7 Safety Analysis For Non-Radiological Hazards

7.1 Fire Hazards Analysis

In June 2000 the DOE approved the SPEAR3 Fire Hazards Analysis and Permanent Equivalency request for not having sprinklers in the accelerator housing, that allowed for the installation of a VESDA (Very Early Smoke Detector Apparatus) warning system coupled with the availability of an on-site Fire Department to mitigate fires in the SPEAR3 accelerator housing.

7.1.1 Description Site, Facilities, and Operations

The SSRL accelerator complex is comprised of several distinct structures: an accelerator housing, experiment areas, control room, power supply room, and RF distribution building. It is expected that during the SPEAR3 upgrade project that the conventional facilities listed above will remain largely unchanged, with no substantial modifications being made to them. However, there will be modifications to the concrete shielding structure or accelerator housing to improve radiation protection and temperature stability and the addition of a pre-engineered metal building to replace the present RF distribution building.

Operation of the accelerator complex will cease during the project installation period and resume upon the project's completion. Because this is an upgrade of an existing facility and not new construction, the functional operation of the accelerator will not change significantly, although procedures (including life safety issues) will need to be updated.

Upon completion of the upgrade project and based on present day operations, a typical SPEAR3 run cycle is shown in Table 7-1.

Table 7-1. SPEAR3 Run Cycle

Condition	Period	Access Mode
Initial Start Up & Commissioning	3 months	Partial - for trouble shooting and maintenance activities
Routine Start Up	2-4 weeks	Partial - for trouble shooting and maintenance activities
Normal Operation	9-10 months	Access once per month for 8-12 hours of routine maintenance
Extended Shutdown	4-8 weeks	Full access, rolling block doors open.

7.1.2 Description of Buildings

The buildings associated with the SPEAR3 operation are described in Table 7-2.

7.1.3 Protection of Essential Safety Class Equipment

Since this is a low-hazard project, no essential safety class equipment is involved.

7.1.4 Fire Protection Features

The following are fire protection features associate with SPEAR3.

Table 7-2. SPEAR3 Buildings

Building # – Location	Size	Occupied Square Footage	Type of Buildings
SPEAR – Stanford Positron Electron Asymmetric Ring (SPEAR Accelerator Housing), including East and West Pits	8,765 ft^2	Not Occupied *	A combination pre-cast reinforced concrete block, cast in place reinforced concrete structure and pre-engineered metal building.
Building 117 – SPEAR Control Room	3,360 ft^2	Occupied	Pre-engineered metal building.
Building 118 – SPEAR Power Supply Room	3,200 ft^2	Not Occupied *	Pre-engineered metal building.
Building 122 – RF Facility	756 ft^2	Not Occupied *	Pre-engineered metal building.
Building 514 – Variable Voltage Transformer (VVT) Housing	766 ft^2	Not Occupied *	Pre-engineered metal building.
Building 120 – SSRL North Arc Bldg	28,350 ft^2	Occupied	A combination pre-cast reinforced concrete block, cast in place reinforced concrete structure and pre-engineered metal buildings.
Building 131 – SSRL South Arc Bldg	23,000 ft^2	Occupied	A combination pre-cast reinforced concrete block, cast in place reinforced concrete structure and pre-engineered metal buildings.

* Not occupied during routine operations, but will be accessed by systems personnel and responsible managers during maintenance and trouble shooting periods.

Water Supply and Hydrants

The SLAC site has a combined fire/domestic water system, which is fed via a 24-inch main, routed from the local community (Menlo Park). The site has two connections to the city water supply and the site system is a looped supply. Adequate supplies of fire hydrants are located throughout SLAC. Within the SSRL complex there are three fire hydrants (see Figure 7-1) located within 150 ft of the center of SPEAR. There are two further fire hydrants located outside the immediate area but still within 200 ft of the center of the SPEAR ring.

