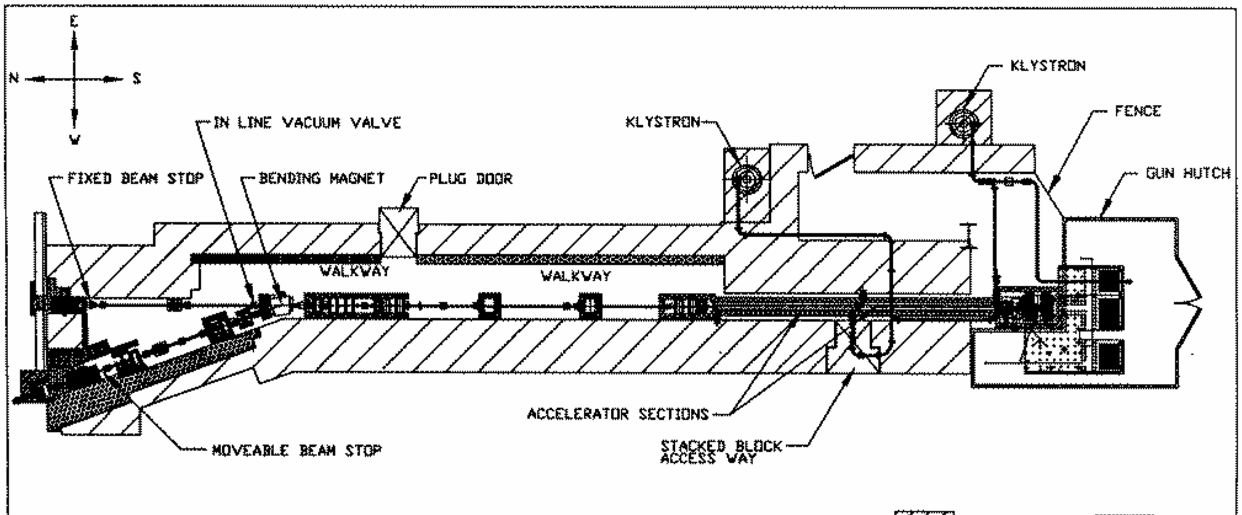

FIGURE 5
BUILDING 820 SHIELDING

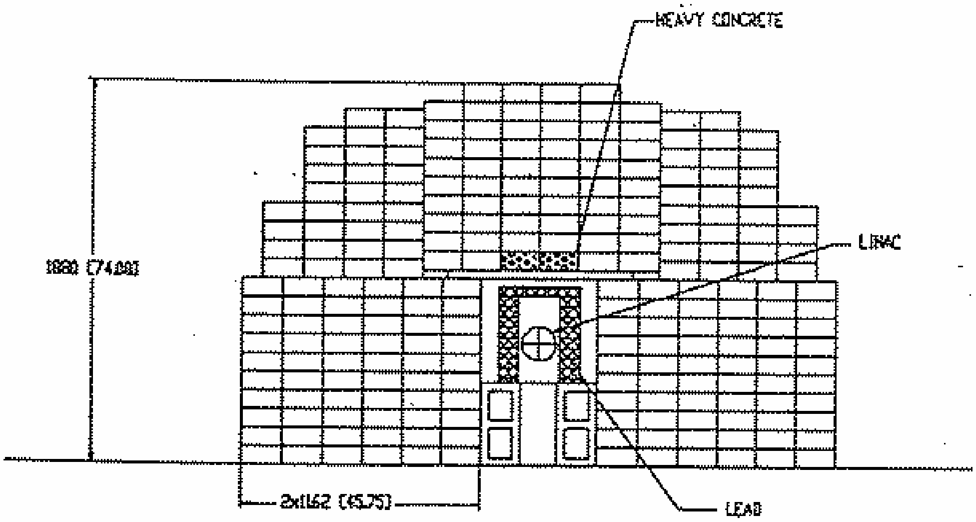

FIGURE 6A
SECTION AT LINAC

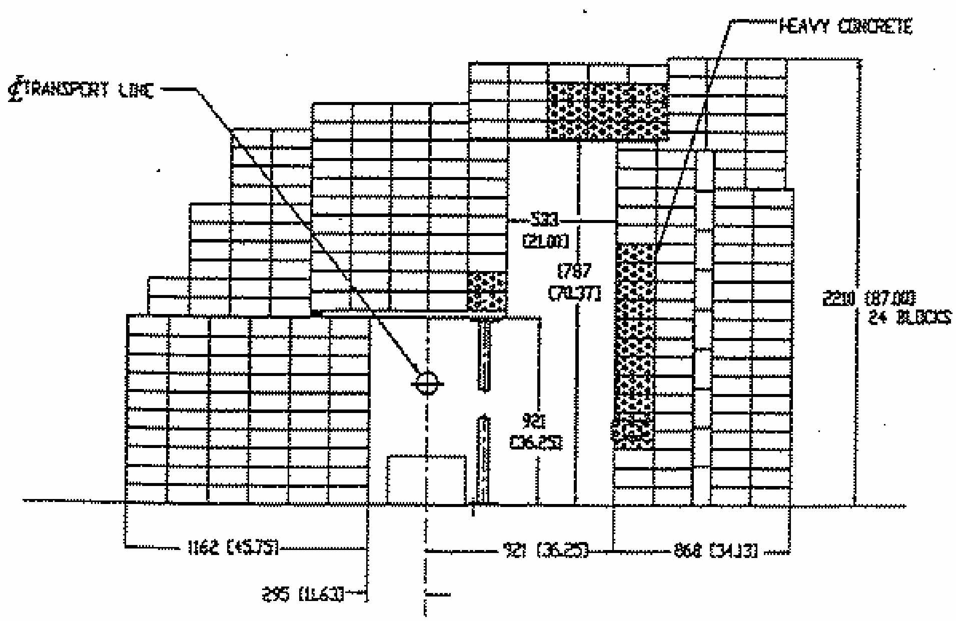

FIGURE 6B
SECTION AT TRANSPORT LINE

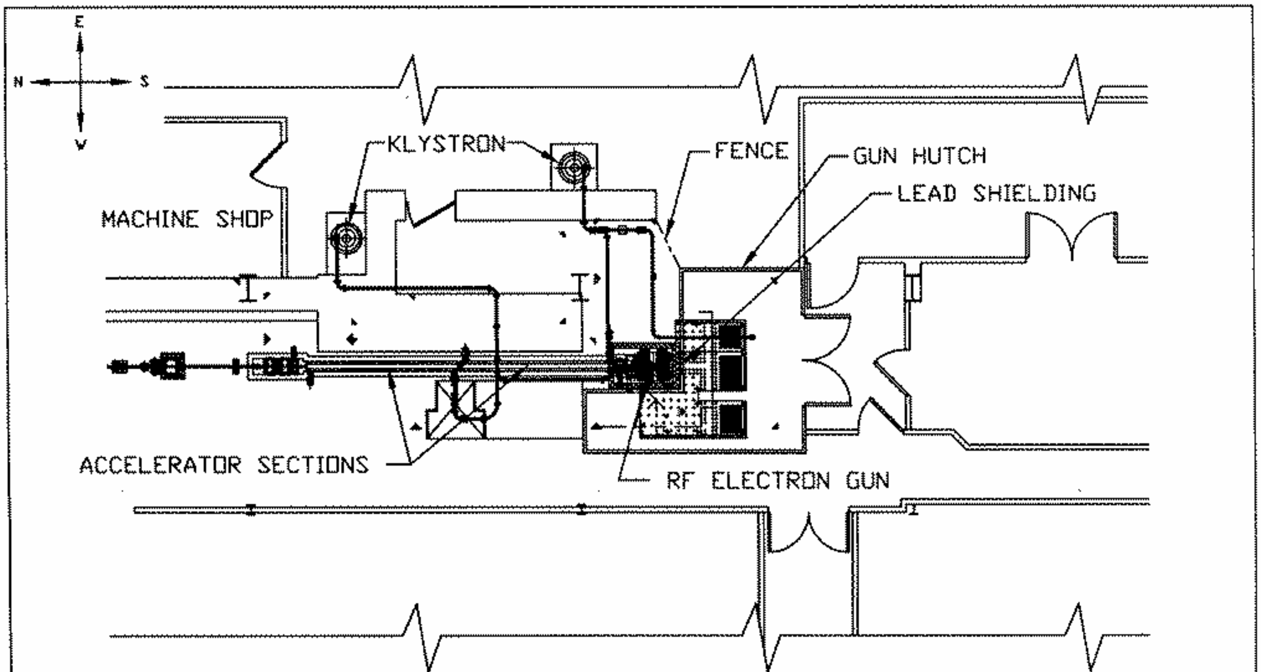

FIGURE 7
ELECTRON GUN AREA ARRANGEMENT

Appendix I

Life Safety Code Analysis
Brookhaven National Laboratory
Building 820, Accelerator Test Facility

Prepared by: J. A. Eckroth

Reviewed by: J. W. Levesque

Date of Survey: October 3, 1997
Updated: February 3, 1999

Date of Report: October 29, 1997
Updated: February 3, 1999

Conferred with: N. Gmur, Environment, Safety and Health Coordinator, NSLS
B. Cahill, Point of Contact at Building 820

Scope

This is an analysis of the level of life safety (i.e.: the ability of occupants to exit during a fire) and compliance with the Life Safety Code (LSC)[1]. The analysis of Bldg. 820 in this report is limited to those areas of Bldg. 820 occupied by the Accelerator Test Facility (ATF). Compliance with the Life Safety Code is one of the performance objectives of DOE Order 420.1[2].

Summary

The uses of the building, as described under "Occupancy", below, are based on a field survey and on discussions with N. Gmur and B. Cahill. The building complies with most aspects of the LSC and is acceptable for continued occupancy.

Recommendations

There are no new recommendations as a result of this updated survey. All recommendations made on previous surveys have been closed out.

Analysis

Building Construction

The ATF portion of Building 820 is a one story building with a mezzanine and is of insulated metal panel and steel frame construction. Interior walls are a combination of concrete block, gypsum *board on wood and steel studs, and metal and composite panels.*

A building layout is shown on the diagram in Attachment 1.

Fire Protection

The *ATF area of Building 820 is protected with a combination of automatic sprinklers, fixed* temperature/rate of rise heat detectors, smoke detectors, and manual fire alarms. Alarms are arranged to annunciate: locally, at BNL Fire/Rescue Headquarters (Building 599), and at BNL Police Headquarters (Building 50).

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[1]*National Fire Protection Association* No. 101, Life Safety Code, 1994 Edition

[2]US Department of Energy Order No. 420.1, Facility Safety, 10/13/95

Appendix I (cont.)

