Fire Hazard Analysis
PHENIX Experimental Complex
Buildings 1008, 1008-A, 1008-B and 1008-C

Brookhaven National Laboratory

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1.0 OVERVIEW AND RECOMMENDATIONS

1.1 Purpose and Methodology

A Fire Hazard Analysis (FHA) was performed for the Building 1008 PHENIX (Pioneering High Energy Nuclear Interaction eXperiment) experimental complex at Brookhaven National Laboratory (BNL), Upton, NY. The buildings associated with PHENIX are Building 1008, Building 1008A, Building 1008B, Building 1008C, Building 1008E, and Building 1008F.

This report fulfills the requirement for documentation of an FHA as outlined in DOE Order 420.1, Facility Safety. This FHA assesses the risk from fire in Building 1008 complex to ascertain whether the facilities meet the objectives of DOE Order 420.1 and the Brookhaven National Laboratory (BNL) Fire Safety Program. The fundamental goal of the BNL Fire Safety Program is to control fire risks such that:

1. Public and employees are not unreasonably endangered by fire;
2. Vital Laboratory missions are maintained without significant interruption from fire;
3. Property losses are limited to less than $1 million dollars per occurrence, and lower when justified by cost-effective, risk reduction measures;
4. Damage to the environment is averted; and
5. The potential for occurrences of fires are avoided whenever economically feasible.

This FHA is an evaluation of the fire hazards (1) that expose the Building 1008 complex and (2) that are inherent in the buildings or operations. The adequacy of the fire safety features in the buildings and the degree of compliance of the facilities with specific fire safety provisions in DOE orders, and related engineering codes and standards, were determined. The results of the analyses are presented in terms of the fire hazards present, the potential extent of fire damage, and the impact on employee and public safety.

The general approach taken to complete this evaluation involved the identification of fire hazards in the buildings and the fire protection features required to mitigate the adverse consequences of a fire. A determination was made as to the adequacy of the proposed fire protection features to effectively control the fire hazards. Concerns for the protection of safety systems, critical processes, and life safety of building occupants from fire were essential considerations in the analysis. Compliance was determined by a comparison of existing conditions found during the site visits with current code requirements. Where conflicting requirements were found the more conservative requirements were used in this evaluation.

Maximum Possible Fire Loss (MPFL) and Maximum Credible Fire Loss (MCFL) potentials were also evaluated. The MPFL, as defined in DOE Order 420.1, is the value of property within a fire area, unless a fire hazard analysis demonstrates a lesser (or greater) loss potential, assuming the failure of both automatic fire suppression systems and manual fire fighting efforts. The MCFL, as defined in DOE Standard 1066-99 Fire Protection Criteria, is the value of property within a fire area, unless a fire hazard analysis demonstrates a lesser (or greater) loss potential. This assumes that all installed fire protection systems function as designed, and the effect of emergency response is omitted except for post-fire actions. Both MPFL and MCFL fire loss estimates are to include the replacement cost of equipment and property and any applicable decontamination and cleanup costs.

The MPFL scenario was based on a qualitative consideration of several factors; the potential to reach flashover conditions based on combustible loading and the geometry of the space(s) under consideration; adequacy of passive protection features; and continuity of combustibles.

The MCFL scenario is one in which automatic suppression systems function as designed. Since properly designed and installed sprinkler systems should limit the fire growth and/or damage to the design area of the system, this floor area is used in the determination of MCFL potentials when protected by automatic sprinkler systems. Without sprinkler protection the MCFL is the same as the postulated MPFL for that area.

MPFL and MCFL potentials were determined based on an average dollar density of the building replacement value divided by the floor area of the building. Building values were obtained from 2004 replacement costs. The content and equipment value were calculated based on the following assumptions:

- An average of $20/ft^2 for content and equipment value within predominantly office areas.
- An average of $100/ft^2 for content and equipment value within the industrial and experimental areas of the building.

The above cost assumptions are considered adequately conservative to address the requirement to include decontamination and cleanup costs.

A qualitative assessment of the risk presented by conditions found to be deficient was also performed and is included in Section 8, Recommendations. This assessment was made by assignment of a risk assessment code (RAC). The RAC methodology is used in a number of industries as a tool to qualitatively prioritize deficiencies and corrective actions and is derived as follows:

1. <u>Hazard Severity</u>. An assessment of the worst potential consequence, defined by degree of occupational injury, illness or property damage which is likely to occur as a result of the deficiency. Hazard severity categories shall be assigned by roman numerals according to the following criteria:

a. Category <u>I</u>. May cause death, permanent total disability, or loss of a facility/asset.

b. Category <u>II</u>. May cause permanent partial disability, temporary total disability in excess of 90 days (severe injury or severe occupational illness), or major property damage.

c. Category <u>III</u>. May cause minor injury, occupational illness, or property damage.

d. Category <u>IV</u>. Presents minimal threat to personnel safety or health, or property, but is still in violation of a standard.

2. Mishap Probability. The probability that a hazard will result in a mishap or loss, based on an assessment of such factors as location, exposure (cycles or hours of operation), affected populations, experience, or previously established statistical information. Mishap probability shall be assigned an English alphabet symbol according to the following criteria:

a. Subcategory A. Likely to occur immediately or within a short period of time. Expected to occur frequently to an individual item or person or continuously to a fleet, inventory or group.

b. Subcategory B. Probably will occur in time. Expected to occur several times to an individual item or person or frequently to a fleet, inventory or group.

c. Subcategory C. May occur in time. Can reasonably be expected to occur some time to an individual item or person or several times to a fleet, inventory or group.

d. Subcategory D. Unlikely to occur.

3. Risk Assessment Code. Using the matrix shown below, the RAC is expressed as a single Arabic number that is used to help determine hazard abatement priorities.

Hazard Severity	**Mishap Probability**			
	A	**B**	**C**	**D**
I	1	1	2	3
II	1	2	3	4
III	2	3	4	5
IV	3	4	5	6

RAC Definitions

1-Critical
2-Serious
3-Moderate
4-Minor
5 & 6-Negligible

1.2 Summary

Building 1008 is the PHENIX Experimental Hall. Buildings 1008A and 1008B are PHENIX Service Buildings, Building 1008C is the PHENIX Pump House, Building 1008E are modular offices, and Building 1008F is the PHENIX Mixing House. Refer to Section 4.2 on the construction types of these buildings.

This Fire Hazards Analysis (FHA) has been performed to comprehensively assess the risk from fire in the Building 1008 PHENIX experimental complex (Buildings 1008, 1008A, 1008B, 1008C, 1008E, and 1008F). The FHA includes an analysis of the fire and life safety features of the facilities to determine the level of compliance with DOE Order 420.1 Fire Protection objectives.

Based on the analysis, it has been determined that, except for a couple of finding, the Building 1008 PHENIX experimental complex complies with DOE Order 420.1 Fire Protection objectives. The following recommendations are the result of this evaluation.

1.3 Findings and Recommendations

1.3.1 New Findings and Recommendations

Finding: Data collected from the experiment is vital. This information is collected by the facility and transported to the RHIC Computing Facility in Building 515, Brookhaven Computing Facility (a separate facility several miles away, connected by computer network).

Hazard Severity	II
Mishap Probability	C
Risk Assessment Code	3

Recommendation HAI-07-1008-01: Given the vital nature of the data collected, the protection of records in Building 515 should be reviewed against the requirements of NFPA 232, *Standard for the Protection of Records* (See Section 6.2.1).

Finding: A lightning protection system is not provided for the building.

Hazard Severity	II
Mishap Probability	C
Risk Assessment Code	3

Recommendation HAI-07-1006-02: Based on a risk analysis per NFPA 780, a lightning protection system should be considered for this facility, (See Section 6.6.1).

The following is a summary of recommendations and their relative priority.

Rec.No.	Recommendation	RAC
HAI-07-1008-01	Given the vital nature of the data collected, the protection of records in Building 515 should be reviewed against the requirements of NFPA 232, *Standard for the Protection of Records* (See Section 6.2.1).	3
HAI-07-1008-02	Based on a risk analysis per NFPA 780, a lightning protection system should be considered for this facility, (See Section 6.6.1).	3

1.3.2 Outstanding Recommendations from Previous Reviews

None

2.0 SCOPE

This FHA is based on information supplied by the Accelerator Department staff, a survey of the facility conducted during a site visit on December 11 – 16, 2006, and a review of available drawings.

The following codes and standards were utilized for this evaluation:

The *Building Code of New York State* - 2002 Edition (BCNYS)

The *Fire Code of New York State* - (FCNYS) 2002 Edition;

National Fire Protection Association (NFPA) Codes, Standards, and Recommended Practices – See Section 9 (Reference Documents) of this report for a complete list.

Factory Mutual Property Loss Prevention Data Sheets – See Section 9 (Reference Documents) of this report for a complete list.