Suppression Systems

All SSRL support buildings are protected by automatic deluge or wet type sprinkler systems, which are designed for a coverage of 0.15 gpm/ft^2 over 150 ft^2 and are considered adequate for the fire hazard present. The SPEAR accelerator ring is not protected by a sprinkler system under a SLAC Permanent Equivalency Request (SLAC ER #96-01) [1] submitted and concurred by the DOE Oakland Operations Office in April 1996.

Stand Pipes

Standpipes for fire department use are part of the automatic sprinkler system and are located throughout the SSRL facility. (See Figure 7-1.)

Fire Extinguishers

Fire extinguishers are located throughout the SSRL facility, SPEAR Accelerator and support buildings (see Figure 7-3) in accordance with NFPA 10. A total of 16 fire

extinguishers are located in the SPEAR accelerator ring as follows: 3 in the North Arc, 3 in the South Arc, 4 in the East Pit area and 6 in the West Pit area.

Alarm System and Smoke Detection Systems

The existing detection and alarm systems at the SSRL facility are a mixture of conventional and intelligent devices. Upgrading all SSRL buildings to a completely intelligent system, with addressable fire alarm panels and devices is in process and will be complete by FY 2004. All fire alarm panels at SSRL are connected to the site wide fire alarm system and the Palo Alto Fire Department (PAFD) dispatch center. Table 7-3 provides details by building.

Table 7-3. SPEAR3 Fire Protection Detection Systems

Building	Detection System
Building 117 – SPEAR Control Room	Pyrotronics MXL system, with addressable fire alarm panel and devices. (Intelligent)
Building 118 – SPEAR Power Supply Room	Pyrotronics MXL system, with addressable fire alarm panel and devices. (Intelligent)
Building 120 – SSRL North Arc Bldg	Pyrotronics System 3 - conventional system
Building 131 – SSRL South Arc Bldg	Pyrotronics MXLR system, with addressable fire alarm panel and devices. (Intelligent)
SPEAR Accelerator Ring	VESDA smoke detection system reporting to the Pyrotronics MXL panel. Installed in FY2002.
SPEAR East and West Pit	VESDA smoke detection system reporting to the Pyrotronics MXL panel. Installed in FY2002.
Building 122 – RF Facility	Pyrotronics MXL system, with addressable fire alarm panel and devices. (Intelligent)
Building 514 – Variable Voltage Transformer (VVT) Housing	Pyrotronics MXL system, with addressable fire alarm panel and devices. (Intelligent)

Pull Stations

Manual fire alarm pull stations are located in every building except the SPEAR accelerator ring.

Smoke Control

The SPEAR3 accelerator upgrade does not provide for conventional smoke control through an engineered ventilation system. The Palo Alto Fire Department has portable positive pressure ventilation and exhaust ventilation fans that can be used to clear buildings or accelerator housings if required.

7.1.5 Description of Fire Hazards

Based on previous experiences at SLAC, the predominant sources of fire initiation have come either from electrical malfunctions or abnormal heat loads/overheating in components, which have caused a break down of the electrical insulation and subsequent arcing. By the completion of the SPEAR3 project, all SSRL support buildings associated with the upgrade (see description of buildings above) will have addressable fire alarm panels and devices, automatic sprinkler systems for protection against the spread of fire and the accelerator ring will have an early warning VESDA system to detect fire incidents. The onsite fire department responds (<5 minutes) to all alarms generated at SSRL. Table 7-4 provides specific hazards and mitigation actions.

