Fire Hazard Analysis
Building 928
Siemens Motor Generator Power Supply

Brookhaven National Laboratory

Prepared by:

B. Campbell,
Hughes Associates, Inc.
2 Garden Center, Suite 204
Broomfield, CO 80020

Project Review by: Signatures on File

M. Kretschmann PE, Fire Protection

Concurrence:

Department Chair

Date of Last Survey: None on record
Date of Report: June 2007

CONFERRED WITH:

Michael Kretschmann, PE	Fire Protection Engineering
Joe Levesque, Manager	Emergency Services Division
John Marauglia.	Collider-Accelerator Department
Mike Bannon	Collider-Accelerator Department
Nick Laloudakis	

TABLE OF CONTENTS

1.0 OVERVIEW AND RECOMMENDATIONS

1.1 Purpose and Methodology

A Fire Hazard Analysis (FHA) was performed for Building 928, the Siemens MG Power Supply Facility at the Brookhaven National Laboratory (BNL), Upton, NY. 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 928 to ascertain whether the facility meets 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 Building 928 and (2) that are inherent in the building or operations. The adequacy of the fire safety features in the building and the degree of compliance of the facility 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 building 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 values were calculated based on the following assumptions:

- An average of $\$20/ft^2$ for content and equipment value within predominantly office or support areas.
- An average of $\$100/ft^2$ for content and equipment value within the industrial and experimental areas of the building, assuming no high dollar equipment present.

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 1.3, Findings and 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. Hazard Severity. 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 I. May cause death, permanent total disability, or loss of a facility/asset.

   b. Category II. 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 III. May cause minor injury, occupational illness, or property damage.

   d. Category IV. 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 928, the Siemens Motor Generator Power Supply facility provides regulated electrical power to the Alternating Gradient Synchrotron (AGS). It was constructed in 1969, operational in 1970 and is 18,086 square feet.

The descriptions are based on field surveys, a review of the as-built documents, and discussions with BNL staff. This assessment and FHA demonstrates the achievement of a reasonable and equivalent level of fire safety that meets DOE improved risk objectives.

Overview of the BNL

This Fire Hazards Analysis (FHA) has been performed to comprehensively assess the risk from fire in Building 928, the Siemens MG Power Supply facility. The FHA includes an analysis of the fire and life safety features of the facility to determine the level of compliance with DOE Order 420.1 Fire Protection objectives.

Based on the analysis, it has been determined that Building 928 is not in compliance 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: Automatic sprinklers are not provided over the lube oil pumps in the basement area.

Hazard Severity	III
Mishap Probability	B
Risk Assessment Code	3

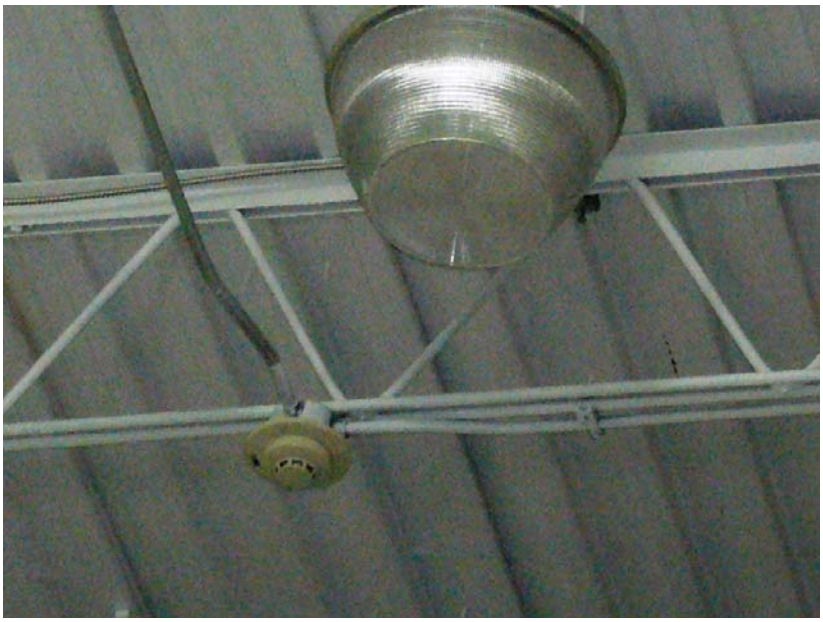
Recommendation HAI-07-928-01: Automatic sprinkler protection should be provided over the lube oil pumps in the basement, as a minimum and throughout out the basement if possible. (See Section 5.1.3)

Photograph #1 – Lube Oil Pumps

Finding: The location of the smoke detectors in the high bay, over the Siemens Motor Generator appear to be too far below the ceiling (greater than 3-feet). It could not be determined from available documentation if the mounting height was in consideration of stratification effects.

Hazard Severity	III
Mishap Probability	B
Risk Assessment Code	3

Recommendation HAI-07-928-02: The smoke detectors should be evaluated by Fire Protection Engineering and either approved or corrective actions initiated to ensure their placement is in accordance with NFPA 72, Sections 5.7.3, 5.7.3.1, 5.7.1.10, 5.7.3.2.1 and 5.7.3.2.3 as well as the listing for these spot detectors. (See Section 5.3)



Photograph #2 – Smoke Detector in the High Bay

Finding: The motor generator hall is not provided with an automatic fixed fire protection system. The motor generator is a high value one-of-a-kind piece of equipment that has a long lead-time and is vital to the AGS.

Hazard Severity	III
Mishap Probability	B
Risk Assessment Code	3

Recommendation HAI-07-928-03: A fixed fire suppression system should be provided in the motor generator hall. Systems that could be considered include, (See Section 5.1.3):

- Automatic sprinklers located at the ceiling (assuming the response time based on the height of the ceiling is evaluated and determined as reasonable)
- Directional spray nozzles for the motor generator, and lube oil pump
- Partial flooding or local flooding (to the height of the motor generator) gaseous fire suppression system

Finding: Combustibles are located in the unprotected high bay.

Hazard Severity	III
Mishap Probability	B
Risk Assessment Code	3

Recommendation HAI-07-928-04: The combustibles should be removed. (See Section 4.2)

Photographs #3 and #4 – Combustibles in the High Bay

Finding: There are ABC fire extinguishers in the electronic areas of the building.

Hazard Severity	III
Mishap Probability	C
Risk Assessment Code	4

Recommendation HAI-07-928-05: The ABC extinguishers should be replaced with extinguishers suitable for areas with electronic equipment. (See Section 5.4)

Finding: The building is not provided with a lightning protection system. Per Appendix B, a lightning system is recommended, based on NFPA 780.