LSC, Building 820, Page 2

Classification of Occupancy

The overall occupancy classification of the ATF area of Building 820 for LSC purposes is General Industrial. The offices and control room located within Bldg. 820 are incidental to the main occupancy. No high hazard operations are associated with the ATF areas in Building 820.

Occupant Load

The ATF facility including the mezzanine and trailers covers approximately 8400 sq. ft. of floor area. Based on an occupancy load factor of 100 sq. ft./ person, the entire occupancy load for this area of Bldg. 820 is 84 people. This occupancy load is for LSC analysis and does not necessarily reflect the actual occupancy load of the building which under normal conditions is expected to be less.

Means of Egress Components

The doors in Bldg. 820 provide for an adequate means of egress in accordance with the LSC. In addition, most of the stairs in Bldg. 820 comply with the requirements of either Class A or Class B stairs as allowed by the LSC for an existing facility.

The landing on the Laser Room side of the 36 inch exit access door into the new YAG Laser Room is 43.5 inches wide by 25 inches deep. In addition, the width of the two steps in the Laser Room are only 25 inches. The LSC normally requires a landing equal to the width of the door on both sides of the door and the width of the stairs to be 36 inches. The current arrangement of this landing and the steps is considered tolerable because of the limited use of the door, landing, and steps into the Laser Room.

The second means of egress from the mezzanine area is via alternating tread device. The use of this device as a secondary means of egress from the mezzanine is tolerable because the mezzanine is not a normally occupied space. When the mezzanine is occupied, it is not occupied by more than three persons and all occupants are capable of using the alternating tread device.

There are no ramps, horizontal exits, exit passageways, fire escape stairs, or fire escape ladders serving this building.

Capacity of Means of Egress

Exit capacity is based on the calculated occupancy load and on exit width factors, such as 0.2 inches/person for horizontal components and 0.3 inches/person for stairs. With the exception of the one item noted below, there is adequate exit width from the ATF area of Building 820 and from each area within the building to accommodate the calculated occupancy load.