Table 7-4. SPEAR3 Fire Hazards And Mitigation

Area	Primary Fire Hazard	Mitigation
Building 117 – Control Room	Electrical - associated with control racks, panels, High Voltage equipment, cabling.	Smoke Detectors. Fire Sprinklers. Proper selection of NEC fire rated cables. Upstream Circuit Breakers. On –site Fire Department. Manned full time during operation.
SPEAR Accelerator Ring	Electrical – via shorting or over heating and insulation breakdown.	VESDA smoke detection system. Careful selection of component materials. Restricted use of flammable materials in ring. Computer monitoring of component cooling lines. Upstream circuit breakers. On-site Fire Department
Klystron Building	Electrical Flammable Mineral Oil (SONTEX) - about 800 gallons per klystron. (requires rupture of transformer tank)	Smoke Detectors. Fire Sprinklers. Secondary Containment. Upstream Circuit Breakers. On –site Fire Department.
Cable Plant	Electrical – Inside the SPEAR ring. I & C Cables DC Power Cables	VESDA smoke detection system. Proper selection of cables per National Electrical Code (TC compliant) and SLAC Bulletin #37. Use of low smoke, non-halogen cables where applicable and available. Upstream Circuit Breakers. Fire breaks placed at discreet locations in the cable trays. On –site Fire Department.
Cable Plant	Electrical – Outside the SPEAR ring. I & C Cables DC Power Cables	Proper selection of cables per National Electrical Code (TC compliant) and SLAC Bulletin #37. Use of low smoke, non-halogen cables where applicable and available. Upstream Circuit Breakers. Fire breaks placed at discreet locations in the cable trays. On –site Fire Department.

7.1.6 Life Safety Considerations

All of the SSRL facility buildings as described in Section 2.1 are special purpose industrial occupancies as classified by NFPA 101, “The Life Safety Code.” These buildings have adequate provisions for life safety, including: multiple means of egress, exit signs, emergency lighting, fire extinguishers, automatic fire sprinklers, and smoke detection systems.

The SPEAR3 accelerator housing is a 767-foot circumference ring with two (2) principal exits equidistant from each other. During normal mode of operation, personnel would have access to both these exits from any location in the accelerator ring. In the case of a fire, or the presence of smoke in either the North or South arc, personnel would be forced to return to the exit they came in from. During periods of

extended shutdown as described in section 2.0, other exits will be open to facilitate the work in progress.

7.1.7 Critical Process Equipment

Critical process equipment is defined as equipment that if damaged or destroyed, would take more than six months to replace. Some items in the SPEAR3 assembly require long lead times (greater than 6 months) to procure, however the present plan does assume spares for many components and systems, while other items not on this list may need to be borrowed, refurbished or rebuilt. We do not at this time foresee the accelerator being down for greater than six months for any single fire related occurrence.

7.1.8 High Value Property

The high value property of the SPEAR3 upgrade is spread among several systems as described below. It should be noted that in considering this issue, we looked globally at the cost to replace items and loss of product. As SSRL is synonymous with a factory, loss of product can be equated to loss of money. Systems and components relating to a. and b. below are housed in pre-engineered metal structures with fully automated, heat activated, automatic sprinkler systems, and smoke detectors.

a. The control room which houses the electronics to manage and operate the accelerator would as a single unit be the most costly to replace (greater than $2M). Total loss of control components would have a substantial effect on the project in two ways. The first is the time and expense to replace damaged components and the second is the loss of synchrotron radiation for experiments. The primary purpose of SSRL is to produce reliable synchrotron radiation beams that are used as analytical tools by research experimenters in various ways. No beam equates to no scientific research program.

b. The total loss of the klystron and building has a value of about $0.6M, and replacement would be time consuming. Spares are available from the PEP-II project and the estimated time for repair is in the order of a month.

c. The SPEAR3 cable plant will run inside and outside of the accelerator housing and into support buildings. As a single unit, its replacement cost would be in the order of about $2M. However, because of the way it is installed, there is little or no chance of the entire cable plant being damaged or destroyed. What is more likely is that a section will be damaged, taking from weeks to months to repair depending on severity. Again the impact on the project is time and cost to replace, and loss of the scientific program.