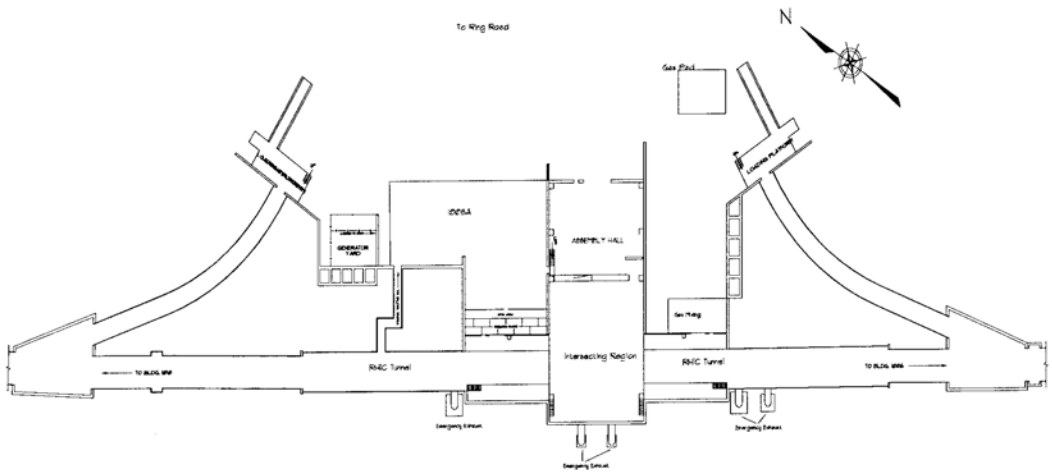
3.0 LOCATION

BNL is a 5,000 acre site owned by the Department of Energy and operated by Brookhaven Science Associates. BNL is located in Upton, New York. The PHENIX experimental complex is located in the northern region of Brookhaven National Laboratory (BNL), in the RHIC Collider site. The location of RHIC facilities is indicated by their relative clock position, with the PHENIX complex located at eight o'clock position.

Building 1008 (PHENIX Experimental Hall)

Building 1008 is a one-story, 11,400 ft2 building, built in 1981. There are two parts to the building; the Interaction Ring (IR) which is the western portion of the facility and is 50-feet high and the 60-foot high Assembly Hall (AH). A 50-foot high, 5-foot thick shielding wall separates the IR from the AH. Floors, walls, and ceiling of the IR are made of reinforced concrete. The north and south walls both have one 900 ft2 (approximate) opening that communicates to the RHIC Accelerator Tunnel.

The AH is the eastern portion of the facility and is used as a staging area for equipment entering the IR. The walls of the AH are constructed of fiberglass insulated metal sandwich panels. Roof construction is Class 1 by Factory Mutual standards. The floor is reinforced concrete.



Layout of Building 1008 PHENIX

Building 1008A

Building 1008A is a one-story metal framed and sided building with a total floor area of approximately 9,800 ft2. Roof construction (standing seam metal roof) is Class 1 by Factory Mutual standards. The building consists of two portions; the southern portion consists of the counting house (built in 1997); the northern portion consists of the original support building (built in 1981).

Building 1008B

Building 1008B is a one-story 9,800 ft2 free standing structure located on the outside of the RHIC ring at the 8 o'clock position. The structure is a 20-foot high prefabricated insulated metal building, built in 1995. A metal framed mezzanine is installed which contains the PHENIX magnet power supplies. A one-hour fire-rated room is located in the building which houses pump controllers, vacuum controllers, and similar instrumentation. Roof construction is Class 1 by Factory Mutual standards.

Building 1008C

Building 1008C is a 1,125 ft^2 free standing structure on the outside of the RHIC ring at the 8 o'clock position. Building 1008C is located just south of Building 1008B. The structure is a one-story, prefabricated insulated metal building, built in 1997. The floor is reinforced concrete. The facility houses water treatment, water circulating pumps, and cooling tower controls for PHENIX. And induced draft, prefabricated metal cooling tower is located to the south of the building.

Building 1008E

Building 1008E is a one-story modular office building with an area of approximately 4,300 ft^2. The building was built in 1999.

Building 1008F

Building 1008F is prefabricated, 2-hour fire rated storage facility. It has an area of approximately 500 ft^2. An open-air pad for the storage of gas cylinders is located to the east of the building. Cylinders are stored and connected to manifolds on a concrete pad. Metal racks are provided to secure the cylinders.

4.0 CONSTRUCTION

4.1 Occupancy Classification

The following occupancy classifications for Buildings 1008, 1008A, 1008B, 1008C, 1008E, and 1008F are based on LSC and BCNYS criteria:

Use	LSC Occupancy Classification	BCNYS Group Classification
Building 1008		
Experimental halls	Existing special purpose industrial	Group F-1
Mechanical and electrical equipment rooms	Incidental	Incidental
Gas mixing and gas storage rooms	Incidental	Incidental
Building 1008A		
Offices	Existing business	Group B
Counting House	Special-Purpose Industrial	Group F-1
Mechanical equipment areas	Incidental	Incidental
Building 1008B		
Control Room	Industrial	Group B
Building 1008C		
Counting House	Industrial	Group F-1
Building 1008E		
Offices	Existing business	Group B
Building 1008F		
Gas Mixing House	Special-Purpose Industrial	Group F-1

The experimental halls are considered as special purpose industrial occupancies based on the relatively low density of population. In addition, much of the area is occupied by equipment.

Since credited fire resistance-rated separations are not provided between occupancies, the building is classified as a mixed occupancy consisting of assembly, business and industrial occupancies based on LSC criteria [§6.1.14.2.2]. Therefore the means of egress facilities, type of construction, protection, and other safeguards must comply with the most restrictive fire and life safety requirements of the occupancies involved [§6.1.14.3.2].

4.2 Construction Type

Building 1008

Building 1008 is a one-story, 11,874 ft^2 building, built in 1981. There are two parts to the building; the Interaction Ring (IR) which is the western portion of the facility and is 50-feet high and the 60-foot high Assembly Hall (AH). A 50-foot high, 5-foot thick shielding wall separates the IR from the AH. Floors, walls, and ceiling of the IR are made of reinforced concrete. The north and south walls both have one 900 ft^2 (approximate) opening that communicates to the RHIC Accelerator Tunnel.

The AH is the eastern portion of the facility and is used as a staging area for equipment entering the IR. The walls of the AH are constructed of fiberglass insulated metal sandwich panels. Roof construction is Class 1 by Factory Mutual standards. The floor is reinforced concrete.

Based on the unprotected steel columns supporting the roof in the Assembly Hall, the construction type is most nearly BCNYS Type IIB and NFPA II (000).

Building 1008A

Building 1008A is a one-story metal framed and sided building with a total floor area of approximately 9,800 ft^2. Roof construction (standing seam metal roof) is Class 1 by Factory Mutual standards. The building consists of two portions; the southern portion consists of the counting house (built in 1997); the northern portion consists of the original support building (built in 1981).

The construction types of this building are considered to be BCNYS Type IIB and NFPA Type II (000).

Building 1008B

Building 1008B is a one-story 4,000 ft^2 free standing structure located on the outside of the RHIC ring at the 8 o'clock position. The structure is a 20-foot high prefabricated insulated metal building, built in 1994. A metal framed mezzanine is installed which contains the PHENIX magnet power supplies. A one-hour fire-rated room is located in the building which houses pump controllers, vacuum controllers, and similar instrumentation. Roof construction is Class 1 by Factory Mutual standards.

The construction types of this building are considered to be BCNYS Type IIB and NFPA Type II (000).

Building 1008C

Building 1008C is a 1,163 ft^2 free standing structure on the outside of the RHIC ring at the 8 o'clock position. Building 1008C is located just south of Building 1008B. The structure is a one-story, prefabricated insulated metal building, built in 1997. The floor is reinforced concrete. The facility houses water treatment, water circulating pumps, and cooling tower controls for PHENIX. And induced draft, prefabricated metal cooling tower is located to the south of the building.

The construction types of this building are considered to be BCNYS Type IIB and NFPA Type II (000).

Building 1008E

Building 1008E is a one-story modular office building with an area of approximately 4,300 ft^2. The building was built in 1999.

The construction types of this building are considered to be BCNYS Type IIB and NFPA Type II (000).

Building 1008F

Building 1008F is prefabricated, 2-hour fire rated storage facility. It has an area of approximately 800 ft^2. An open-air pad for the storage of gas cylinders is located to the east of the building. Cylinders are stored and connected to manifolds on a concrete pad. Metal racks are provided to secure the cylinders. The building was built in 2000.

The construction types of this building are considered to be BCNYS Type IB and NFPA Type II (222).

Life Safety Code

The LSC does not specify a minimum construction type for existing business and industrial [§39.1.6; §40.1.6] occupancies. Thus, the existing construction for each of the buildings complies with LSC requirements.

Building Code of New York State

Section 503 and Table 503 of the BCNYS contain criteria for the allowable height and area of buildings based on their occupancies and construction type.