The minimum width of all means of egress in an industrial occupancy, including exit egress width, should be no less than 28 in (LSC 5-3.4.1). There is one location in the ATF areas of Bldg. 820 where the exit egress width is reduced to less than 28 in. The location is in the Experimental Area of the ATF where a survey pole is periodically placed in the egress path to allow alignment of the beamlines in this area. It was indicated by facility personnel that the survey pole is only installed when surveys are taking place and is removed when not in use. This incidental obstruction to the egress path during limited time periods while surveys are being performed is considered tolerable.

Appendix I (cont.)

LSC, Building 820, Page 3

Number and Arrangement of Means of Egress

All ATF areas of Building 820 are provided with an adequate number of properly arranged exits. Common paths of travel and dead end corridors are within the 50 ft. maximum LSC allowance.

Travel Distances to Exits

Total travel distance to an exit from all ATF areas of Building 820 are within the 200 ft. LSC limitations for General Industrial occupancies.

Discharge from Exits

All required exits in the ATF area of Building 820 discharge directly to a public way or at an exit discharge.

Emergency Lighting and Marking of Means of Egress

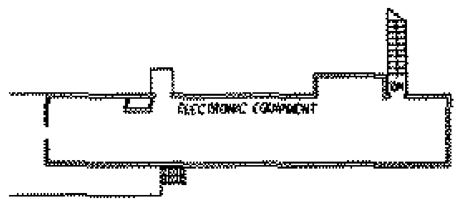
Adequate emergency lighting is provided in the exit access areas of Building 820. The required means of egress for this facility are adequately marked.

Protection of Vertical Openings

There are no vertical openings in this one story building.

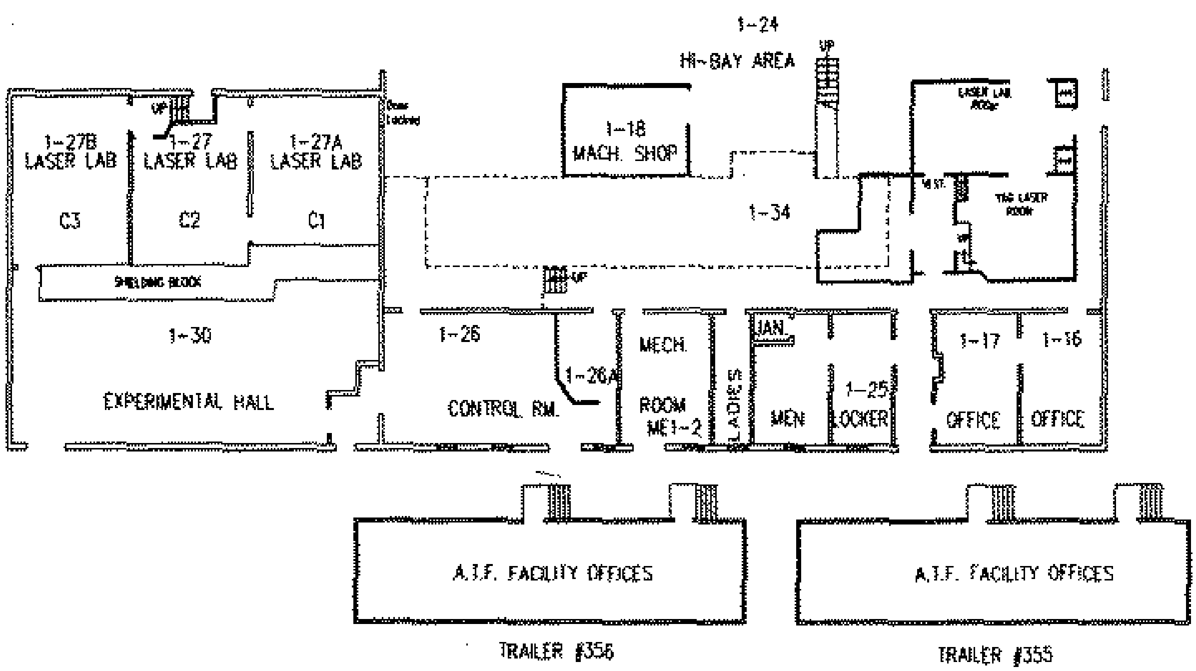
Appendix I (cont.)

LSC, Building 820, Attachment 1
Page 1 of 1



MEZZANINE

N <----



Not to Scale

Appendix II

Fire Protection Assessment / Fire Hazard Analysis
Brookhaven National Laboratory
Building 820, NSLS Accelerator Test Facility

Prepared by: J. A. Eckroth
Reviewed by: J. W. Levesque

Date of Survey:	October 3, 1997	Date of Report:	March 16, 1998
Updated:	February 11, 1999	Updated:	February 11, 1999

Conferred with: I. Ben-Zvi, ATF Head
N. Gmur, Environment, Safety and Health Coordinator - NSLS

Purpose/Scope

The purpose of this assessment is to evaluate the facility related fire protection aspects of the Accelerator Test Facility (ATF) areas of Building 820 to ensure compliance with DOE fire protection criteria. DOE fire protection criteria are outlined in DOE Order 420.1[1]. A Fire Hazard Analysis, required for the Safety Analysis Document for this facility, is incorporated in this assessment.

Summary

The current and proposed use of the ATF areas of the building, described under "Occupancy and Associated Fire Hazards" below, are based on a field survey, a review of the planned installations, and discussions with I. Ben Zvi and N. Gmur. The level of fire protection in most of the non-ATF areas of Bldg. 820 and in several areas of the ATF are not sufficient to classify this building as an "improved risk", one of the overall objectives of DOE Order 420.1. Four items exist for which improvement measures are recommended.

The recommendation for the installation of automatic sprinkler protection throughout the unprotected areas of Bldg. 820 is beyond the scope of the department. However, the recommendation for the installation of sprinkler protection is included in this report to ensure an awareness of the loss potential that exists due to the lack of full sprinkler protection. The recommendation for the installation of automatic sprinkler protection in Bldg. 820 has been added to a proposed line item funded BNL site-wide fire protection improvements project (Phase IV - ADS A92D0127).

Recommendations

1. Status of Recommendations from Previous Survey

FHA97-820-1 With the exception of those areas recommended to be protected by a clean agent fire suppression system, automatic sprinkler protection should be provided throughout all areas of Bldg. 820 which are currently not protected. A preaction sprinkler system should be installed in the areas of ATF containing high value equipment susceptible to water damage (ADS A92D0127).