Hazard Severity	I
Mishap Probability	C
Risk Assessment Code	2

Recommendation HAI-07-928-06: The building should be provided with a lightning protection system in accordance with NFPA 780. (See Section 6.6.1)

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

Rec.No.	Recommendation	RAC
HAI-07-928-1	Automatic sprinklers for the lube oil pump area	3
HAI-07-928-2	Location of smoke detectors in the high bay	3
HAI-07-928-3	Fire Protection for the Motor Generator	3
HAI-07-928-4	Remove combustibles from the high bay	3
HAI-07-928-5	Replace the ABC fire extinguishers with	4

Rec.No.	Recommendation	RAC
	extinguishers suitable for electronic equipment areas	
HAI-07-928-6	Provide a lightning protection system	2

1.3.2 Outstanding Recommendations from Previous Reviews

Factory Mutual

FMR74-928-1 Automatic sprinklers on a wet pipe system should be provided in the basement of Building 928 in the lubrication oil pump room and over the oil heat exchanger area and for 40 feet to the east or provide a 1-hour rated cutoff between the oil handling equipment and the remainder of the basement. Sprinklers would be needed over the oil handling equipment in either case.

Note: The oil pumps are located in a metal enclosure that appears to meet the 1-hour criteria, thus HAI-07-928-01 only recommends automatic sprinklers above the oil pumps as a minimum and for the entire basement if possible.

Hazard Severity	III
Mishap Probability	B
Risk Assessment Code	3

FMR74-928-2 Automatic water spray protection should be provided for the transformers and associated equipment located south of and adjacent to Building 928.

Note: This recommendation is being carried forward because water spray protection will provide exposure protection for the building.

Hazard Severity	II
Mishap Probability	C
Risk Assessment Code	3

FMR74-928-3 The house trailer occupied as a machine shop adjacent to the north wall of Building 928 should be relocated.

Note: The trailer has been removed.

Hazard Severity	N/A
Mishap Probability	N/A
Risk Assessment Code	N/A

2.0 SCOPE

This FHA is based on information supplied by the Accelerator Department staff, a survey of the facility conducted in May 2007, 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)

International Code Council (ICC), International Building Code (IBC) 2003 Edition;

ICC, International Fire Code (IFC) 2003 Edition

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

3.0 LOCATION

Building 928 is located in the central west region of Brookhaven National Laboratory (BNL). 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.

4.0 CONSTRUCTION

4.1 Occupancy Classification

Building 928, the Siemens MG Power Supply Building is classified by the BCNYS (Sec. 306.1) as "Factory Industrial F-2 Low Hazard" occupancy." NFPA 101 (3.3.152.8.3) classifies this buildings as "Industrial, Special Purpose" occupancy.

4.2 Construction Type

The building consists of metal panel walls on unprotected steel with a metal deck roof on unprotected steel. The floor is concrete on unprotected steel.

The building construction type is BCNYS Type IIB and NFPA Type II (000).

The primary combustible loading in the building consists of the motor generator (MG), power and control wiring for the MG, and the lubrication oil and oil pumps for the MG. Except for the lubrication oil, none of the materials are highly flammable. The small amounts of control cable, all are expected to self-extinguish upon the de-energizing of electric power without propagation to other equipment. Wood and other combustible loading was found in the high bay that introduces unnecessary combustible loading (**See Recommendation HAI-06-928-04**).

Life Safety Code

The LSC does not specify a minimum construction type for existing special purpose industrial occupancies [§39.1.6; §40.1.6]. The LSC permits an occupant load of not more than 1,000 persons and located at the level of exit discharge to be within a building of Type II(000) construction regardless of automatic sprinkler protection [LSC Table 13.1.6]. Thus, the existing construction 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.

The BCNYS permits an increase in allowable areas for buildings that have more than 25 percent of their perimeter on a public way or open space having a minimum width of 20 feet [IBC, §506.2]. The area increase due to frontage is determined in accordance with the following equation:

$$I_f = 100[F/P - 0.25] W/30, \text{ where:}$$

If = Area increase due to frontage.

F = Building perimeter which fronts on a public way or open space having 20 feet open minimum width (feet).

P = Perimeter of entire building (feet).

W = Width of public way or open space (feet). The width (W) must be at least 20 feet and W/30 cannot exceed 1.0.

Building 928 is 18,086 square feet, which is within the base allowable area of 23,000 square feet for Type IIB, thus it is not necessary to apply the increase for public way.

Table 4.2-1. Allowable Height and Areas for BCNYS Group F-2

	Group F-2	
	Type IIA*	**Type IIB**
Base Height	65 ft 5 stories	55 ft 3 stories
Base Area (ft^2)	37,500	23,000
Modified Area (ft^2) based on public way	65,625	40,250

increases		

*Shown for illustration purposes only

International Building Code

Based on an F2 occupancy and Type II-B construction, Table 503 of the IBC permits the maximum allowable area to be 23,000 square feet and a height of 3 stories. Since Building 928 is 18,086 square feet, which is within the base allowable area of 23,000 square feet, it is not necessary to apply the increase for public way.

Section 506 and 507 of the IBC contain allowable area increases based on the location of the building and sprinkler protection, if provided. The areas limited by Table 503 can be increased due to frontage and automatic sprinklers based on the following:

$A_a = A_t + [A_t I_f / 100] + [A_t I_s / 100]$

Where:

A_a = Allowable area per floor

A_t = Allowable floor area per Table 503

I_f = Area increase due to frontage (percent) as calculated in accordance with 506.2

I_s = Area increase due to sprinkler protection (percent) as calculated in accordance with Section 506.3.

$I_f = 100[F/P - 0.25] W/30$

Where:

I_f = Area increase due to frontage

F = Building perimeter which fronts on a public way or open space having 20 feet open minimum width

P = Perimeter of entire building

W = Width of public way

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

Building 928 is not subdivided; however, most of the penetrations from the basement to the first floor are protected. The door from the basement to the first floor is not rated.

Photographs #5 – Penetrations; Basement to First Floor

Building 928 complies with the codes of record with respect to occupancy separations. There are no areas in this facility that are defined as incidental or accessory occupancy use areas as noted in BCNYS "§302.1.1" or NFPA 101 §6.1.14.1.2 and "§6.1.14.1.3."

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.

5.0 FIRE PROTECTION

Existing fire protection systems that provide protection to full or segmented portions of this facility can be classified in four categories; Automatic Fire Suppression Systems, Fire Alarm, Automatic Detection Systems, and Fire Extinguishers. The following is a description of the existing installed 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 one 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 of service and one storage tank unavailable. The piping distribution network is well gridded. The distribution system in the vicinity of Building 928 has a static supply pressure of approximately 57 pounds per square inch (PSI) at low elevated tank levels; and approximately 70 psi normally (as read at Building 929). The water supply system in the area can supply about 5,500 GPM at 20 PSI (based on the Water Distribution Model Analysis developed by the Fire Protection Engineering Group during the summer of 2004.)

Frost proof Fire hydrants are provided within 300 ft of the entrances of the building. 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

Building 928 is generally not provided with automatic sprinklers. The new control room is protected with automatic sprinklers, fed from Building 929.