Special industrial-style buildings that are required to have large areas and unusual heights in order to accommodate special equipment are exempt from the prescribed height and area limitations [BCNYS §503.1.2]. This code provision is considered applicable to Building 1008.

Based on the limited sizes of Buildings 1008A (9,800 ft^2), 1008B (4,000 ft^2), 1008C (1,125 ft^2), 1008E (4,300 ft^2), and 1008F (500 ft^2), the buildings comply with the construction type criteria as prescribed in Chapter 5 of the BCNYS.

4.3 Passive Fire Protection

Passive fire protection features include fire-resistive construction, fire doors, fire windows, and fire and smoke dampers. The features are provided to limit fire spread and damage from the area of fire origin to other portions of the building.

4.3.1 Fire Areas

A fire area is defined as a portion of a building that is bounded by a combination of fire-resistive walls and floor/ceiling assemblies, and/or exterior walls. In DOE facilities, fire areas are typically provided for property protection. The Implementation Guide for DOE Order 420.1 requires credited fire areas to be separated from the remainder of the building by a minimum of 2-hour fire barriers (walls and horizontal assemblies). Fire areas may also be provided for compliance with building code limitations for building additions. With the exception of Building 1008, all buildings in the PHENIX experimental complex are considered as single fire areas for the purposes of this analysis. Building 1008 is not subdivided with physical fire barriers multiple fire areas are possible due to construction features, inherent fire resistance, and operational considerations. The following section discusses fire barriers within the building.

4.3.2 Fire Barrier Integrity

The IR houses the majority of high valued equipment (greater than $50 million). The RHIC tunnel opens to the IR on the north and south sides. Generally a fire barrier would be provided to separate such a concentration of high value magnet strings in the tunnel from the PHENIX Experiment. Due to the configuration of the beam transport system and the IR, a fire rated barrier was not installed.

An Exemption Request has been granted from DOE allowing the Fire Walls to be omitted. [“Approval of Exemption Request for the Relativistic Heavy Ion Collider at Brookhaven National Laboratory (BNL),” dated February 19, 1999.]

The following is a list of mitigating features described in the granted exemption request:

1) Low combustibility of the RHIC Tunnel and contents

2) Spot type smoke detection in the tunnel

3) Redundant rate of rise/fixed temperature heat detection units at each detector location

4) Heat detection and preaction sprinkler system in the IR (area of some combustibles)

5) Highly sensitive smoke detection in the IR at the ceiling level

6) Low pressure of flammable gases in the IR (no significant flame impingement from a leak)

7) Limited volume of gas in the IR (limited burn time)

8) Shielding effect of the Muon Steel Plates from the PHENIX gas systems

9) A vapor barrier for the liquid helium oxygen deficiency hazard that acts as a smoke barrier, segregating the tunnel sections from the IR on both sides

10) The RHIC tunnel has an emergency smoke ventilation system, activated by tunnel smoke detectors

11) The IR has an emergency ventilation system independent from the RHIC tunnel system

5.0 FIRE PROTECTION

Existing fire protection systems that provide protection to all or portions of this facility can be classified into four categories; Automatic Fire Suppression Systems, Fire Alarm Systems, Automatic Detection Systems, and Fire Extinguishers. The following is a description of the existing systems in the building.

5.1 Automatic Fire Suppression Systems

5.1.1 Site Water Supply

BNL has a combination domestic and fire protection water supply system. The system is supplied by several deep wells and is stabilized by two elevated water storage tanks (one 1 million gallon and 300,000 gallon capacity). The wells have electric primary drivers and a limited number have backup internal combustion drivers. The system can sustain three days of domestic supply and a maximum fire demand (4,000 gallons per minute (GPM) for 4 hours) for BNL with two of the system's largest pumps out and one storage tank unavailable. The piping distribution network is well gridded. BNL has a combination domestic and fire protection water supply system. The system is supplied by several deep wells and is stabilized by two elevated water storage tanks (one 1 million gallon and 350,000 gallon capacity). The wells have electric primary drivers and a limited number have backup internal combustion drivers. The system can sustain three days of domestic supply and a maximum fire demand (4,000 gpm for 4 hours) for BNL with two of the system's largest pumps out and one storage tank unavailable. The piping distribution network is well gridded. Water supplies around the RHIC Ring Road are fed from two well separated connections to the BNL system. Ample valves provide isolation in case of a main break. Static water pressure to the PHENIX complex is typically 70 psi. Water supplies to the complex are capable of supplying 1,700 gpm with 60 psi residual pressure.

Frost proof fire hydrants are provided within 300 ft of each facility. Frost proof hydrants are needed since the frost line extends to 4 feet below the surface in the winter. BNL and the local Suffolk County Fire Departments use National Standard Thread couplings.

BNL's Plant Engineering Division maintains the water supply system. BNL's Fire/Rescue Group conducts valve inspections on the distribution system to ensure reliability of firefighting water supplies.

5.1.2 Building Water Supply and Fire Department Connection

Each sprinkler system riser is provided with a Fire Department Connection (FDC). The nearest hydrant is less than 100 feet from the fire department connections as required by code. The two 2 ½ inch outlets on the FDCs conform to National Standard Thread couplings standard. The piping between the Fire Department Connections and the supply side of the Alarm Check Valve Assembly is 4 inch. The pipe connects to the system side of the Alarm Check Valves.

5.1.3 Sprinkler Systems

Building 1008

The PHENIX Experimental Hall and Assembly Hall are provided with automatic pre-action sprinkler protection in accordance with NFPA 13. The systems are designed to provide 0.17 gpm/ft^2 over a design area of 3,000 ft^2 with a hose stream demand of 250 gpm. Waterflow alarms are connected to the building fire alarm system. Sprinkler valve supervision reports through the Site Fire Alarm System as supervisory devices.

Building 1008A

The PHENIX Service Building area and mechanical equipment spaces in Building 1008A are provided with automatic pre-action sprinkler protection in accordance with NFPA 13. The systems are designed to provide 0.15 gpm/ft^2 over a design area of 2,500 ft^2 with a hose stream demand of 250 gpm. Waterflow alarms are connected to the building fire alarm system. Sprinkler valve supervision reports through the Site Fire Alarm System as supervisory devices.

Buildings 1008B, 1008C, 1008E, and 1008F

Buildings 1008B, 1008C, 1008E, and 1008F are not sprinklered protected.

5.1.4 Fire Standpipe Systems

Standpipes are provided in the IR and AH via the wet pipe standpipe system serving the RHIC Accelerator Tunnel. This is a wet system, provided with hose connections (no hose provided) for Fire/Rescue use.

5.1.5 Gaseous Suppression System

None

5.2 Fire Alarm Systems

The facilities have fire alarm systems that are connected to the Site Fire Alarm system.

5.2.1 Site Fire Alarm System

Brookhaven National Laboratory provides central fire alarm station coverage using a fault tolerant sever infrastructure based multiplexed Site Fire Alarm System. The system is an Andover Continuum; installed in 2005 (Andover is a part of Simplex Grinnell). The system complies with the requirements of NFPA 72 defined as a Style 6 Class “A” System.

Two mirrored servers are located in separate buildings. If the lead server fails the system automatically switches over to the working server. The Site Fire Alarm System operates on a fault tolerant high speed Ethernet infrastructure that utilizes network switches and fiber wiring between each of the major components.

The Site Fire Alarm System monitors fire alarm panels located throughout BNL by uses the existing site telephone cable plant. RS232 signals are sent via full duplex line drivers. Each fire alarm panel has two channels connected to the Site Fire Alarm System. The panels are divided into 9 communication “loops.” It is currently monitoring 9,700 points. Response time from alarm at the panel to alarm indication at the Central Station is less than 82 seconds, which is within the 90 seconds allowed by NFPA 72.

The main console is at the Firehouse, Bldg. 599. This station monitors all fire alarm signals, trouble and communication status alarms. A satellite station is provided at Safeguards and Security, Bldg. 50, and receives only the fire alarm signals. If the Firehouse does not acknowledge an alarm within 90 seconds, the satellite station at Bldg. 50 will receive an audible indication to handle the alarm. A second satellite station is provided at AGS Main Control Room, Bldg. 911, and receives only the fire alarm signals from the RHIC/AGS accelerator buildings. A team of Collider-Accelerator Control Room operators and Health Physics Support personnel respond during accelerator operating times.

5.3 Automatic Detection Systems

5.3.1 PHENIX Detector

<u>Electronics Cabinets</u>

On the PHENIX Detector, electronics are housed in enclosed steel racks. These racks are purged with air; therefore ceiling level detection is not effective. Given the high value of the equipment, smoke detection has been installed in the racks. Each rack is provided with a spot-type smoke detector. The detectors in the racks are grouped to allow interlocks to shutdown power to specific racks upon alarm. The rack system is tied into the building fire alarm system and will activate building wide audible/visual devices. Building fire alarms and the rack fire alarm panel have battery backup (24 hour capacity) and emergency generator power (24 hour capacity).