FHA97-820-2 To the extent possible, the Class 4 laser installations and their use in Bldg. 820 should comply with the recommended practices in NFPA 115, Laser Fire Protection.

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[1] US Department of Energy Order No. 420.1, Facility Safety, 11/16/95

FPA/FHA, ATF area of Bldg. 820, page 2

FHA97-820-3 This recommendation has been completed and is considered closed.

FHA97-820-4 A clean agent automatic fire extinguishing system such as FM200 or Inergen should be installed in the Yag Laser Room to provide protection for the high value electronic equipment located within this combustible enclosure. The adjacent Laser Lab Room and Vestibule should also be protected by the clean agent fire extinguishing system due to the combustible construction of these areas.

FHA97-820-5 To minimize the exposure of the Yag Laser Room and the Laser Lab Room from an external fire, the exterior surfaces of this combustible enclosure should be covered with a fire rated barrier such as gypsum wallboard or by a noncombustible material such as sheet metal (P.E. Job No. 8625A).

2. New Recommendations Resulting from the Current Survey

There are no new recommendations as a result of the current survey.

Analysis

1. Construction

Building 820 is a one-story steel framed building with insulated metal panel walls on a poured concrete slab. The original portion of the building was constructed in 1957. The roof is partially a Class II insulated metal roof deck and partially a standing seam metal roof deck. The total building area is approximately 25000 sq. ft. with the ATF occupying approximately 4225 sq. ft. of the total area. The ATF area is contiguous with the other areas of Bldg. 820.

There are no major fire rated interior walls associated with Bldg. 820. The control area for the ATF is located in a room adjacent to the accelerator, with no fire rated separation (see Section 2.2.1 for details). A clean room that houses the YAG laser system is located in the south section of the area occupied by ATF. The clean room is constructed of a 3 in. thick polystyrene core wall system covered with a vinyl covered hardboard. The wall panels have a Class C flame spread rating and are considered to be combustible.

1.1 Fire Barrier Integrity

There are no fire barriers required for the ATF areas of Building 820. As indicated above, the ATF area of Building 820 is contiguous and open to other areas of Building 820. Therefore, the entire building is considered to be a single fire area. Potential fire hazards in other areas of Building 820 which could affect the operations of the ATF are discussed in the appropriate sections below.

1.2 Windstorm Damage Potential

Due to the substantial metal panel construction, the windstorm damage potential at this facility is considered to be very slight.

2. Occupancy and Associated Fire Hazards

The existing and proposed occupancy of the ATF areas of Building 820 are considered to be industrial type operations. The ATF area is occupied by accelerator equipment, laser equipment,

FPA/FHA, ATF area of Bldg. 820, page 3

and associated experiment equipment. The accelerator equipment includes an electron gun, a linac, a transport line, and related equipment enclosed in concrete shielding walls. The major laser equipment includes a YAG laser in the clean room, a CO_2 laser, and a Terawatt laser by the north end of the accelerator. The Experiment Hall area of the ATF is occupied by beamlines and optical equipment associated with experiment operations. The remainder of the ATF areas of the building are occupied by various electrical, electronic, and mechanical equipment to provide for operation and control of the Accelerator and experiment equipment. There is also a mechanical equipment room, a machine shop room, and technicians space in separate rooms in the ATF area of Building 820. Combustible loading within the ATF areas of Bldg. 820 is light.

Automatic sprinkler protection is provided throughout the FEL Room, the CO_2 Laser Room, the north end of the Terawatt Laser Room, the Experiment Hall and vestibule, and the mezzanine area which houses the power supplies for the ATF. The two office trailers affiliated with the ATF also have automatic sprinkler protection. Other areas of Bldg. 820 do not have automatic sprinkler protection (see Recommendation FHA97-820-1). Attachment A and Attachment B show the areas currently provided with automatic sprinkler protection.

The CO2 laser, the Terawatt Laser, and the YAG laser are classified as Class 4 laser systems. Class 4 lasers are considered to be beam ignition hazards. To the extent possible, these laser installations and uses should comply with the recommended practices in NFPA 115, Laser Fire Protection. N. Gmur, the ES&H Coordinator and C. Weilandics, the Laboratory Laser Safety Officer, are in receipt of a copy of NFPA 115 (see Recommendation FHA97-820-2).

The scope of NFPA 318, Protection of Clean Rooms, is for semiconductor facilities containing clean rooms. The clean room in Bldg. 820 is not intended for semiconductor production and therefore was not designed to the requirements of NFPA 318. The clean room in Bldg. 820 was designed as a structure containing high value electronic equipment. The existing smoke detection within the clean room is adequate for the loss potential that exists within the room (less than one million dollars).

The clean room was specified to be constructed of a Class A building material. However, a Class C wall panel was used in the actual construction. To mitigate the hazards associated with this combustible construction, a clean agent automatic fire extinguishing system such as FM200 or Inergen is being recommended for the interior portions of the clean room (see Recommendation FHA97-820-4). In addition, to minimize the exposure of the Yag Laser Room and Laser Lab Room from an external fire, it is being recommended that the exterior surfaces of this combustible enclosure be covered with a fire rated barrier such as gypsum wallboard or by a noncombustible material such as sheet metal (see Recommendation FHA97-820-5).

Providing protection for the clean room as recommended above will reduce the probability of a large loss occurrence in Bldg. 820, but would not fully eliminate the potential for a large loss due to the exposure to the clean room and other areas of the ATF from unprotected areas of Bldg. 820. With the exception of the areas recommended to be protected by a clean agent fire suppression system, sprinkler protection in the unprotected areas of Bldg. 820 is warranted to reduce this exposure (see Recommendation FHA97-820-1).

The remainder of Bldg. 820 not occupied by the ATF is used by DAS as experiment lab space and by RHIC for work associated with cryogenic magnet production. The combustible loading in these areas of Bldg. 820 are considered to be light to moderate. Automatic sprinkler protection is not provided in these areas (see Recommendation FHA97-820-1). Automatic fire detection is provided in areas not protected by automatic sprinkler protection.

Appendix II (Cont.)

FPA/FHA, ATF area of Bldg. 820, page 4

2.1 Critical Process Equipment

By DOE standards, critical process equipment is considered to be equipment which, if lost or damaged in a credible fire, could delay a significant component of a major program for a period in excess of 6 months.
By the above definition, the accelerator and the associated equipment in the ATF areas of Building 820 are not considered to be critical process equipment.