5.1.3 Sprinkler Systems

There is no automatic sprinkler protection in the building. A recommendation is being submitted to provide automatic sprinklers or another form of fixed protection in the generator hall and over the lube oil tanks to limit the loss potential in the building.

5.1.4 Fire Standpipe Systems

One automatic wet standpipe system conforming to NFPA 14 is installed in this facility, located near the stairway from the first floor to the basement. The class of the standpipe systems, as listed in the BCNYS, is “Class II”. A 1 ½ inch hose outlet is provided that is not provided with hose or nozzles, which is the acceptable practice.

5.1.5 Other Suppression Systems

There is a Halon 1301 fire suppression system in the old control room that consists of two 278 pound (full weight) cylinders. The system is activated via four smoke detectors at the ceiling and four underneath the non-combustible raised floor.

5.2 Fire Alarm Systems

The facility is provided with an automatic fire alarm system as described below.

5.2.1 Building Fire Alarm System

The Building is provided with an automatic fire alarm system, refer to Section 5.3. The main fire alarm panel is a Thorne Multi Zone 20, Number 138, Address 27, Loop 7.

5.2.2 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 using 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

The building is provided with heat and smoke detectors in the following areas:

- Old control room (four smoke detectors at the ceiling and four beneath the sub-floor),
- Basement,
- Motor Generator High Bay,
- New control room, (three smoke detectors and 2 heat detectors beneath sub-floor),
- Rectifier room,

- Mezzanine; 1 heat detector and 1 smoke detector in the storage area,
- 1 heat detector for the two air handling units in the mezzanine area,
- 1 heat detector for the air conditioning unit in the mezzanine area.

The smoke detectors located in the Motor Generator Hall are located on the bottom chord of the bar joists that appear to be greater than 3 feet from the ceiling (roof). Smoke detectors should be mounted to take advantage of the concentration and subsequent spread of the smoke plume when it reaches the ceiling (roof). It appears that the smoke detectors were placed on the bottom chord of the truss for ease of mounting of the j-box.

5.4 Fire Extinguishers

Fire extinguishers are provided in the building. The location and placement of portable fire extinguishers is in accordance with NFPA 10, *Standard for Portable Fire Extinguishers*. However, ABC extinguishers are used in areas with electronic equipment (old control room, rectifier room). These extinguishers should be replaced with extinguishers that are more appropriate in areas with sensitive equipment.

5.5 Smoke Exhaust System

The building is not provided with a manual or automatic smoke exhaust system.

6.0 FIRE HAZARDS

Fire hazard potentials are classified into four major categories; Special Occupancies, Unique Fire Hazards, Housekeeping in Vital Areas, Building Materials, Exterior Exposure Hazards, Natural Phenomenon Hazard Exposure, Toxic Fire Potential, Biological Fire Potential, and Radiation Fire Potential. The following is an evaluation of Building 928 for each category.

6.1 Special Occupancies

Special occupancies include: instrumentation and data processing equipment, vital and important records, trailers, cooling towers, electrical substations, flammable liquid and gas storage, cables and raceways, . The special occupancies applicable to Building 928 are expanded upon in Sections 6.1.1 thru 6.1.7, below.

Building 928 is the Siemens Motor Generator Facility. The motor generator supplies regulated electrical power for the AGS. The motor generator is used to isolate the primary site power from the local utility. It utilizes 120 tons of rotating mass to accomplish this. The input to the generator is 13.8 KV and the output is 7500 volts. The generator is rated at 9000 KW at 1200 rpm. This is the only one of its kind in the country, and would be very difficult to replace. It is equipped with an excess vibration detector.

Photograph #6 – Siemens Motor Generator

6.1.1 Instrumentation and Data Processing Equipment

DOE/EP-0108 established levels of protection for Instrumentation and Data Processing equipment and the facility in which it is housed. The facility does not contain any significant instrumentation or data processing equipment and does not exceed any of the thresholds in DOE/EP-0108 for smoke detection, automatic sprinklers or fire barriers beyond the present level of protection.

Automatic Smoke Detection Protection

Computer equipment rooms or areas that exceed the $250,000 limit established by DOE require smoke detection. There are no computer rooms associated with Building 928. However, there are two control rooms that are protected with single station smoke detectors. Refer to Section 5.3 for details on the areas protected with smoke and heat detection.

Automatic Sprinkler Protection

Computer equipment rooms or areas that exceed the 1 million dollar value limit require sprinkler protection. There are no computer rooms associated with the building. The New Control Room is protected with automatic sprinklers, fed from Building 929.

Fire Barriers

DOE requires fire barriers if the structure and contents exceed 50 million dollar value. No fire barriers are required by this DOE standard in this facility.

6.1.2 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 significant extra expense.

Based on the above definitions, there are no vital or important records in this facility.

6.1.3 Trailers and Portable Structures

Building 937 is a single wide trailer with offices that is provided with heat detection. It is located sufficiently distant (40 feet) from the building to not present an exposure hazard.

6.1.4 Cooling Towers

There is a two cell non-combustible cooling tower located outside of Building 929. This cooling tower does not present a hazard to either Building 928 or 929.

6.1.5 Electrical Substations

There are a number of transformers associated with this facility. Eight large oil filled transformers are located on the South side of the building. The main transformers are located 45 feet apart (center line to center line). They are located 8 feet from the building. These Siemens transformers are unique and one-of-a-kind. Currently new transformers are on order and are scheduled to be placed in service in the summer of 2008. The existing transformers will then be repaired/refurbished and kept as spares. The primary voltage is 7000 volts, the P transformers have a secondary of 2200 volts and the F transformers have a secondary of 434 volts. There are no fire barrier walls between the transformers, nor is there any fixed fire protection systems, the Factory Mutual Recommendation for water spray protection is being carried over to provide exposure protection to the building. From the standpoint of just the transformers, according to facility management, fire walls and fire suppression is not utilized since the facility needs both sets of transformers to operate and a fire wall and fire suppression system will not prevent the damage to the initial unit that is involved in a fire or explosion. Thus the loss of one unit is just as bad as the loss of both units. Additionally new units being placed in-service in about 14 months, with the old units being rebuilt, there will be sufficient redundancy. This view however does not consider the potential damage to the facility from a transformer fire.

The following are details on the transformers for Building 928:

Transformer No.	Voltage (V)	Power (kVA)	Oil (gal)
AGS-149	13800/480	2500	550
AGS-155	13800/480	2500	550
AGS-150	13800/1639	928	400
AGS-151	13800/1639	928	400
AGS-152	13800/1639	928	400
AGS-153	13800/1639	928	400
AGS-154	13800/1639	928	400

Photograph #7 – Siemens Transformers

6.1.6 Flammable Liquid & Gas Storage

The use of flammable liquids in the Building 928 is minimal. The quantity of flammable gases and liquids in the facility is less than the limits mandated by BCNYS Table 307.7(1) "*Maximum Allowable Quantity per Control Area of Hazardous Materials Posing a Physical Hazard*." Use of flammable liquids is in accordance with BNL ES&H Standards (found at https://sbms.bnl.gov/ld/ld08/ld08d481.pdf). A single flammable liquids cabinet is located in the motor generator hall.