7.1.9 Damage Potential

Due to the nature of the construction of SPEAR3 and the availability of an on-site fire department, the damage potential to structures is minimal. The SPEAR3 fire loading will be light and lower than for present operations. Past experience at SLAC and other accelerator facilities has shown that some accelerator components (magnet coils, cabling, *etc.*) can melt, creating smoke and damage, but there is insufficient combustible material to support a fire sweeping though an area.[2]

7.1.10 Fire Department/Brigade Response

SLAC subcontracts with the Palo Alto Fire Department to operate an on-site fire station and to provide emergency response services to conduct ongoing fire safety inspections of SLAC facilities, and to train SLAC personnel on fire safety.

7.1.11 Recovery Potential

Recovery time after a fire incident is largely dependant on the severity of the fire. Spares for most major components are planned in the SPEAR3 upgrade and others may be borrowed (if needed) from SLAC. Obviously, because of the large amount of work involved with the removal and installation of major components after a fire incident, weeks or months may pass before recommencing operations. Smaller or isolated fires; such as those resulting in the loss of a klystron, partial loss of cable plant or an electronic control unit/rack; would result in a much reduced recovery time, spanning from hours to days. In some cases it may be even possible to continue operating the storage ring, but at reduced energies or power levels until the corrective actions have taken place.

7.1.12 Potential For Toxic, Biological And/Or Radiation Incidents Due To Fire

The potential for a toxic incident in SPEAR is minimal. As with any fire, toxic by-products are produced as part of the combustion process. These products represent a hazard to workers within the various structures during the fire. However early warning smoke detection systems and mandated evacuation of buildings will minimize exposure.[3] A biological incident is non-existent. A radiation incident due to a fire is extremely unlikely due to the operating nature of the storage ring, low energies involved and no past history of activated components.

7.1.13 Emergency Preplanning

The Safety, Health and Assurance Department's Emergency Management Coordinator has established a comprehensive *SLAC Emergency Preparedness Plan* (SLAC-I-730-0A14A-001). SSRL has established a Facility Emergency Plan that covers evacuation and emergency procedures for the SSRL facility including the accelerator housing and all the support buildings.

7.1.14 Security Considerations Related To Fire Protection

The SSRL accelerator housing and support buildings, including experimental areas, all lie within the exclusion fence (accelerator area) at SLAC and are protected from the general public by SLAC security officers. Personnel entering this area either require training and issuance of a badge card or a SLAC escort. The fire alarm system not only contacts the local authority (fire department) but will also inform SLAC Security, the Main Control Center and the SSRL Accelerator Operator during machine operation of a potential fire or ongoing emergency. These groups will follow normal SLAC protocols for security during emergencies.

There are no impediments created by security needs, that would prevent a timely evacuation from any SSRL building or accelerator housing.

7.1.15 Natural Hazards (Earthquake, Flood, Wind) Impact On Fire Safety

Because SLAC is located near an active earthquake fault in an area classed by UBC as seismic zone 4 all of the structures were designed and built to meet the current UBC at the time of construction. The SLAC Safety, Health and Assurance Department is creating an earthquake emergency plan. Fire safety during and after an earthquake is covered in this document. This document provides SLAC with a mechanism and infrastructure to direct its resources in the event of an earthquake or other emergency in the following manner: To protect life and property, protect the environment, secure critical infrastructure and facilities, and resume laboratory operations.

The SLAC property is located topographically higher than the surrounding areas that drain the San Francisquito Creek watershed. As a result, according to Flood Insurance Rate Maps from the Federal Emergency Management Agency, the 50- and 100-year flood plains do not extend to the SLAC property except for the limited area where the property line follows San Francisquito Creek (Ref: Fire Hazards Analysis PEP-II). There are no buildings or operations of any kind in or near this area. Flood flows were also derived by Santa Clara Valley Water District (1987), which reported the flows shown in Table 7-5.