2.2 Special Occupancies

Special occupancies include electronic data processing and vital/important records. The special occupancies of the ATF areas of Building 820 are expanded upon in sections 2.2.1 and 2.2.2, below.

2.2.1 Electronic Data Processing

The control equipment associated with the operation of the Accelerator at the ATF is located in a control room of substantial concrete block construction. Due to unrated penetrations, the walls of the control room are not considered to be fire rated. This arrangement is acceptable since the control room equipment is not considered to be essential as defined by DOE/EP-0108, Standard for Fire Protection of DOE Electronic Computer/Data Processing Systems. Smoke detection is provided in the control room.

2.2.2 Vital and Important Records Storage

Vital records are those records which are essential to the mission of an important program and which, if lost, could not be reproduced or obtained elsewhere. Important records are those records possessing a high value to the mission of an important program but which, if lost, could be reproduced or reconstructed with difficulty or extra expense.

Based on the above definition, there are no vital or important records associated with this program.

2.3 Unique Fire Hazards

Unique fire hazards include; modular buildings, trailers, cooling towers, flammable liquid & gas storage, cable trays, housekeeping in vital areas, and highly combustible building materials. The unique fire hazards of Building 820 are expanded upon in sections 2.3.1 through 2.3.7, below.

2.3.1 Modular Buildings

There is one modular building attached directly to Building 820. The modular building is remote in relation to the ATF and therefore does not present a direct exposure to the ATF.

2.3.2 Trailers

There are two trailers located 15 ft. west of the ATF area of Building 820. These trailers have a moderate amount of combustible loading and are considered to be an exposure hazard to the ATF areas of Building 820 (see section 6 for details). These two trailers are provided with automatic sprinkler protection. There is also a trailer at the north end of Building 820 which is attached directly to the building. This trailer has a moderate amount of combustible loading but its location is remote in relation to the ATF and therefore does not present a direct exposure to the ATF. This trailer is currently protected by an automatic Halon fire extinguishing system.

2.3.3 Cooling Towers

There are no cooling towers associated with the ATF area of Building 820. There is a large pad mounted chiller located approximately 5 ft. south of Bldg. 820. The chiller is constructed of noncombustible materials.

2.3.4 Flammable Liquid & Gas Storage

The amount of flammable liquids stored in the ATF area of Building 820 and that which exists in other areas of the building is minimal. Storage is generally restricted to a safety cabinet. Incidental use and storage outside of the flammable liquid storage cabinet does not exceed the quantities allowed by NFPA 30, Flammable and Combustible Liquids Code.

There is a Klystron/modulator system located in the ATF area of Building 820. The system contains approximately 150 gallons of a Class IIIB (FP > 300 deg. F.) combustible oil coolant similar to transformer oil. The system is provided with secondary containment. The oil coolant in the Klystron is considered not to contain PCBs. The oil was changed out several years ago from a documented source of PCB free oil coolant. Analysis of the oil performed on 10/31/97 showed that the oil contained less than 50 ppm PCBs. There is no automatic sprinkler protection associated with this combustible liquid hazard (see Recommendation FHA97-820-1).

There is also a high voltage insulator system associated with the Terawatt laser. The insulator system will contain approximately 500 gallons of a Class IIIB (FP > 295 deg. F.) combustible oil coolant similar to transformer oil. The oil coolant in the Terawatt is PCB free. The insulator system is provided with secondary containment. There is no automatic sprinkler protection associated with this hazard (see Recommendation FHA97-820-1). There are also two other devices associated with the Terawatt laser that contain oil. A D.C. power supply containing appx. 15 gallons of oil and a Pulse Forming Network (PFN) on the Terawatt laser which contains 25 gallons of oil. Automatic sprinkler protection is provided in the area of these two devices.

There is experiment use of flammable gas associated with the apparatus in the Experiment Hall area of the ATF. The flammable gas cylinders are located outside of the building and the system is hard piped to the experiment equipment. The flammable gas system is in compliance with the requirements in ES&H Standard 4.11.0, Installation of Flammable Gas Systems (Experiment and Temporary Systems).

2.3.5 Cable Trays

High voltage, low voltage, control, and signaling cables are generally segregated in accordance with NEC requirements throughout the ATF areas of Building 820. The cabling is located in conduits, raceways and cable trays. In most instances, the cables provided in the cable trays meet the IEEE 383 flammability test criteria. Automatic sprinkler protection is not provided in some of the areas of the ATF that contain cable trays (see Recommendation FHA97-820-1).

2.3.6 Housekeeping in Vital Areas

In general, housekeeping in Building 820 is adequate to minimize potential fire hazards. Some transient combustibles associated with the recent building renovations exist but it was indicated this material would be removed upon completion of the various upgrades.

2.3.7 Highly Combustible Building Materials

No significant amounts of exposed polystyrene insulation or other highly combustible building materials are used in the construction or operations at Building 820. The clean room which houses the YAG laser system is constructed of a 3 in. thick polystyrene core wall system covered with a vinyl covered hardboard. The wall panels have a Class C flame spread rating and are considered to be of combustible construction.

3. Fire Protection/Suppression Features

Automatic sprinkler protection is provided in the North Addition to the ATF area of Bldg. 820 and throughout the mezzanine area of the ATF. This sprinkler system is designed to provide a minimum density of 0.15 gpm over the hydraulically most remote 2500 sq. ft. area. The water supply in the area of Building 820 is adequate to meet the required demand of this system including 250 gpm for hose streams.

Manual fire alarm pull stations are installed at all egress doors throughout Building 820. Partially supervised fire alarm bells are located throughout the facility. A duct smoke detector is provided on the air supply system which serves the CO_2 Laser Room, the Terawatt Laser Room, and the Experiment Hall areas of the ATF. Spot-type smoke detectors are located in the Laser Lab area, the Control Room, the power supply mezzanine, the Terawatt Laser Room, the CO_2 Laser Room, the Experimental Hall area, the FEL Room, and at the ceiling and below the raised floor in the Yag Laser Room.

Automatic heat detection is provided in the areas of the ATF not protected by automatic sprinklers or smoke detectors. Automatic sprinkler protection is not provided in the other areas of Bldg. 820 not occupied by the ATF (see Recommendation FHA97-820-1). Heat and/or smoke detectors are provided in these areas.

The building fire alarm system is arranged to annunciate: locally, at BNL Fire/Rescue Headquarters (Building 599), and BNL Police Headquarters (Building 50).