6.1.7 Cables and Raceways

High voltage, low voltage, control, and signaling cables are segregated throughout the building in accordance with NEC requirements. The cabling is located in conduits, raceways and cable trays. Most of the power and control cables and wiring in the building have Hypalon

jacketing which has low-toxicity, low-smoke, and self-extinguishing ratings. The use of this jacketing will minimize fire propagation and smoke generation in the event of a fire. Polyvinyl Chloride (PVC) and other flammable types of insulation and jacketing have been kept to a minimum, in accordance with the fire protection program.

Cable trays are easily accessible for manual fire fighting, most are from the basement to the first floor. Cable tray fires are not fast spreading. There is no early warning or fire suppression provided for the cable trays, thus the time to detection of a cable fire will be delayed. This philosophy of easy access by manual fire fighting efforts and early warning detection (which is not present in this building) is described as acceptable in Factory Mutual Loss Prevention Data Sheet 5-31 "Cables and Buss Bars". Recovery time to repair damaged cables is expected to be less than 3 months, as the extent of cable trays in Building 928 is not excessive.

6.2 Unique Fire Hazards

The motor generator utilizes approximately 3200 liters/1200 gallons of DTE-25 lubricating oil. There are three lift pumps and one circulating pump. These pumps are utilized during start-up. Once the motor generator is started, one shaft pump that is located in the motor generator hall is used. The pumps are located in the basement within a steel enclosure. A recommendation has been submitted to provide automatic sprinklers in the enclosure. During normal operation the lubricating oil is at approximately 60 bar and 160 liters/minute.

The basement also contains seven cooling water pumps for the electronic equipment in the building, exciter, motor control center, DC switches, DC filter, and a reference magnet for the AGS.

6.3 Housekeeping in Vital Areas

Good housekeeping and control of combustibles was observed during this survey, except as noted in the motor generator hall (**See Recommendation HAI-07-928-04**). The Collider-Accelerator department self-inspection program (Tier I) monitors routine experimental aspects. The BNL Plan Review Process screens conventional construction operations.

6.4 Building Materials

No exposed polystyrene insulation or other highly combustible building materials are used in the construction or operations at Building 928. Therefore, no special fire protection precautions are required for this facility.

6.5 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.

There are no exterior fire exposures to Building 928, except for Building 929, which is integral to Building 928.

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

Based on NFPA standard 780 a lightning system should be installed. Refer to Appendix B.

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 area is 'Exposure B." Based on the calculations this building should have roof assemblies classified as "Class 90" rated assemblies.

6.6.3 Brush Fire Potential

Building 928 was not included in the "*BNL Wildland Fire Interface Survey Report*," dated August 2002.

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 928. 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.

Based on the analysis, the hazard from wildfire to Building 928 is "LOW" (score of 30, with 40 being the cut-off for low hazard). 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.*"

Groundwater runoff from a severe rainstorm could be a concern for Building 928 due to the surrounding terrain. However, further evaluation is beyond the scope of this analysis.

6.7 Toxic Fire Potential

There are no known toxic materials present in the building that present a release potential due to fire. There were no identified PCB's within the building.

6.8 Biological Fire Potential

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

6.9 Radiation Fire Potential

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

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 operations associated with this facility are not considered to be a DOE vital program. Therefore, no special fire protection precautions, beyond those that are described in this report, 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 Siemens motor generator and transformers meet this criterion. The exact value of this equipment could not be obtained, but clearly exceed $1M.

7.4 Critical Process Equipment

By DOE standards, critical process equipment is considered to be equipment which, if lost or damaged in a fire, could delay a significant component of a major program for a period in excess of 6 months.

By the above definition, the Siemens motor generator and transformers meet this criterion and if lost would impact the operation of the AGS.

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

The building is considered one fire area and thus a single MPFL calculation is being performed. The area contains the support and control equipment for the Siemens Motor Generator Power Supply. The amount and continuity of combustible material is low, with the exception of the combustibles in the Motor Generator Hall (**See Recommendation HAI-07-928-04**).

With the exception of the motor generator hall, combustible loading throughout the building could conservatively be sufficient to potentially reach flashover conditions for heat release rates and fire duration. Flashover indicates that the temperature inside the area would be sufficiently hot to cause multiple fuel package ignitions within the space and result in loss of all contents. Associated compartment temperatures at flashover are generally accepted to be between 500°C (900°F) to 600°C (1100°F). Flashover is generally defined as the transition from a growing fire to a fully developed fire. Fully developed fires impose extensive thermal and physical stresses on fire barriers, the failure of which could lead to fire spread throughout the area. This comparison is conservative since the areas where the combustibles are located within the

building represent a relatively large volume, making flashover unlikely, but possible, and only if there would be significant transient combustibles in any particular area (which would be a gross failure of the combustible loading program).

7.5.2 MPFL Calculation

The building has a replacement value of approximately $3,000,000 ($2,753,573). The building value was obtained from 2004 replacement costs. The average dollar density of the building is the replacement value divided by the floor area of the building $3,000,000/18,086 ft^2 = $166/$ft^2$.

The content and equipment value is calculated based on the following assumptions:

- An average of $20/$ft^2$ for content and equipment value within predominantly office areas, which does not apply to Building 928.
- An average of $100/$ft^2$ for content and equipment value within the industrial and experimental areas of the building.
- There were no available replacement costs provided for the equipment within Building 928. For the purposes of this FHA the value is assumed to be approximately $20,000,000, based on the uniqueness of the Siemens motor generator and associated power supplies and electrical equipment.

MPFL Summary

Attribute	Value
Building Value*	$3,000,000
Contents*	$20,000,000
MPFL Total	$23,000,000

*For this MPFL calculation, Building 928 is considered a single fire area. Continuity of combustibles is not generally present throughout the building, except in the motor generator hall and basement where an oil leak and fire is possible. The MPFL value is within the DOE limits.

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 the fire protection systems function as designed. For Building 928, there is limited automatic sprinklers, thus for the MCFL calculation, the building is assumed to be unsprinklered.

Without sprinkler protection the MCFL is the same as the postulated MPFL for that area.

MCFL Summary

Attribute	Value
Building Value	$3,000,000
Contents	$20,000,000
MCFL Total	$23,000,000

7.5.4 MPFL/MCFL Summary

Fire Area	MPFL	MCFL
Building 928	$23,000,000	$23,000,000

7.6 Recovery Potential

Critical process parts have been identified by the Department. Critical process parts are those items essential to the operations of the facility that require a long lead-time for replacement. Recovery potential is based on the ability to produce and replace electronic equipment and the various power supplies. For Building 928, the Siemens motor generator and the transformers are critical, long lead time equipment. Without this equipment the AGS could not operate.