HSSD on the Detector

An HSSD is installed within the PHENIX Detector and has three levels of alarm; the first level alarm requires PHENIX Detector operator attention; the second level alarm involves the operator and the Fire/Rescue Group for investigation; the third level alarm will initiate electrical shutdown, flammable gas detector purge/vent sequences, and building emergency exhaust ventilation for the IR, as appropriate.

This application of HSSD technology does not fit standard installation rules. Best engineering judgment has been used for detector port placement. Factors influencing placement included normal air flow, collection points for smoke, location of ignition sources (electronic printed circuit cards, power devices as opposed to signal circuits). Detector ports have been spaced at 400 sq ft spacing.

5.3.2 Highly Sensitive Smoke Detection (HSSD)

A Highly Sensitive Smoke Detection (HSSD) System is provided within the IR and AH of the PHENIX Detector. The HSSD system has three levels of alarm. The first level alarm is a local alarm intended for the control operators. Second level alarms also sound locally, but also summons the Fire/Rescue Group for investigation. A third level alarm requires a full response by the Fire/Rescue Group and activates building audible/visual devices, PHENIX Detector power off, emergency Detector vent/purge, and building emergency exhaust fans.

The HSSD Control Panel is tied into the building fire alarm system and will activate building-wide audible/visual devices upon a third level alarm. The building fire alarms and the HSSD system have battery backup (24 hour capacity) and emergency generator power (24 hour capacity).

5.3.3 Combustible Gas Detection

An air-sampling combustible gas detection system is installed for experimental operations using flammable gases within the PHENIX Detector. The air-sampling system consists of a network of tubes that connect to a selector valve system. The selector valves and detection assembly are located outside of the IR. Sample points are located on and around the detector based on potential leak points, potential collection points, normal air flow patterns, and the detector's construction. There is no installation standard for this type of application. The flame ionization system uses a selector valve system to cycle through the sampling tubes and monitor combustible gas levels. Detection cycles and lengths of sampling points will ensure response to a leak within 90 seconds. Individual channel values are displayed and programmed for alarm and output functions. There will be warning levels in the ppm range, in which operators will investigate and monitor the situation. Higher readings will force action levels at 25% of the Lower Explosive Limit, which will entail notification of Fire/Rescue, electrical shutdowns, vent and purge of detector chambers. The system will be on emergency power to provide continued operations during power outages.

5.3.4 Building 1008A PHENIX Counting House

Spot-type smoke detection is provided in the tech lab area and office area of Building 1008A. Smoke detectors are also provided in areas where high-value electronics are present. Heat detection is installed in areas not provided with smoke detection.

5.4 Fire Extinguishers

Portable fire extinguishers are required in existing business and industrial occupancies [§39.3.5;].

Fire extinguishers have been installed throughout facilities associated with the PHENIX Experimental Complex. Clean agent units are installed in the IR, AH, and Rack Room. Multipurpose units are installed in other areas. The location and placement of portable fire extinguishers is in accordance with NFPA 10, *Standard for Portable Fire Extinguishers*.

6.0 FIRE HAZARDS

Fire hazard potentials are classified into four major categories; Building Materials, Special Occupancies, Exterior Hazard Exposure, and Natural Hazard Exposure. The following is an evaluation of the Building 1006 complex for each category.

6.1 Occupancy and Associated Fire Hazards

6.1.1 PHENIX Detector

The PHENIX Detector is located in the IR. Two heavy ion beams from the Relativistic Heavy Ion Collider (RHIC) collide in the middle of the hall. The detector and its multiple subsystems monitor the ensuing events. Various systems are used to track these interactions. Six of the eleven systems at PHENIX have gas mixtures with flammable components; the largest being the RICH detector with two chambers each containing 40 m^3 of pure ethane. These large quantities of flammable gas are housed in thin-windowed pressure vessels. Typically the windows on these vessels are Kapton, with a thickness of 5 mils. Maximum operating pressures are ½-inch water column.

The electronics on the PHENIX Detector is the main potential ignition source. Therefore the cabinets on the Carriages are pressurized with air to prevent infiltration of flammable gases.

The electronics and cable within the PHENIX Detector have been selected to be low combustibility and self-extinguishing (FR4 printed circuit boards, IEEE 383 rated cables, UL listed cables for NEC plenum/riser/general use applications, IEC 332-2/UL1581 VW-1 ratings).

6.1.2 Intersection Region

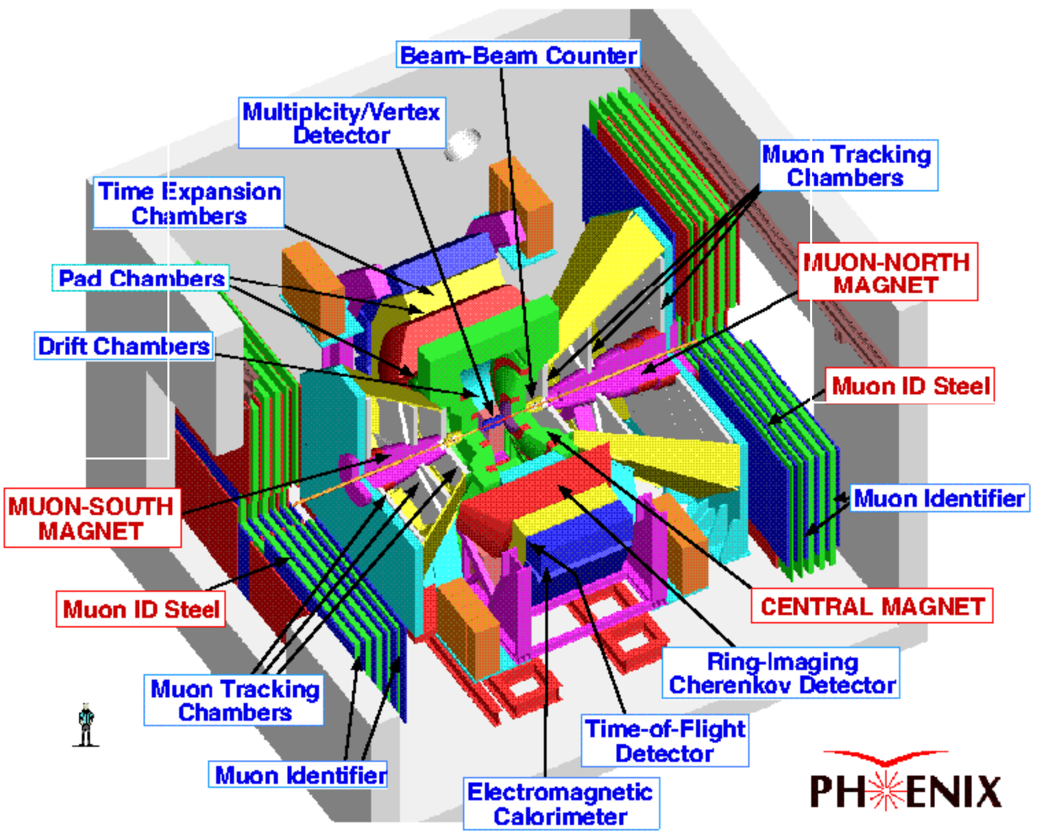
The IR is classified as Group F-1, special-purpose industrial occupancy. The area is considered a high hazard industrial occupancy in accordance with the Life Safety Code due to the likelihood of a rapidly developing fire.

6.1.3 Assembly Hall

The AH is used for staging and as an assembly area for the various PHENIX Detector subsystems. Fire hazards in the AH include those discussed for the IR, with the exception of flammable gases. However, small quantities of flammable gases may be permitted with the review and approval of the RHIC Experimental Safety Review Committee. The occupancy is considered an ordinary hazard industrial facility for the purpose of classifying this facility for code applications.

6.1.4 Building 1008A

Building 1008A is used as a control facility and houses the support services (Data Acquisition, control electronics, laser calibration, control room, console room). The Rack Room



will occasionally be occupied. The Control/Console room will have operators and support staff on a frequent basis. The primary fire hazards associated with this building are electronics, cabling, and ordinary combustible materials. The facility is classified as a predominantly Group B, business occupancy with incidental equipment spaces.

6.1.5 Building 1008B

An interior one-hour fire rated room is located in the building to house pump controllers, vacuum controllers, and similar instrumentation (valued at less than $500,000). PHENIX has several power supplies on a metal frame, metal deck mezzanine in the building. There are three supplies valued at approximately $100,000 each. They consist of dry transformers and associated electronics. The remainder of the facility is a RHIC “cold box”. This is the power supply transition point from warm to cryogenic buss for the RHIC Accelerator Magnets in the RHIC Tunnel. The building is classified as a low hazard industrial facility.

6.1.6 Building 1008C

Building 1008 C is used for a pump house and water system supporting PHENIX. Circulating pumps and deionizers for the cooling water system are located in the building. A prefabricated metal cooling tower is located to the south. There is no high value equipment located in the facility.