An adequate number of properly rated hand-held fire extinguishers are located throughout this facility.

The fire protection/suppression features of vital programs, high valued property, and essential safety class systems at Building 820 are expanded upon in sections 3.1 through 3.3, below.

3.1 Fire Protection of Vital Programs

The operation associated with this facility is not considered to be a vital program. Therefore, no special fire protection precautions, beyond those that are described above, are required for this facility.

3.2 Fire Protection of High Value Property

The major equipment and lasers associated with the ATF are considered to be high value property. Spot-type smoke detectors, a duct smoke detector, and sprinkler protection is provided in the area of the Experiment Hall, Terawatt Laser (partially), and CO_2 Laser. The Yag Laser Room is provided with spot-type smoke detectors. The power supplies on the mezzanine are protected with automatic sprinklers and spot-type smoke detectors. To provide further in-depth protection from a fire, a combination of automatic sprinkler protection and a clean agent fire extinguishing system is being recommended for areas that contain high value equipment (see Recommendation FHA97-820-1 and Recommendation FHA97-820-4). To reduce the facility user's concern of water damage to the high value equipment from an accidental sprinkler system discharge, a preaction sprinkler system should be used in the areas of the high valued equipment which will not be protected by a clean agent fire suppression system.

3.3 Protection of Essential Safety Class Systems

There are no essential safety class systems associated with this non-nuclear facility.

4. Fire Loss Potentials

Fire loss potentials are classified into three major categories; the maximum credible fire loss, the maximum possible fire loss, and the recovery potential. The loss potentials for Building 820 are expanded upon in sections 4.1 through 4.3, below.

4.1 Maximum Credible Fire Loss (MCFL)

The Maximum Credible Fire Loss (MCFL) for the ATF area of Building 820 is expected to be from $250,000 to over $1 million. Typical areas where a loss of this magnitude could be expected to occur include any of the three major laser installations, cable trays in the vicinity of the Accelerator and/or electron gun, electronic control equipment for the accelerator, and the oil filled Klystron/modulator system on the general floor area. Since the facility is not fully protected by automatic sprinkler protection, the maximum credible fire loss is estimated to be equal to the maximum possible fire loss as specified by DOE. Per DOE direction, manual firefighting operations can not be given credit in reducing the MCFL of an unsprinklered building. With the installation of an automatic sprinkler system throughout Bldg. 820, the maximum credible fire loss would be reduced to an acceptable level (under $250,000) (see Recommendation FHA97-820-1 and Recommendation FHA97-820-4).

4.2 Maximum Possible Fire Loss (MPFL)

The Maximum Possible Fire Loss (MPFL) for this facility is estimated to be the result of an uncontrolled fire in the general building area which would involve the coolant oil in the Klystron/modulator system or the insulator oil in the Terawatt laser system. Assuming a 25% loss and/or damage to the building and a 25% loss and/or damage to the building contents, including the accelerator and associated equipment and extensive damage to the associated cabling, a loss in excess of $1 million could be anticipated.

The MPFL for the ATF resulting from an uncontrolled fire originating in other areas of Building 820 is also estimated to be in excess of $1 million due to the continuity of combustibles and the smoke damage potential that could occur to the ATF equipment.

4.3 Recovery Potential

Due to the lack of fire protection, a credible fire in Building 820 could result in a shutdown of the ATF or a major component of the ATF for an excessive period of time (greater than 6 months).

5. Security Considerations Related to Fire Protection

There are no security considerations which relate to fire protection at this facility.

FPA/FHA, ATF area of Bldg. 820, page 8

6. Exposure Fire Potential

Exposure fire potential for the ATF area of Building 820 is limited to the possible exposure from the non-ATF areas of Building 820, two portable trailers west of the building, and a 1500 kVA transformer yard also located west of the facility. The space separations and other relevant factors of these exposures are discussed below. There are no additional fire exposures beyond those noted above.

There is a 15 foot separation between Building 820 and the two trailers to the west of the building. The trailers are fully sprinklered metal panel buildings with light combustible loading. Based on this information, the separation distance between Bldg. 820 and the trailers complies with the requirements in DOE-STD-1088-95, Fire Protection for Relocatable Structures and are not considered to be exposure hazards to Building 820.

Two oil filled transformers, rated at 2000 kVA and a 500 kVA respectively, are located more that 25 feet west of Building 820. The transformers are provided with adequate containment curbing. Based on Factory Mutual Data Sheet 5-4, the transformers are not considered an exposure hazard to Building 820.

The non-ATF areas of Bldg. 820 are considered to be a direct exposure to the ATF operations due to the lack of fire protection in most areas of the building (see Recommendation FHA97-820-1).

7. Environmental Impact due to a Fire (Including Water Runoff)

Toxic, biological, and radiation incidents resulting from a fire, including water runoff, could have an impact on the environment. The potential for these incidents occurring in the ATF areas of Building 820 are expanded upon in sections 7.1 through 7.3, below.

7.1 Toxic Incident

There are no known materials in the ATF areas of Building 820 that, if involved in a fire, would result in a significant quantity of toxic material being created and released.

7.2 Biological Incident

Due to the lack of biological matter at this facility, an incident of this type is unforeseeable.

7.3 Radiation Incident

No radioactive materials are used or stored in the ATF areas of Building 820. By the nature of the operations of the accelerator, various pieces of equipment can be expected to become activated. This activation is not expected to pose a significant environmental impact in the event of a fire.

8. Prefire and Emergency Planning

The BNL Fire Department maintains an adequate prefire plan book for this facility. A local emergency plan is maintained by the NSLS department.

8.1 Fire Apparatus Accessibility

Fire apparatus accessibility is adequate at this facility.

Appendix II (Cont.)

FPA/FHA, ATF area of Bldg. 820, page 9

9. Life Safety Considerations

Major life safety considerations for this industrial facility include the following components; means of egress components and capacity, number and arrangement of the means of egress, travel distances to exits, discharge from the exits, and emergency lighting and marking of the means of egress.

At Building 820, most of the above components are in accordance with the requirements of NFPA 101-94, The Life Safety Code. For further details, see the Life Safety Code analysis for this facility dated October 29, 1997 and updated February 3, 1999.