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. A minimum 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 928 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. Roadways are located on the north, east and south sides of the building.

7.9 Security Considerations Related to Fire Protection

The facility has limited security measures to restrict access (locked doors). Provisions have been made for Fire/Rescue access via provision of master key.

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 the state building code 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. This building was likely constructed to comply with the version of the Life Safety Code NFPA 101 in effect at the time of construction; 1969. DOE now requires all buildings to conform to local building codes and NFPA 101.

8.1 Occupancy Load Factor and Calculations

Occupancy load factor and calculations

The following table summarizes the occupancy load calculations based on both the BCNYS Table 1003.2.2.2 and NFPA 101 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

Location	Occupancy Load Factor (per person)		Area (feet)	Occupant Load Calculations	
	BCNYS	NFPA		BCNYS	NFPA
Building 928	100 gross	300 gross	18,086	181	61
TOTAL			18,086	181	61

The total building occupant load for code compliance purposes is 181 occupants based on the BCNYS or 61 per the NFPA 101. This occupant load exceeds the probable actual number of occupants. The building is occupied routinely throughout the day by generally only a dozen or so personnel at a time. The maximum occupancy is not expected to exceed 25 under most normal activities.

8.2 Means of Egress

The means of egress for the building meets the present code requirements for number and arrangement of exits, capacity of exits, travel distance, common path of travel, dead ends, and security considerations related to egress. The following subsections provide the egress detail for each of the elements.

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.

The building has the following exits:

- First floor; two to the west, three to the North, there are no exits to the east as an exit would lead the personnel into the transformer yard.
- Mezzanine; there is a stairwell to the mezzanine from the first floor, located in the middle of the mezzanine that terminate near an exterior exit. There is also a secondary exit out of the mezzanine to the roof of Building 929.
- Basement; there is a single stairway to the basement and a secondary exit that leads into Building 929. The stairs nearly lead directly to the outside of the building where they terminate on the first floor. The exit into Building 929 is acceptable since the hazards are not higher than those in the basement of Building 928.

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.

Street floor exits (i.e., First Floor) must be sufficient for the occupant load of the street floor plus the required capacity of stairs discharging through the street floor [LSC §40.2.3.3]. The building meets this criterion..

The available exit capacity of Building 928 exceeds the occupant loading based on the BCNYS (Table 1003.2.3) and NFPA 101 (Table 7.3.3.1) for stairways and other egress components in a non-sprinklered facility. Due to the low occupancy of the building, the minimum 36 width is sufficient per Section §7.3.4.1.

8.2.3 Travel Distance

Building 928 egress paths do not exceed the BCNYS and NFPA 101 travel distance limitations. BCNYS (Table 1004.2.4) limits egress travel distance to 300 feet in this type of unsprinklered F-2 occupancy. NFPA 101 (Table 40.2.6 and Section 40.2.6.3) limits egress travel distance to 300 feet in this type of unsprinklered Industrial Special Purpose occupancy.

8.2.4 Common Path of Travel

The building meets the common path of travel criteria found in Section 40.2.5.3 in the Life Safety Code. Since the building is not protected with automatic sprinklers the allowable common path of travel is 50 feet.

8.2.5 Dead Ends

Per Section 40.2.5.2 of the Life Safety Code, and the Fire Code of New York State (FCNYS) (Table 1010.17.2) a dead end corridor cannot exceed 50 feet. The building is in compliance with these criteria.

8.2.6 Security Considerations Related to Fire Protection

The building does not have special access controls to restrict egress or fire rescue ingress.

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-half the length of the maximum overall diagonal dimension of the building or area served [LSC §7.5.1.3.2; BCNYS §]. The building is provided with primary exits that meet this requirement.

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 building.

Emergency lighting for means of egress is required in accordance with Section 7.9 of the LSC. Emergency lighting is required in industrial occupancies [§40.2.9.1] except special-purpose industrial occupancies without routine human habitation. Emergency lighting modules with battery packs are provided on a limited basis in the building.

8.4 Emergency Roof Exits

A means of escape is defined as a way out of a building or structure that does not conform to the strict definition of means of egress but does provide an alternate way out [LSC §3.3.152]. The building has no such arrangement, but does have an exit from the mezzanine to the roof of Building 929, in addition to the stairway that is located in the middle of the mezzanine. It was not necessary to credit this secondary exit.

8.5 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 building complies with this requirement. Intervening rooms through which required egress occurs are accessory and not a higher hazard to the area served.

8.6 Exit Discharge

Exits are required to terminate directly at a public way or at an exterior exit discharge. The LSC permits a maximum of 50 percent of the required number of exits to discharge inside the building provided the level of discharge is fully-sprinklered or the area of discharge is sprinklered and separated from the remainder of the building by fire barriers [§7.7.2.2; §7.7.2.4]. The criterion does not apply to Building 928.

8.7 Horizontal Sliding Doors

Approved, existing horizontal-sliding or vertical-rolling fire doors are permitted in means of egress under the following conditions [LSC §40.2.2.2.4]:

- They are held open by fusible links.
- The fusible links are rated at not less than 165°F.
- The fusible links are located not more than 10 ft above the door.
- The fusible links are in immediate proximity to the door opening.
- The fusible links are not located above a ceiling.
- The door is not credited with providing any protection for life safety purposes (i.e., property protection only).

There are no horizontal exit doors utilized in Building 928.

8.8 Fire Escape Ladders

Fire escape ladders complying with 7.2.9 are permitted in industrial and business occupancies [§40.2.2.10; §39.2.2.10]. Fire escape ladders are permitted as means of egress only where one of the following conditions exists:

- Access to unoccupied roof spaces as permitted by 7.2.8.3.4.
- Secondary means of egress from boiler rooms or similar spaces subject to occupancy not to exceed three persons who are all capable of using the ladder.
- Means of egress from towers and elevated platforms around machinery or similar spaces subject to occupancy not to exceed three persons who are all capable of using the ladder.

Fire escape ladders are not provided in the building.

8.9 Door Heights

Means of egress are required to provide a headroom clearance of not less than 6 ft 8 in. at doorways [LSC §7.1.5.1]. The existing doors meet this requirement.

8.10 Discharge to Roofs

Exits are permitted to discharge to roofs or other sections of the building where the following criteria are met and with approval by the authority having jurisdiction [LSC §7.7.6]:

- The roof/ceiling assembly construction has a fire-resistance rating not less than that required for the exit enclosure.
- A continuous and safe means of egress from the roof is available.

There is an exit from the mezzanine that exits to the roof of Building 929. This is not a credited exit as the single stairway to the mezzanine is sufficient.