6.1.7 Building 1008E

Building 1008E is a modular office building. There is no high value equipment located in the facility.

6.1.8 Building 1008F

Building 1008F is the PHENIX Gas Mixing building. There is no high value equipment located in the facility.

6.2 Special Occupancies

6.2.1 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, the data collected from the experiment is vital. Given the vital nature and cost associated with the collection of the data, the protection of records in Building 515 should be reviewed (**See Recommendation HAI-07-1008-01**). This information is collected by the facility and transported to the RHIC Computing Facility in Building 515, Brookhaven Computing Facility (a separate facility several miles away, connected by computer network). Except for a minimally sized buffer arrangement, on-site storage of data in not provided.

6.2.2 Trailers and Portable Structures

There are no trailers or portable structures associated with Building 1008.

6.2.3 Electrical Substations

An electrical substation is located to the north of Building 1008A. According to the previous FHA the installation complies with the recommendations in Factory Mutual Loss Prevention Data Sheet 5-4 for fire protection. The emergency generator is separated by a two hour rated firewall from the transformer yard. The transformers and generator do not present an exposure hazard to the facility or each other.

6.2.4 Flammable Liquid and Gas Storage

Six of the subsystems at PHENIX use gas mixtures containing flammable gases. Their inventory represents significant hazards. The PHENIX Design Basis Accident study assumed a release of the full gas inventory of all systems with subsequent homogeneous mixture prior to ignition. The results demonstrated that damage does not extend to areas outside of the normally occupied PHENIX Experimental Hall area and only minimally affects the AH. The following is an inventory of flammable gases in use:

Detector	Gases Used	Total Detector Volume (m^3)
Drift Chamber (DC)	Ar/C_2H_6 (50%/50%)	5.6
Pad Chambers (PC)	Ar/C_2H_6 (50%/50%)	1.12
Time Expansion Chamber (TEC)	Ar/CH_4 (90%/10%)	11.5
Ring Imaging Cherenkov Counter (RICH)	C_2H_6 (100%)	80
Muon Tracker (Mu Tr)	CF_4/C_4H_{10} (50%/50%)	2.92
Muon Identifier (Mu ID)	CO_2/C_4H_{10} (91%/9%)	59

The RHIC Experimental Safety Review Committee has examined the design and installed configurations of the Detector and its subsystems. Release of gases into the IR has been addressed by the following features:

1) Flow limiters in supply lines and limitations on the quantities for flammable gas systems,

2) Solid metal piping from the supply to the Detector’s distribution systems (with the exception being at the base of both carriages and the Muon Magnet System where a flexible pipe is used),

3) Requirements for leak checking of piping systems,

4) Detector chambers are designed to ensure window integrity (burst safety factor),

5) Pressure tests that assure chamber construction meets design boundary limits,

6) Designed to fail-safe upon loss of power (i.e. purge of flammables with inert gases),

7) Combustible gas detection in the regions where gas could be released and collect,

8) Highly sensitive smoke detection to promptly indicate off-normal conditions,

9) Interlocks to shut off power to the Detector in the event of fire alarm conditions from within the Detector (Detector purge/vent is also started),

10) Fusing of power distribution system on printed circuit boards within the PHENIX Detector to limit the maximum front end power dissipation potential (normally under 80 watts),

11) Mechanical protection for chamber windows that may expand during over pressurization and contact electronics,

12) Continuous purging of the interstitial space between Pad Chambers, Front End Electronics and RICH windows with an inert gas,

13) Continuous purging of electronic racks and AC power distribution panels with fresh air to prevent flammable gas contacting non-rated electrical equipment,

14) Normal ventilation in the IR to dissipate combustible gases ("normal leakage"),

15) High rate purge, activated with interlocks, in the IR to dilute and remove released gases,

16) Monitoring of oxygen content of flammable detector gas in the detector system,

17) For all new equipment brought into the interior of the IR, Class I, Division II criteria was imposed for classification of electrical devices (existing circuits were not retrofitted, but dilution over the travel distance from the devices to the source makes these devices unlikely ignition sources).

The quantity of flammable gas is of particular concern. The PHENIX Project study on the explosion potential from the flammable gases used (refer to PHENX Safety Analysis Document) reviewed several cases of accidents. Under "ideal" conditions severe damage could occur to the entire contents of the IR.

The vent/purge time of the Detector's larger flammable gas chamber is complicated by the window chamber relief pressure of ¾-inches of water column, the distance and height of the vent stack through the radiation shielding, and the density of the gas.

Normal venting of excess Detector gas occurs through a system called the Low Capacity Vent Stack (LCVS). Gas lines terminate within an exhaust duct, located in the soil, on the outside back wall of the IR. A ventilation fan forces a draft up the bent stack from the bottom. The fan is monitored for flow. The fan's cfm dilutes the gases below their lower explosive limits by at least a factor of four (assuming maximum flow from the vent lines). The LCVS vents about the radiation shield, above the roof.

Emergency venting of the Detector gasses occurs through a second system called the High Capacity Vent Stack (HCVS). The Detector is connected to a 4-1/2 inch O.D. header and then to a 30-inch stack which travels in the soil up the outer wall of the IR to above the roof's berm. The system has a fan mounted on the top of the vent to induce air flow by aspiration. This arrangement requires 3 to 4 hours in order to effect several air changes and ensure concentrations less than the lower explosive limit in the detector.

The Gas Mixing House contains flammable gas cylinders connected to supply manifolds. Connects are made often, therefore the room is classified as a Class I, Division II area for electrical equipment.

6.3 Housekeeping in Vital Areas

Acceptable housekeeping and control of combustibles was observed during this survey. The BNL Plan Review Process screens conventional construction operations.

6.4 Building Materials

There are no building or construction materials that pose a significant fire hazard.

6.5 Exposure Hazards

6.5.1 Exterior Exposure Hazards

Any exterior structure, area or piece of equipment that is subject to harmful effects from, or can cause harmful effects to this facility is defined as an exterior exposure. Exterior exposures can be categorized as: elements outside of the facility, and as components of the facility.

The PHENIX Gas mixing shed and gas storage pads meet the National Fire Protection Association and Factory Mutual Loss Prevention Data sheets separation guidelines. These exposures do not present an undue hazard to Building 1008.

The electrical sub station to the north of Building 1008A meets the Factory Mutual Loss Prevention Data Sheet on electrical transformer yard separation. The emergency generator is separated by a two hour fire wall from the house transformer yard. These exposures do not present an undue hazard to Building 1008.

The PHENIX complex is located in the middle of the Pine Barrens. Pine trees and shrubs pose a potential exposure to the facilities. Although the roof systems will not ignite from burning brands produced in a brush fire, the metal walls do not provide a thermal barrier. Vegetation management is in place to maintain a clear area around the structures.

6.5.2 Components of the Facility

Exposures between components of the facility are minimal. Suppression, detection, and passive fire barriers are in place to provide adequate protection.

6.6 Natural Phenomenon Hazard Exposure

Natural Hazards can be classified in five hazard categories: lightning, windstorm, wild fire, earthquake and flooding. The following is an evaluation for each category.

6.6.1 Lightning Potential

The lightning damage potential for Building 1008 is a concern based on NFPA 780 Annex L “Lightning Risk Assessment” calculation. Following the Risk Assessment methodology the expected lightning frequency (N_d) of 0.0239 is greater than the tolerable lightning frequency (N_c) of 0.0002 (calculations shown in Appendix B of this report). NFPA 780 recommends that a lightning protection system be installed when the expected frequency is greater than the tolerable frequency (**See Recommendation HAI-07-1008-02**).

6.6.2 Windstorm Potential

The Long Island area basic wind speed (3-second gust) is 120 MPH based on Factory Mutual Data Sheet 1-28 and BCNYS figure 1609.4. The ground roughness exposure category for the Building 1008 area is ‘Exposure B.” Based on the calculations this building should have roof assemblies classified as “Class 90” rated assemblies. The portions of Building 1008 and the seamed roof metal built up roofs of Buildings 1008A, 1008B, and 1008C are in good repair. The roof of the Counting House complies with Factory Mutual I-90 rating from windstorm resistance.

Potions of the PHENIX Experiment have gas filled chambers with thin windows, typically 5 mil Kapton (the TEC is 1 mil). These chambers operate at pressures slightly over atmospheric pressure. The gas system design is capable of accommodating rapid pressure drops due to storms. For large chambers, buffer volumes are provided to provide prompt supplies. Details are contained in the RHIC Experimental Review Committee files.

6.6.3 Brush Fire Potential

An analysis was completed consistent with the requirements and guidelines of NFPA 1144 *Protection of Life and Property from Wildfire* (2002) to determine the wildfire risk to Building 1008. The risk assessment was conducted in accordance with the Wildfire Hazard Severity Form checklist of NFPA 1144. The checklist is a summary of typical desirable characteristics found in various wildfire hazards analyses. Elements include emergency response ingress and egress, type of vegetation, topography, building construction and roofing materials, available fire protection, and utilities.