FPA/FHA, ATF area of Bldg. 820, page 10

Appendix A

Blind Recommendations

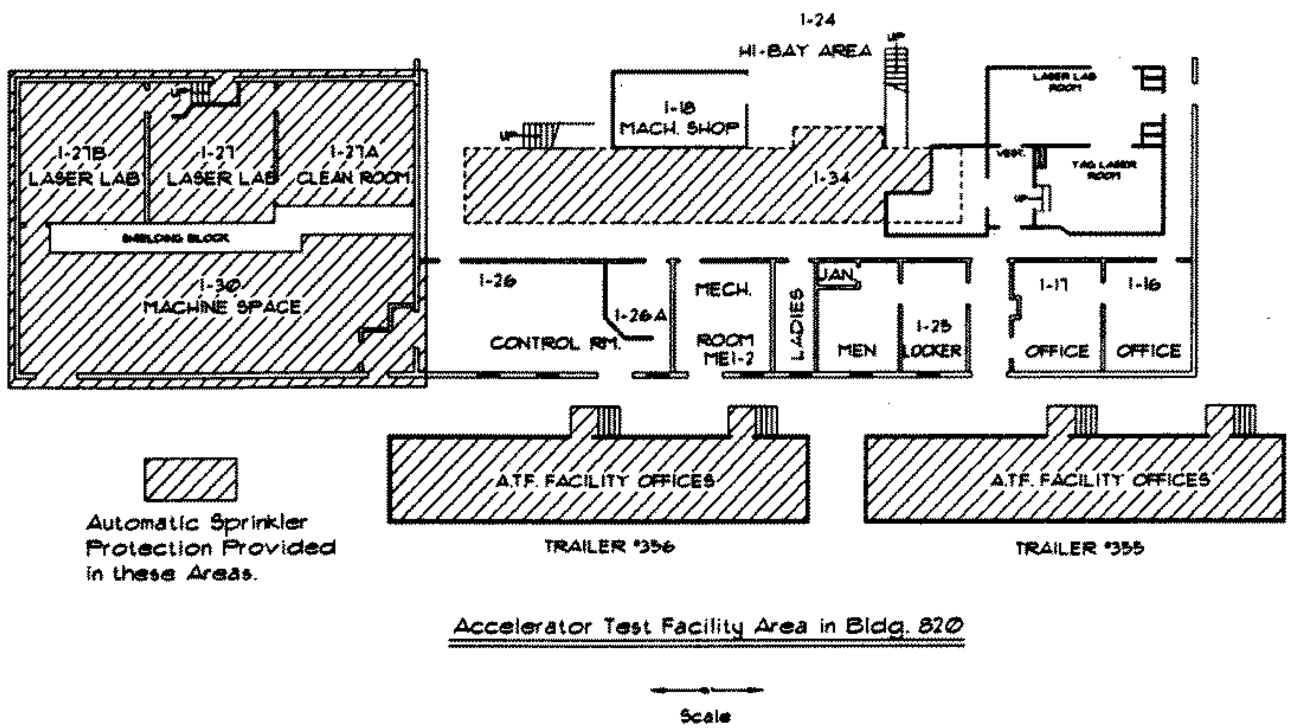
This appendix provides documentation for recommendations which are in the best interest of fire prevention but for which corrective action is not considered to be cost beneficial.

There are no blind recommendations as a result of this survey.