8.11 Barriers

8.11.1 Occupancy Separations

Occupancy separations are not required for Building 928 since there is a single occupancy for the building.

8.11.2 Incidental Use Areas

Incidental use areas or hazardous areas are considered those spaces that pose a relatively higher hazard than the predominant occupancy of the area in which they are located. Such spaces are not necessarily classified as high-hazard (Group H) occupancies. Hazardous areas include general storage rooms, boiler or furnace rooms, and maintenance shops. The LSC requires hazardous areas to be separated from adjoining areas by a 1-hour fire resistance-rated barrier without windows or protected by automatic fire suppression systems [LSC §8.7.1.1]. Rooms with severe hazards such as maintenance shops with woodworking and painting are required to have both fire barrier enclosure and automatic fire suppression.

There are no such rooms associated with Building 928.

8.11.3 Separation of Means of Egress

The exits within the building are well separated and meet the separation criteria within NFPA 101.

8.11.4 Exit Access Corridors

Exit access corridor walls are typically constructed of concrete masonry and extend from the floor to the underside of the floor slab above. Fire resistance-rated corridor walls are not required in existing industrial occupancies [LSC §40.3.6].

The BCNYS requires exit access corridors serving a Group F occupancy in non- or partially-sprinklered buildings to be enclosed with 1-hour fire partitions [BCNYS Table 1004.3.2.1].

There are no exit access corridors in Building 928, thus this criterion does not apply.

8.11.5 Vertical Opening Barriers

Not applicable to Building 928.

8.11.6 Egress Stairways

Vertical openings, including stairways, are required to be enclosed with fire-resistive construction to limit fire and smoke spread to other floors.

Vertical openings must be enclosed or protected in accordance with LSC Section §8.6 unless otherwise permitted by the following [§40.3.1]:

1. Unenclosed vertical openings in accordance with 8.6.8.2 shall be permitted.
2. Exit access stairs shall be permitted to be unenclosed in two-story, single-tenant spaces that are provided with a single exit in accordance with §39.2.4.2(5).
3. Unprotected vertical openings shall be permitted in buildings complying with all of the following:

    a. Where protected throughout by an approved automatic sprinkler system in accordance with §9.7.1.1(1);

    b. Where no unprotected vertical opening serves as any part of any required means of egress; and

    c. Where required exits consist of exit doors that discharge directly to grade in accordance with §7.2.1, outside stairs in accordance with §7.2.2, smokeproof enclosures in accordance with §7.2.3, or horizontal exits in accordance with §7.2.4.

The there are no protected egress stairways for Building 928.

8.12 Fire Protection Systems Required by Code

Automatic sprinkler protection is not required to address conditions found in the building.

8.13 Operational Requirements that are Required by Code

When performed, cutting and welding operations in the building are required to be conducted in accordance with NFPA 51B**,** *Standard for Fire Prevention during Welding, Cutting, and Other Hot Work*, 2003 Edition.

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 70, *National Electrical Code*®, 2005 Edition

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

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

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

NFPA 220, Standard on *Types of Building Construction*

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

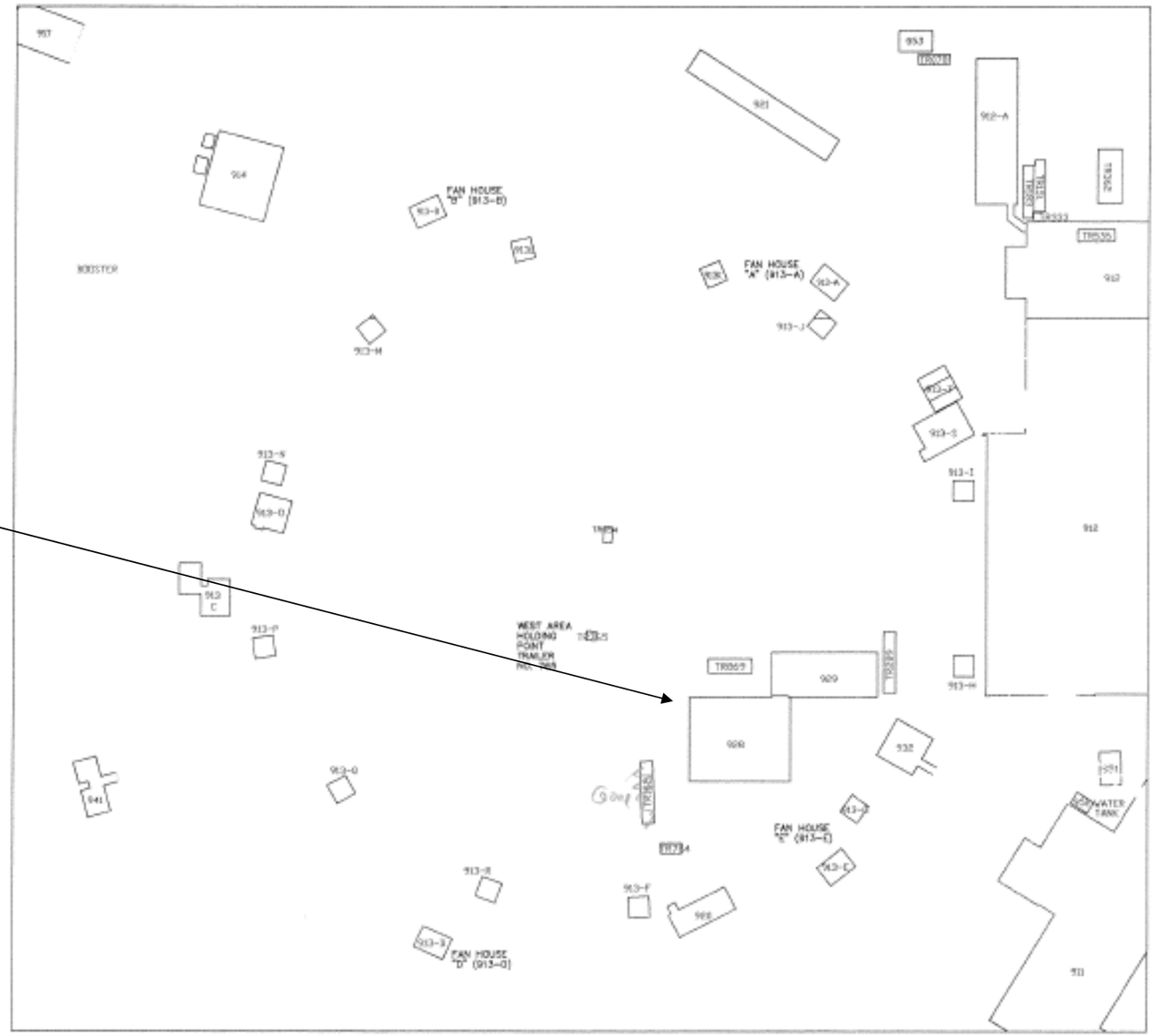
NFPA 1144, *Standard for Protection of Life and Property from Wildfire*, 2002 Edition