The PHENIX Complex is located in the middle of the Pine Barrens. Pine trees and shrubs do pose a potential exposure to the insulated metal structures. Vegetation control practices limit the exposure potential to the structures.

Based on the analysis, the hazard from wildfire to the Building 1006 Complex is “LOW.” Specifics of the Wildfire Hazard Severity Analysis are shown in Appendix C of this report.

6.6.4 Earthquake Potential

The seismic damage potential for this facility is classified as low based on a Natural Hazards analysis produced for the BNL campus titled “DOE Accelerator Order 5480.25 Implementation Plane for Brookhaven National Laboratory National Phenomena Hazards Evaluation” dated April 1994. A low seismic classification means that the buildings and fire protection systems are not required to comply with seismic design standards.

6.6.5 Flooding Potential

Flood potential from bodies of water overflowing their normal levees is low for the BNL area. The flooding potential for this facility was classified as low in a Natural Hazards Analysis report produced for the BNL site, dated April 1994, titled “DOE Accelerator Order 5480.25 Implementation Plane for Brookhaven National Laboratory National Phenomena Hazards Evaluation.”

Ground water runoff from a severe rainstorm could be a concern for the Building 1006 complex due to the surrounding terrain which is at a higher elevation along the south side of the WAH (an earth berm is provided along the RHIC tunnel). However, further evaluation is beyond the scope of this analysis.

6.7 Toxic Fire Potential

There are no known toxic materials present in the complex that present a release potential due to fire.

6.8 Biological Fire Potential

There are no known biological materials present in the complex that present a release potential due to fire.

6.9 Radiation Fire Potential

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 since the material will not be easily disbursed.

For calibration of instruments, several small sealed calibration sources will be present. These sources do not have the curie content or the physical state to present a radiological concern if exposed to or involved in a fire.

No other radioactive materials are used or stored in the PHENIX Complex.

7.0 PRE-FIRE AND EMERGENCY PLANNING

The BNL Fire Department maintains an adequate pre-fire plan book for this facility **(**http://intranet.bnl.gov/emergencyservices/runcards/main_i.asp**).** The pre-plan was reviewed as part of this analysis.

7.1 Protection of Essential Safety Class Systems

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

7.2 Protection of Vital Programs

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

7.3 Protection of High Value Property

High value equipment is generally regarded as any single item that is valued at $1 million or more, or where the loss of a single item could result in a loss of program continuity of greater than six months.

The majority of the dollar value is concentrated in the IR and the Control Room. During periods of maintenance, the PHENIX Detector is relocated to the AH. With over $60 million concentrated in the IR, multiple fire systems have been installed.

The HSSD detection system on the PHENIX Detector, combined with the on-site Fire/Rescue Group, is considered the primary response system. This system will summon aid at the earliest practical stages (local alarms and signals to Fire/Rescue) and initiate protective actions (power off, vent/purge flammable gases, activate emergency vent in IR as appropriate). This primary response posture is unusual in the DOE arena; typically automatic sprinkler protection is considered the primary protection with detection and manual response redundant protection. However, based on the type of hazards involved with the PHENIX experiment, the automatic sprinklers are considered the third level of response capability due to their relative slow activation in this type of environment. Spot-type smoke detectors have been placed above the platform racks and initiate the same actions as the HSSD. Printed circuit boards are FR-4 (flame resistant). Wires, cables, and materials were also specified as flame resistant.

A secondary level of protection is provided by the building's ceiling-level HSSD system. It will detect a fire in the IR/AH and start the same protective actions (fire department response) as the HSSD on the Detector.

A third level of protection will be provided by the pre-action sprinkler system. It is anticipated that this system will only activate when a sustained fire occurs in the Detector and all other controls have failed. As addressed above, normally automatic sprinklers would be considered the primary protection, but due to the long activation time, for this case sprinklers are considered the third level of protection.

7.4 Critical Process Equipment

The PHENIX Detector is divided into several sub-systems, some of which are not required for the entire experiment to operate. However without the full compliment of systems, the quality of physics will suffer. The following is a matrix of subsystems, total construction costs (including engineering and design), and a replacement value for as-is systems.

System	Total Construction Cost	Estimated Replacement Cost
Ring Imaging Cherenkov (RICH) Counter	$6.8 million	$6.3 million
Time Expansion Chamber (TEC)	$5.4 million	$2.9 million
Drift Chamber (DC)	$2.2 million	$1.8 million
Central Magnet	$2.5 million	$1.8 million
Muon Magnet North	$8.8 million	$5.9 million
Muon Magnet South	$6.6 million	$5.6 million
Electro Magnetic Calorimeter (EM Cal) (Lead Scintillator)	$4.7 million	$3.7 million
Electro Magnetic Calorimeter (EM Cal) (Lead Glass)	$6 million	$5.6 million
Time of Flight (ToF)	$2 million	$1.6 million
Muon ID North	$4.8 million	$3.5 million
Muon ID South	$3.6 million	$3.3 million
Beam-Beam Counter	$.9 million	$.7 million
Pad Chambers	$4.3 million	$2.8 million

The Support Systems (such as magnets, cooling water, electrical power) are required for PHENIX operations. The majority of components in these systems are common and easily deliverable.

7.5 Maximum Possible Fire Loss (MPFL) and Maximum Credible Fire Loss (MCFL)

The MPFL, as defined in DOE Order 420.1, is the value of property within a fire area, unless a fire hazard analysis demonstrates a lesser (or greater) loss potential, assuming the failure of both automatic fire suppression systems and manual fire fighting efforts. The fire loss estimate includes the replacement cost of equipment and property and any applicable decontamination and cleanup costs.

In accordance with the BNL Fire Safety Program, protection is required for facilities having an MPFL in excess of established thresholds as follows:

- When the MPFL exceeds $1 million an automatic sprinkler system designed in accordance with applicable NFPA standards is required;
- When the MPFL exceeds $25 million, a redundant fire protection system is required such that, despite the failure of the primary fire protection system, the loss will be limited to $25 million; and
- When the MPFL exceeds $50 million, a redundant fire protection system and a 3-hour fire resistance rated barrier are required to limit the MPFL to $50 million.

7.5.1 MPFL Scenario

A single MPFL is considered for the buildings of the PHENIX Experimental Complex.

The following fire area tabulations are utilized when determining the MPFL and MCFL loss potentials.

Fire Area	Building Area (ft^2)
Building 1008	11,874
Building 1008A	9,848
Building 1008B	4,007
Building 1008C	1,163
Building 1008E	4,276
Building 1008F	787

7.5.2 MPFL Calculation

Building values were obtained from 2004 replacement costs. The average dollar density of a building is the replacement value divided by the floor area of the building. Content and equipment values were calculated based on the following assumptions:

- An average of $20/ft^2 for content and equipment value within predominantly office areas.
- An average of $100/ft^2 for content and equipment value within the industrial and experimental areas of the building.

- The PHENIX experiment has a replacement value of approximately $43,000,000.

PHENIX Experiment (11,874 ft²)		$ Value
Building		$3,000,000
Contents – PHENIX Experiment		$43,000,000
Contents – Misc.		$500,000
	MPFL	$46,500,000
Building 1008A (9,848 ft²)		$ Value
Building		$1,500,000
Contents		$1,000,000
	MPFL	$2,500,000
Building 1008B (4,007 ft²)		$ Value
Building		$600,000
Contents		$400,000
	MPFL	$1,000,000
Building 1008C (1,163 ft²)		$ Value
Building		$350,000
Contents		$200,000
	MPFL	$550,000
Building 1008E (4,276 ft²)		$ Value
Building		$1,000,000
Contents		$100,000
	MPFL	$1,100,000
Building 1008F (787 ft²)		$ Value
Building		$100,000
Contents		$50,000
	MPFL	$150,000

7.5.3 MCFL Scenario

The MCFL, as defined in DOE Standard 1066-99 Fire Protection Criteria, is the value of property within a fire area, unless a fire hazard analysis demonstrates a lesser (or greater) loss potential. This assumes that all installed fire protection systems function as designed, and the effect of emergency response is omitted except for post-fire actions.

The maximum credible fire scenario is one in which automatic suppression systems function as designed. For the purposes of the MCFL determination a design area of 3,000 ft^2, is assumed. Since properly designed and installed sprinkler systems should limit the fire growth and/or damage to the design area this floor area was used in the determination of MCFL potentials when protected by automatic sprinkler systems. For those buildings without sprinkler protection the MCFL is the same as the postulated MPFL for that area. The following building cost factors are approximated and have been utilized in the determination of the MCFL:

Building	Cost ($)	Area (ft^2)	Factor ($\$/ft^2$)
1008	3,000,000	11,874	253
1008A	1,500,000	9,848	152

PHENIX Experiment ($11,874\ ft^2$)		$ Value
Building	$3000\ ft^2 \times \$253/ft^2 =$	$760,000
Contents	$3000\ ft^2 \times \$100/ft^2 =$	$300,000
	MCFL	$1,060,000
Building 1008A ($9,848\ ft^2$)		**$ Value**
Building	$3000\ ft^2 \times \$152/ft^2 =$	$460,000
Contents	$3000\ ft^2 \times \$100/ft^2 =$	$300,000
	MCFL	$760,000

Buildings 1008B, 1008C, 1008E, and 1008F are not provided with sprinkler protection. Therefore the MCFL is the same as the MPFL.