FPA/FHA, ATF area of Bldg. 820, page 11

Attachment A

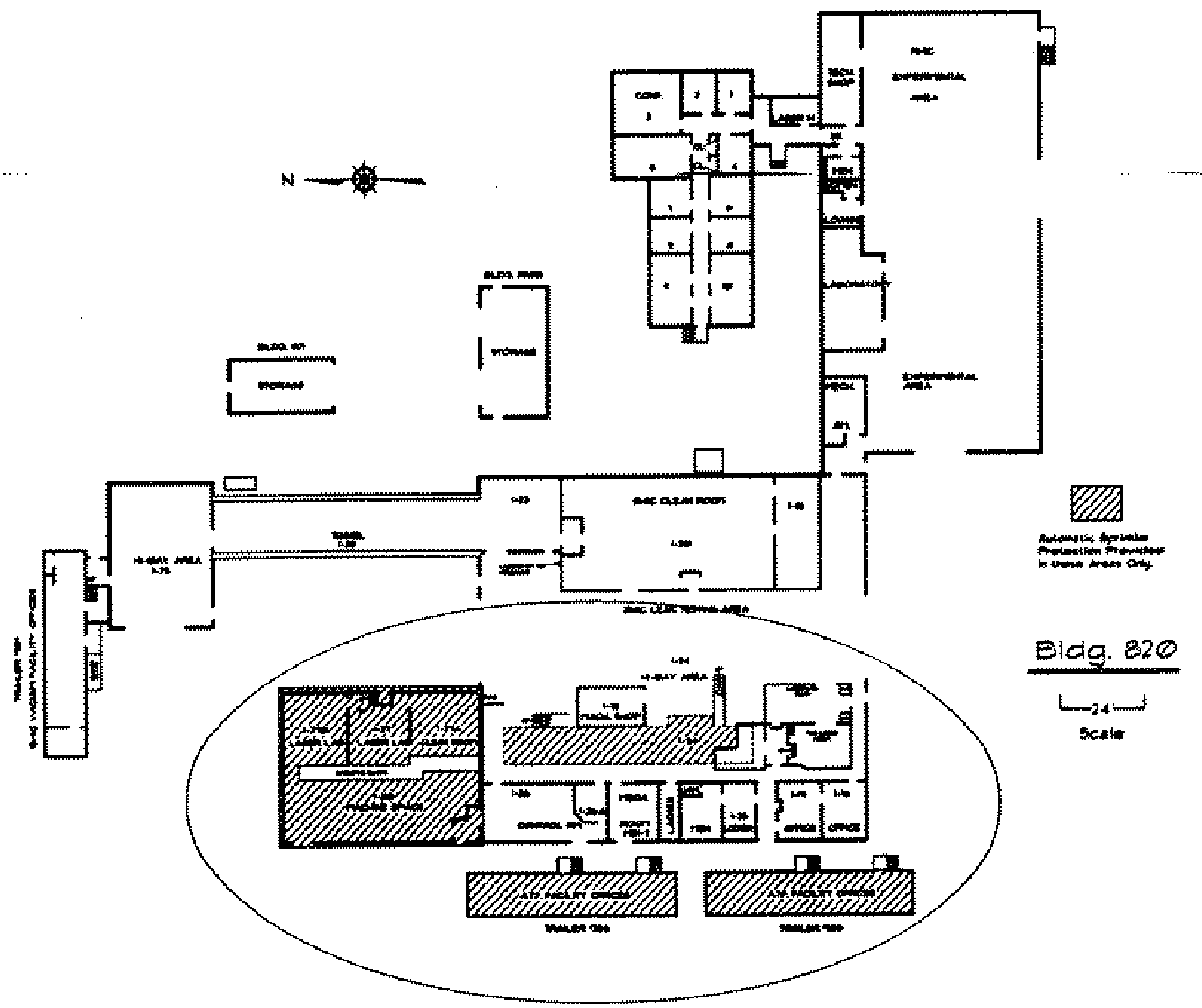
Accelerator Test Facility Layout



FPA/FHA, ATF area of Bldg. 820, page 12

Attachment B

Building 820 Layout



ATF Area within Bldg. 820

Appendix III

Department of Energy
Brookhaven Area Office
53 Bell Avenue
Upton, New York 11973

November 24, 1989

U. S. Environmental Protection Agency
ATTN: Alan Feldman, Ph.D.
Director, Air & Waste Management Division
26 Federal Plaza
New York, New York 10278

Dear Dr. Feldman:

SUBJECT: STARTUP OF THE ACCELERATOR TEST FACILITY (ATF)

The Brookhaven Area Office of the Department of Energy wishes to notify EPA Region II that the Accelerator Test Facility commenced operation on November 1, 1989. This notification is provided to comply with Approval Condition III of the ATF NESHAPs Permit No. BNL-589-01 which requires notification to EPA of facility startup. As stated in prior correspondence, the ATF is operating in a test mode at energies on the order of 5 Mev. Operation of the facility at full design energies of 100 Mev is still several months in the future and will occur only after testing and beam reconfiguration at intermediate energies. Generation on any airborne activity is unlikely prior to 1990.

Sincerely,

Jerry L. Bellows
Area Manager

cc: K. Batchelor, BNL
W. Casey, BNL
M. Davis, BNL
M. Goldman, BNL
R. Miltenberger, BNL
J. Naidu, BNL
G. Penny, BHO
B. Royce, BNL
J. P. Kennedy, ESHD, CH

Appendix III (Cont.)

BROOKHAVEN NATIONAL LABORATORY
ASSOCIATED UNIVERSITIES, INC.

Upton, Long Island, New York 11973

(516) 282 \ 3711
FTS 666 /

Office of the Director

September 26, 1991

Ms. Jane L. Monhart
Acting Area Manager
U.S. Department of Energy
Brookhaven National Laboratory
Upton, New York 11973

Dear Ms. Monhart:

SUBJECT: START-UP OF ACCELERATOR TEST FACILITY (ATF) AT 100 MeV AND COMPLIANCE WITH NOTICE OF OPERATION REQUIREMENTS IN 40 CFR 61

According to the conditions listed in the EPA approval to construct ATF (NESHAPs Approval Number BNL-589-01), EPA requires notification of the facility start-up date within 30 days of the anticipated date of operation. The facility has informed us that operations are expected to commence at an increased energy of 100 MeV within the next 30 days (as of September 25, 1991). The EPA Region II should be notified of this. The notification should be sent to:

U.S. Environmental Protection Agency
Director, Air & Waste Management Division
26 Federal Plaza
New York, New York 10278

Attention: Florie Caporuscio, Ph.D.

Sincerely,

Gerald C. Kinne
Associate Director

GS:blc
cc: K. Batchelor
W. Casey
M. Davis
H. Kahnhauser
R. Miltenberger

Appendix III (Cont.)

Department of Energy
Brookhaven Area Office
Building 464
P.O. Box 5000
Upton, New York 11973

January 24, 1995

Dr. M. S. Davis
Associated Universities, Inc.
Brookhaven National Laboratory
Upton, New York 11973

Dear Dr. Davis:

SUBJECT: OPERATION OF THE ACCELERATOR TEST FACILITY (ATF) UP TO 120 MEV

The Brookhaven Area Office (BHO), Operations and Safety Management Division (OSMD), has reviewed the BNL Operational Readiness Review (ORR) of the ATF, the ATF's action plan and response, and the ORR's final concurrence.

BHO has subsequently conducted a walkthrough of the ATF that covered the equipment, accelerator, experimental, and control areas and included discussions with ATF staff on procedures, training, and system readiness for operation up to 120 MeV.

BHO found the facility to be in good order and in a state of readiness. BHO recognizes the good work done by the ATF and S&EP staffs to improve ATF practices and documentation with regard to safety and operations. Accordingly, BHO concurs with BNL's authorization to operate the ATF up to an energy of 120 MeV.

BHO fully expects that the ATF and S&EP staffs will continue to maintain the progress that has been demonstrated with respect to safety at the ATF. If you have any questions on this matter, please contact Pepin Carolan of my staff at extension 5966.

Sincerely,

Carson L. Nealy
Area Manager

cc: W. R. Casey, BNL
I. Ben-Zvi, BNL

1 May 1994

APPENDIX IV

Permit for Work on NSLS Injector Storage Ring Safety Systems

This section to be completed by Requesting Personnel

Date: ______________________

Person(S) Requesting Permit: ______________________

System Affected: Linac/Booster ☐ VUV ☐ Xray ☐ Other ☐

Date(s) Work Will Be in Progress: ______________________

Person(s) Doing Work: ______________________

Description Of Work: ______________________

____

____

This section to be completed by Safety Personnel:

Required Safeguard (Lock and tag or other): ______________________

____

Safeguard Placed By (Personnel): ______________________ Time/Date ____________

Required Condition Or Restrictions On Work: ______________________

____

____

☐ Check Here If Changes Are Required In Shielding Configuration.

☐ Check Here If Action By NSLS Environmental Safety and Health Committee Is Required.

Permit Approved By ______________________ Date: ____________

Approval For Return To Beam Operations

Shielding Conforms To Design (Or Photograph On Display)

NSLS Safety Official: ______________________ Date: ____________

Radiation Survey

NSLS S & EP Representative(Or Operations Coordinator): ______________________ Date: ____________

- Original (White) Copy Of Approved Permit Must Be Posted At The Work Site.
- Second (Yellow) Copy Must Be Retained By Safety Official Who Approved The Permit.
- Third (Pink Copy Must Be Delivered To The Machine Operator On Duty In the Control Room.

Permit Number - ____________