9.2 FM Global Loss Prevention Data Sheets

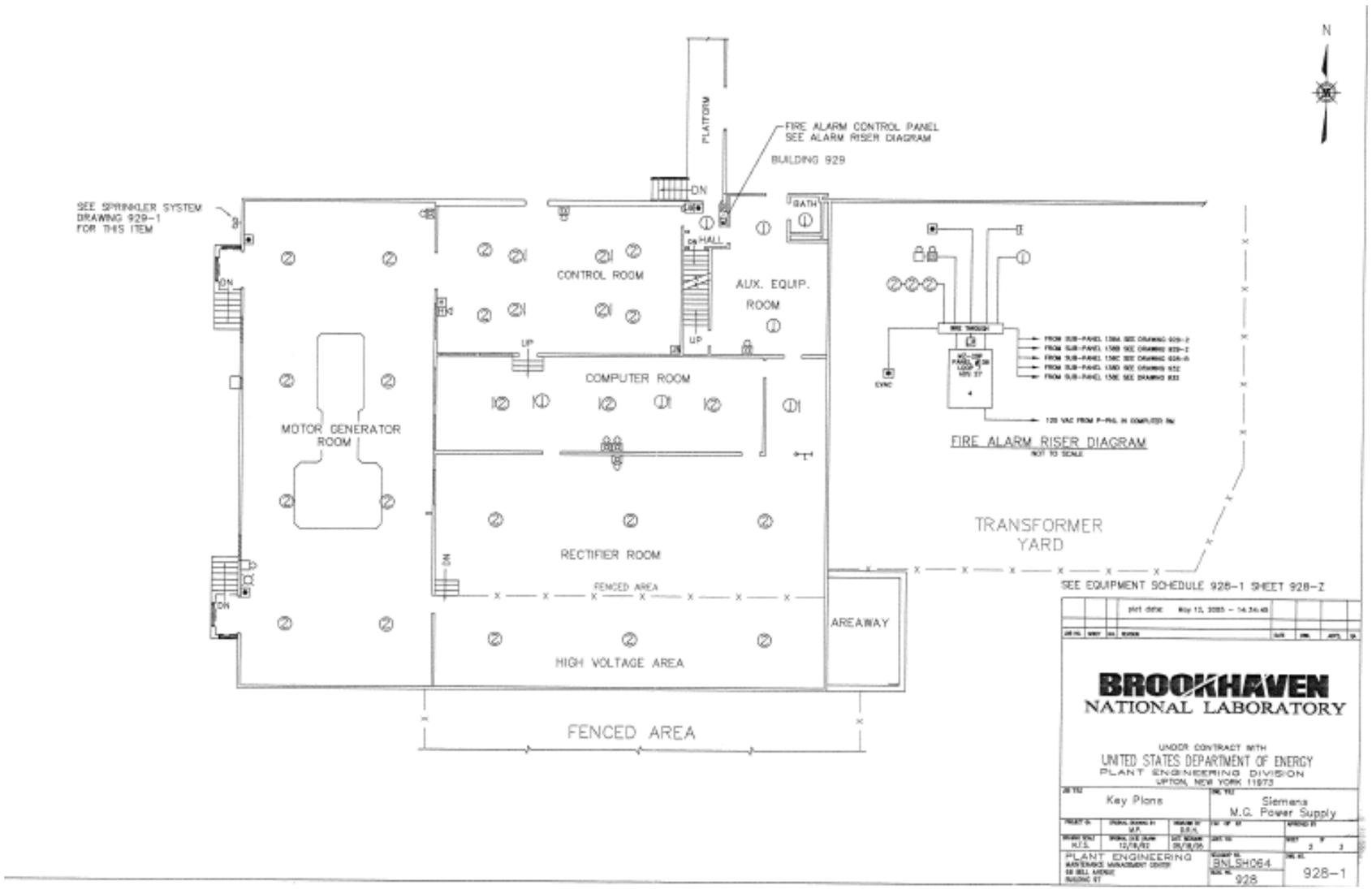
None.