7.5.4 MPFL/MCFL Summary

Fire Area	MPFL	MCFL
Building 1008	$46,500,000	$1,060,000
Building 1008A	$2,500,000	$760,000
Building 1008B	$1,000,000	$1,000,000
Building 1008C	$550,000	$550,000
Building 1008E	$1,100,000	$1,100,000
Building 1008F	$150,000	$150,000

7.6 Recovery Potential

The recovery time to rebuild the PHENIX Experiment could easily exceed 6 months.

7.7 BNL Fire/Rescue Group

The BNL Fire/Rescue Group is a full time, paid department. Minimum staffing is five firefighters and one officer per shift. The firefighters are trained to meet Firefighter Level III by International Fire Service Training Association standard, National Fire Protection Association (NFPA) Fire Fighter Level II standard, and (NFPA) Hazardous Material Technician Level and they are Suffolk County Certified Confined Space Rescuers.

The BNL Fire/Rescue Group also provides emergency medical services to an on-site population of 3200 people. Minimums of two members per shift hold New York State “Emergency Medical Technician - D” certifications (“D” is for defibrillation). Normally all five firefighters have EMT status. The Group operates a New York State Certified Basic Life Support ambulance. Medivac services are available to BNL via the Suffolk County Police Department. Additionally the Fire/Rescue Group has two 1500 GPM "Class A" Pumpers, one

Rescue Vehicle for initial hazardous material incident response and heavy rescue operation, and one Incident Command Vehicle.

The single Fire Station is located on the west side of the BNL Site. Response time to the most remote section of the BNL Site is less than eight minutes. Response time to Building 1008 is estimated at 5 minutes.

BNL participates in the Suffolk County Mutual Aid Agreement. This allows the resources from over 130 departments to assist BNL. BNL is also a member of the Town of Brookhaven Foam Bank. BNL has a mutual aid agreement for hazardous material incidents with the Town of Brookhaven and Stonybrook University.

7.8 Fire Apparatus Accessibility

Fire apparatus accessibility is adequate for the facility. Current parking lot configurations allow access by apparatus in the event of an emergency.

7.9 Security Considerations Related to Fire Protection

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

8.0 LIFE SAFETY CONSIDERATIONS

Life safety considerations for this facility include means of egress consisting of exit access, exits and exit discharge, exit signage, and emergency lighting. This building is required to comply with state building codes and NFPA 101, the *Life Safety Code* (LSC). The requirements of both the 2002 edition of the Building Code of New York State (BCNYS) and the 2006 edition of the LSC have been applied to this analysis. It should be noted that the BCNYS is not intended to apply to existing structures. Appendix K of the BCNYS addresses alterations to existing structures.

8.1 Occupancy Load Factor and Calculations

The occupant load per floor level for code purposes is calculated in Table 8.1-1 based on applicable occupant load factors specified in LSC Table 7.3.1.2. An occupant load factor of 300 sq ft per person was applied to special-purpose industrial and mechanical/electrical equipment areas. Factors for these spaces are not specified in the LSC.

Table 8.1-1

Occupant Load Calculation

Building	Floor Area (sq ft)	Occupant Load Factor (sq ft per person)	Occupant Load (persons)
Building 1008	11,400	300	38
Building 1008A	9,800	100	43
Building 1008B	9,800	100	18
Building 1008C	1,125	100	12
Building 1008E	4,300	100	43
Building 1008F	500	300	2

8.2 Means of Egress

8.2.1 Number and Arrangement of Exits

The LSC requires that a floor with an occupant load of 500 or fewer persons must have a minimum of two means of egress [§7.4.1.1]. Additional exits may be required for compliance with exit capacity or arrangement of exits criteria.

Building 1008

The AH is provided with two exits directly to the exterior. The electrical equipment, mechanical equipment, and gas (storage and mixing) rooms are each provided with exit doors to the exterior. The IR is considered a high hazard industrial occupancy per the Life Safety Code. Placement of doors is sufficiently separated to comply with the separation of exits. By using the removable plug doors for all access, two exits are available whenever the IR is entered..

Buildings 1008A, 1008B, 1008C, 1008E, and 1008F,

The number and capacity of exits serving Buildings 1008A, 1008B, 1008C, 1008E, and 1008F, are adequate for the specific occupancies.

8.2.2 Capacity of Exits

The egress capacity provided from a floor or portion thereof must be sufficient to accommodate the occupant load. The egress capacity for an egress component is based on the width of the component. For stairways, the factor of 0.3 in. of stair width per person is applied. For doors, ramps, corridors, and other level components, the factor of 0.2 in. of width per person is applied.

Based on the limited occupancy of the buildings and the egress widths of exit doors, the egress capacity provided is adequate for the buildings.

8.2.3 Travel Distance

The exit access travel distance is the distance from an occupiable point to the nearest exit or exit enclosure. The maximum exit access travel distances for the occupancies involved are provided in Table 3.2.3 [LSC §39.2.6; §40.2.6].

Occupancy	Maximum Allowable Exit Access Travel Distance (ft) (sprinklered)
Business (sprinklered)	300
Special-Purpose Industrial	400

Where open stairways serve as means of egress, the travel distance must include the travel on the stairway and the distance to reach an outside door or other exit [§7.6.2].

The buildings are in compliance with exit access travel distance limitations.

8.2.4 Common Path of Travel

The maximum allowable common path of travel for business and special purpose industrial occupancies is 100 ft (sprinklered)/75 ft (nonsprinklered) and 100 ft respectively. The common path of travel from mechanical equipment rooms, boiler rooms, and similar spaces is permitted to be not more than 100 ft [LSC §7.12.1(1) (c)].

8.2.5 Dead Ends

Dead-end corridors must not exceed 50 ft in industrial and business occupancies [LSC §39.2.5.2; Table 40.2.5]. The BCNYS limits dead-end corridors to not more than 50 ft in fully-sprinklered Group B or Group F occupancies [§1004.3.2.3, Ex. 2]. No dead-end corridors exceeding these limitations were identified.

8.2.6 Security Considerations Related to Fire Protection

There are no security considerations which relate to fire protection at this facility. Radiation Security barriers comply with the Life Safety Code for egress.

8.2.7 Separation of Means of Egress

Where two exits or exit access doors are required, they must be located at a distance from one another not less than one-third the length of the maximum overall diagonal dimension of the building or area served [LSC §7.5.1.3.2; BCNYS §1004.2.2.1, Ex. 2]. The buildings comply with the separation of means of egress criteria as required by the BCNYS and LSC in all areas.

8.3 Exit Signs and Emergency Lighting

Exit signage is required in accordance with Section 7.10 of the LSC. Exit signs should be placed in corridors and in rooms required to have at least two means of egress. Internally-illuminated exit signs and exit placards are provided in the buildings.

Emergency lighting for means of egress is required in accordance with Section 7.9 of the LSC. Emergency lighting is required in a building classified as a business occupancy where the business occupancy is subject to 100 or more occupants above the level of exit discharge, the building is two or more stories in height above the level of exit discharge, or the business occupancy is subject to 1,000 or more total occupants [§39.2.9.1]. Emergency lighting is required in industrial occupancies [§40.2.9.1] except special-purpose industrial occupancies without routine human habitation. Emergency lighting is provided throughout the buildings. Ceiling light fixtures connected to the emergency generator are distributed in many areas. Emergency light modules equipped with battery packs are provided elsewhere.

8.4 Egress through Adjoining/Intervening Spaces

Exit access from rooms or spaces is permitted to be through adjoining or intervening rooms or areas, provided that such rooms or areas are accessory to the area served and the intervening rooms or areas are not spaces identified under Protection from Hazards (e.g., storage rooms) [LSC §7.5.1.6]. The buildings comply with this requirement. Intervening rooms through which required egress occurs are accessory and not higher hazard to the area served.

8.5 Exit Discharge

Exits are required to terminate directly at a public way or at an exterior exit discharge. Exits provided from the buildings discharge to the exterior of the buildings as required.

8.6 Fire Protection Systems Required by Code

Additional protection measures have not been identified as necessary. The MPFL and MCFL calculations included in this analysis are approximations. The estimated amounts can be considered in compliance with DOE thresholds requiring automatic suppression.

8.7 Operational Requirements that are Required by Code

There are no other fire protection related operational requirements required by code.

9.0 REFERENCE DOCUMENTS

9.1 National Fire Protection Association

NFPA 10, *Standard for Portable Fire Extinguishers*, 2002 Edition

NFPA 13, *Standard for the Installation of Sprinkler Systems*, 2002 Edition

NFPA 30, *Flammable and Combustible Liquids Code*, 2003 Edition

NFPA 51B**,** *Standard for Fire Prevention during Welding, Cutting, and Other Hot Work*, 2003 Edition

NFPA 55, *Standard for the Storage, Use, and Handling of Compressed Gases and Cryogenic Fluids in Portable and Stationary Containers, Cylinders, and Tanks*, 2005 Edition

NFPA 70, *National Electrical Code*®, 2005 Edition

NFPA 72®, *National Fire Alarm Code*®, 2002 Edition

NFPA 80, *Standard for Fire Doors and Fire Windows*, 1999 Edition

NFPA 90A, *Standard for the Installation of Air-Conditioning and Ventilating Systems*, 2002 Edition

NFPA 101®, *Life Safety Code*®, 2006 Edition

NFPA 780, *Standard for the Installation of Lightning Protection Systems*, 2004 Edition

NFPA 1144, *Standard for Protection of Life and Property from Wildfire*, 2002 Edition

9.2 FM Global Loss Prevention Data Sheets

5-4, Transformers

APPENDIX A –

FHA FIGURES

APPENDIX B –

LIGHTNING RISK CALCULATION

The expected lightning frequency (Nd) is **0.0394** and the tolerable lightning frequency (Nc) is **0.0008**. Based on NFPA 780, If Nd > Nc, a lightning protection system should be installed.

EXPECTED LIGHTNING STROKE FREQUENCY FROM NFPA 780 ANNEX L

$$N_d = (N_g)(A_e)(C_1)(10^{-6})$$

N_d =	**0.0239**	= yearly average flash density in the region where the structure is located
(N_g) =	**2.0**	= the yearly lightning strike frequency to the structure
(C_1) =	**1.00**	= the environmental coefficient
(A_e) =	**11,962**	= the equivalent collective area of the structure in square meters from calculation below

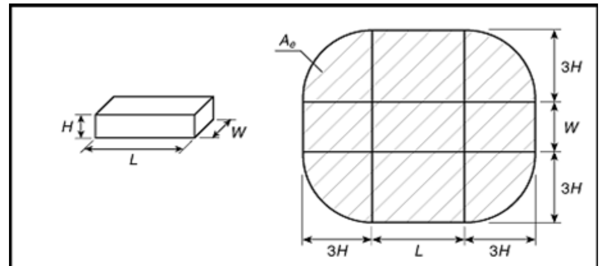
Length (L)	**110**	Feet
Width (W)	**110**	Feet
Height (H)	**45**	Feet
	0.25	
Figure H.4.2(a) Results	11,962	sq. meters
Figure H.4.2(b) Results	5,319	sq. meters

Table H.4.3 Determination of Environmental Coefficient C_1

Relative Structure Location	C_1
Structure located within a space containing structures or trees of the same height or taller within a distance of 3*H*	0.25
Structure surrounded by smaller structures within a distance of 3*H*	0.5
Isolated structure, no other structures located within a distance of 3*H*	1
Isolated structure on a hilltop	2

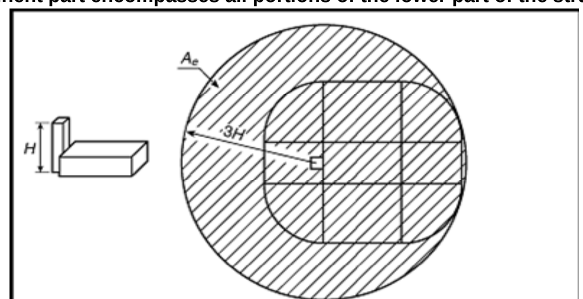
Assume
1.00

Figure H.4.2(a) Calculation of the equivalent collective area for a rectangular structure.



For a rectangular structure, $A_e = LW + 6H(L + W) + \pi 9H^2$.

Figure H.4.2(b) Calculation of the equivalent collective area for a structure where a prominent part encompasses all portions of the lower part of the structure.



Note: For a structure where a prominent part encompasses all portions of the lower part, $A_e = \pi 9H^2$

= input required

TOLERABLE LIGHTNING FREQUENCY FROM NFPA 780 APPENDIX L

$$N_c = \frac{1.5 \times 10^{-3}}{C}$$

where $C = (C_2)(C_3)(C_4)(C_5)$.

N_c = **0.0002**

Assume **1.0**

C_2 — Structural Coefficients			
	Roof		
Structure	**Metal**	**Nonmetallic**	**Flammable**
Metal	0.5	1.0	2.0
Nonmetallic	1.0	1.0	2.5
Flammable	2.0	2.5	3.0

Assume **2.0**

Structure Contents	C_3
Low value and nonflammable	0.5
Standard value and nonflammable	1.0
High value, moderate flammability	2.0
Exceptional value, flammable, computer or electronics	3.0
Exceptional value, irreplaceable cultural items	4.0

Assume **1.0**

Structure Occupancy	C_4
Unoccupied	0.5
Normally Occupied	1.0
Difficult to evacuate or risk of panic	3.0

Assume **5.0**

Lightning Consequence	C_5
Continuity of facility services not required, no environmental impact	1.0
Continuity of facility services required, no environmental impact	5.0
Consequences to the environment	10.0

[ ] = input required

APPENDIX C –

DETERMINATION OF WILDFIRE HAZARD SEVERITY USING NFPA 1144

ELEMENT	POINTS
A. Means of Access	
1. Ingress and egress	
a. Two or more roads in/out	**0**√
b. One road in/out	7
2. Road width	
a. >= 24 ft	0
b. >= 20 ft and < 24 ft	**2**√
c. < 20 ft	4
3. All-season road condition	
a. Surfaced road, grade <5%	**0**√
b. Surfaced road, grade > 5%	2
c. Non-surface road, grade < 5%	2
d. Non-surface road, grade > 5%	5
e. Other than all-season	7
4. Fire Service Access	
a. <= 300 ft with turnaround	**0**√
b. > 300 ft with turnaround	2
c. < 300 ft with no turnaround	4
d. >= 300 ft with no turnaround	5
5. Street Signs	
a. Present	**0**√
b. Not present	5
B. Vegetation (Fuel Models)	
1. Characteristics of predominate vegetation within 300 ft.	
a. Light (e.g., grasses, forbs, sawgrassess, and tundra) NFDRS Fuel Models A,C,L,N,S, and T	5
b. Medium (e.g. light brush and small trees) NFDRS Fuel Models D,E,F,H,P,Q, and U	**10**√
c. Heavy (e.g. dense brush, timber, and hardwoods) NFDRS Fuel Models B,G, and O	20
d. Slash (e.g. timber harvesting residue) NFDRS Fuel Models J,K, and L	25
2. Defensible space	
a. More than 100 ft of vegetation treatment from the structures	1
b. 71 ft to 100 ft of vegetation treatment from the structures	
c. 30 ft to 70 ft of vegetation treatment from the structures	**10**√
d. < 30 ft of vegetation treatment from the structures	25
C. Topography Within 300 of Structures	
1. Slope < 9%	**1**√
2. Slope 10% to 20 %	4
3. Slope 21% to 30%	7

4. Slope 31% to 40%	8
5. Slope > 41%	10

D. Additional Rating Factors

1. Topographical features that adversely affect wildland fire behavior	0-5 [**0**√]
2. Areas with a history of higher fire occurrence than surrounding areas due to special situations	0-5 [**0**√]
3. Areas that are periodically exposed to unusually severe fire weather and strong dry winds.	0-5 [**0**√]
4. Separation of adjacent structures that can contribute to fire spread	0-5 [**0**√]

E. Roofing Assembly

1. Class A roof	0
2. Class B roof	**3**√
3. Class C roof	15
4. Nonrated	25

F. Building Construction

1. Materials	
a. Noncombustible/fire-resistive siding, eaves, and deck	**0**√
b. Noncombustible/fire-resistive siding and combustible deck	5
c. Combustible siding and deck	10
2. Building setback relative to slopes of 30% or more	
a. >= 30 ft to slope	1
b. < 30 ft to slope	5

G. Available Fire Protection

1. Water source availability	
a. Pressurized water source availability	
500 gpm hydrants <= 1000ft apart	**0**√
250 gpm hydrants <= 1000ft apart	1
b. Nonpressurized water source availability	
>= 250 gpm continuous for 2 hours	3
< 250 gpm continuous for 2 hours	5
c. Water unavailable	10
2. Organized response resources	
a. Station <= 5 miles from structure	**1**√
b. Station > 5 miles from structure	3
3. Fixed fire protection	
a. NFPA 13	**0**√
b. None	5

H. Placement of Gas and Electric Utilities

1.	Both underground	**0**√
2.	One underground, one aboveground	3
3.	Both aboveground	5

I. Total **18**

Hazard Assessment	Total Points
Low hazard	**< 40**
Moderate hazard	40-69
High hazard	70-112
Extreme hazard	> 112

A Wildfire Severity Level of 32 = A LOW Hazard