APPENDIX A – FHA FIGURES

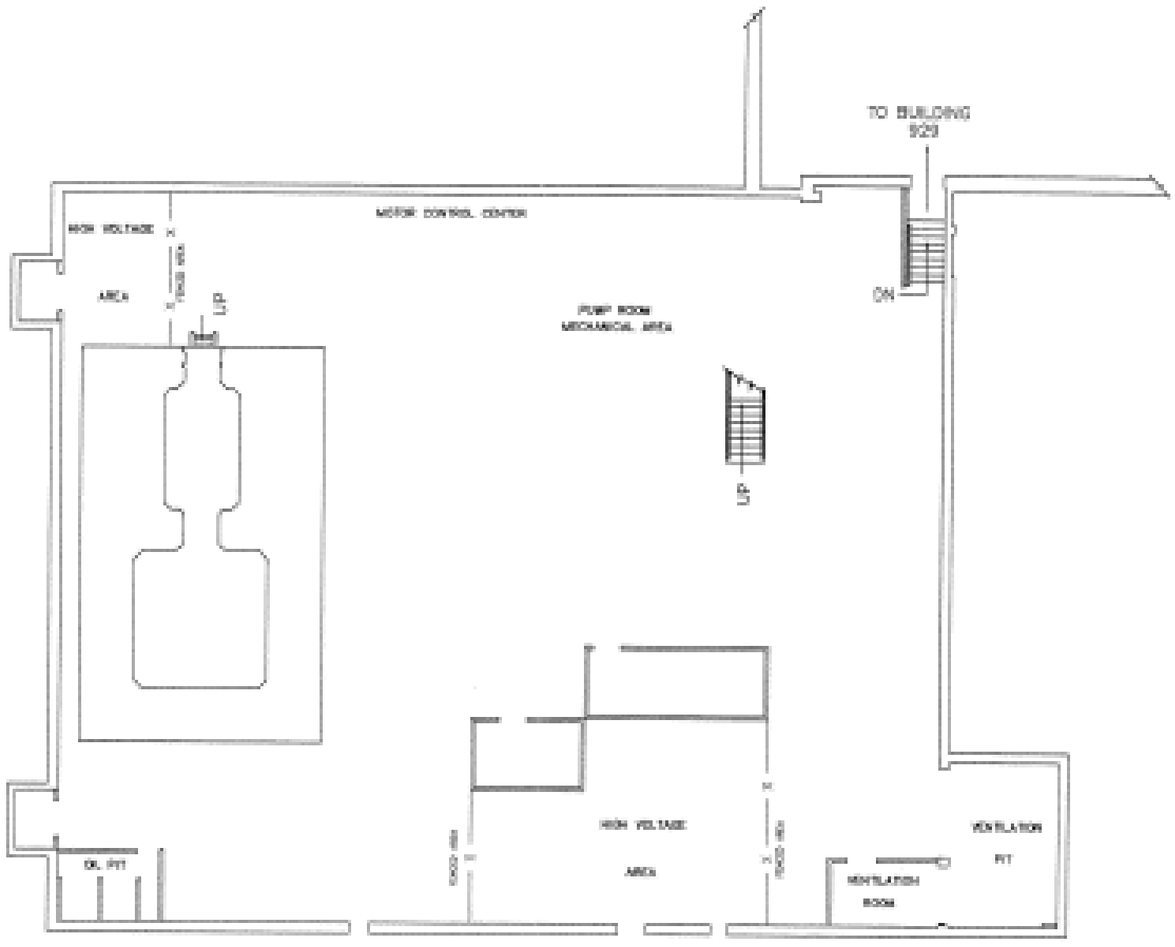
Buildings 928 and 929



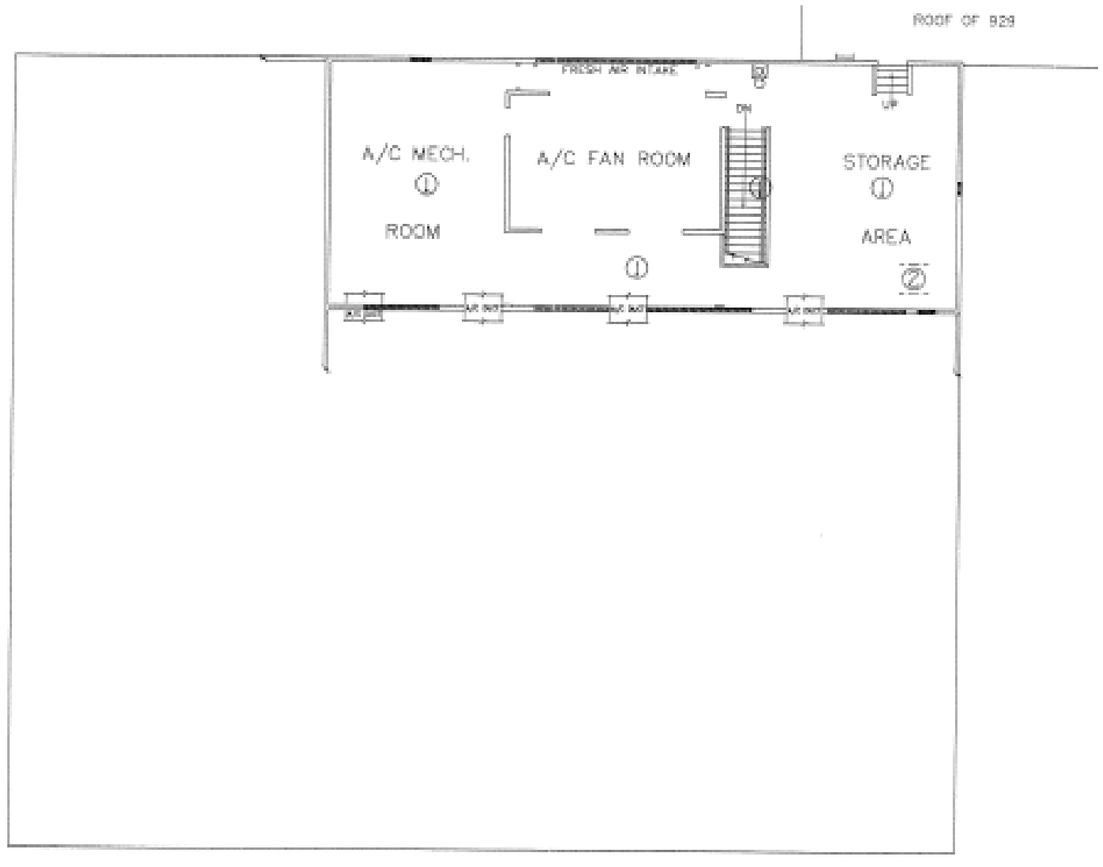
Area around Building 928/929



Building 928 – First Floor



Building 928 - Basement



Building 928 – Mezzanine

APPENDIX B –

LIGHTNING RISK CALCULATION

The expected lightning frequency (Nd) is **0.0121** and the tolerable lightning frequency (Nc) is **0.0003**. 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 = **0.0121** = 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) = **0.50** = the environmental coefficient

(A_e) = **12,090** = the equivalent collective area of the structure in square meters from calculation below

Length (L)	**135**	Feet
Width (W)	**140**	Feet
Height (H)	**40**	Feet

0.25

Figure H.4.2(a) Results 12,090 sq. meters

Figure H.4.2(b) Results 4,203 sq. meters

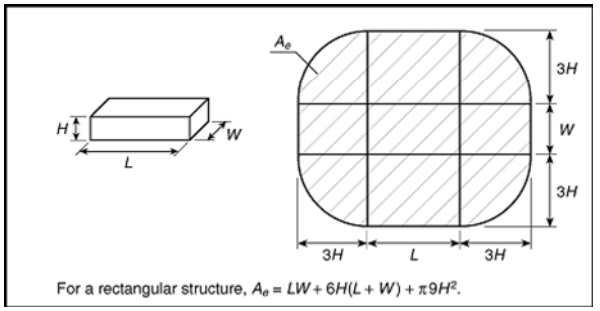
Assume

0.50

Table H.4.3 Determination of Environmental Coefficient C_1

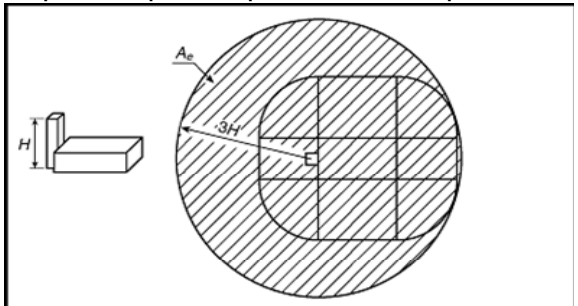
Relative Structure Location	C_1
Structure located within a space containing structures or trees of the same height or taller within a distance of $3H$	0.25
Structure surrounded by smaller structures within a distance of $3H$	0.5
Isolated structure, no other structures located within a distance of $3H$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

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 = **0.0003**

= input required

Assume **0.5**

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

APPENDIX C – Determination of Wildfire Hazard Severity

Using NFPA 1144

WILDLAND FIRE RISK AND HAZARD SEVERITY ASSESSMENT FORM
Appendix A, Figure A.4.2 from 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	3
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√ (partial)
H.	**Placement of Gas and Electric Utilities**	
1.	Both underground	**0**√
2.	One underground, one aboveground	3
3.	Both aboveground	5
I.	**Total**	**30**

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

A Wildfire Severity Level of 30 = A **LOW** Hazard