Table 7-5. Peak Flow (Los Trancos and San Francisquito Creeks)

Return Period (Years)	Peak Flow*
10	4,050 cfs (115 cms)
50	6,720 cfs (190 cms)
100	7,860 cfs (223 cms)
500	10,500 cfs (297 cms)

* cfs = cubic feet per second; cms = cubic meters per second

Note that the peak flows shown in Table 7-5 are for San Francisquito Creek and Los Trancos Creek combined. Therefore, peak flows for San Francisquito Creek along the south side of SLAC will be less. Another study, entitled "Flood Studies, Limits of Flooding in the Event of a Failure of Searsville Dam owned by Stanford University" (Delta Consulting Engineers 1974), mapped the flood plain that would result from the maximum catastrophic failure of the Searsville Dam and the corresponding release of 60,433 cfs. This release is about 6 times the 500-year peak flow of 10,500 cfs for San Francisquito Creek and Los Trancos Creek combined. According to this study, the catastrophic release of water from the failure of Searsville Dam would not encroach on the SLAC facility except for the SLAC property that is immediately adjacent to the San Francisquito Creek and up one of the intermittent streams located west of Highway 280. Since the 500-year flood represents one-sixth or less of the flow caused by dam failure, the 500-year flood would not encroach on any of the operations on SLAC property.

The San Francisco bay area is located in an area that according to the Uniform Building Code (UBC) receives winds of up to 70 mph. For this reason all structures at SSRL were designed to withstand winds in excess of this speed per the UBC that was in effect at the time of the original construction.

7.1.16 Potential Exposure To Fire Including Potential Fire Spread Between Fire Areas

The campus area of SLAC is located on rolling hills. Portions of the facility are landscaped and represent a minimal hazard from wildfire. The area upon which the SSRL accelerator housing is located, is a paved area surrounded by support buildings. Beyond the buildings are natural foothills with native grasses and trees. There is a potential that fire could spread from structure to structure and for this reason SLAC in cooperation with the Palo Alto Fire Department conducts routine assessments of the potential fire danger and requires the SLAC Systems Engineering and Maintenance (SEM) Department to keep the grasses and trees trimmed around their structures to limit fire spread. Past experience has shown that with an on-site fire brigade the hazards from wildfire spread has been kept to a minimum.

7.1.17 Recommendations

The recommendations are to complete the installations outlined in this document by the end of the project and to pursue with the DOE a “Permanent Equivalency” for the non-compliance of SPEAR3 with the provision of automatic suppression system in the accelerator housing.

7.1.18 Conclusion

This Preliminary Fire Hazards Analysis for the SPEAR3 upgrade has comprehensively assessed the fire risks presented, has identified and evaluated the fire protection systems presently in use and has determined the requirements of future protection systems that will be installed during the project’s lifetime. Implementation of all the fire protection measures outlined in this document are adequate to ensure that the risk associated with potential fire is minimized and acceptable, and to provide for adequate mitigation features in the design and operation of the accelerator facility while ensuring that the objectives of the DOE Fire Protection Order 120.1A are met.

7.1.19 Approvals

This Preliminary Fire Hazards Analysis was approved by: Robert Reek, SLAC Fire Protection Engineer; Ian Evans, SSRL Safety Officer; Tom Elioff, SSRL SPEAR3 Project Manager; Keith Hodgson, SSRL Associate Director; and Kenneth R. Kase, EH&H Associate Director.

7.1.20 SPEAR3 Fire Hazard Analysis

Personnel could be injured and equipment could be damaged by a fire event.

Method of Detection

The SPEAR3 fire alarm and smoke detection system are the automated means of a fire in process.

Preventive/Mitigating features

Performance of fire inspections and mitigation of specific concerns.

Consequences

The consequences of a fire in SPEAR3 are low.

Likelihood

The probability of a fire in SPEAR3 is unlikely .

Risk

The risk from this operation is acceptable.

Figure 7-1. Fire Water Supply, Hydrants and Stand Pipes

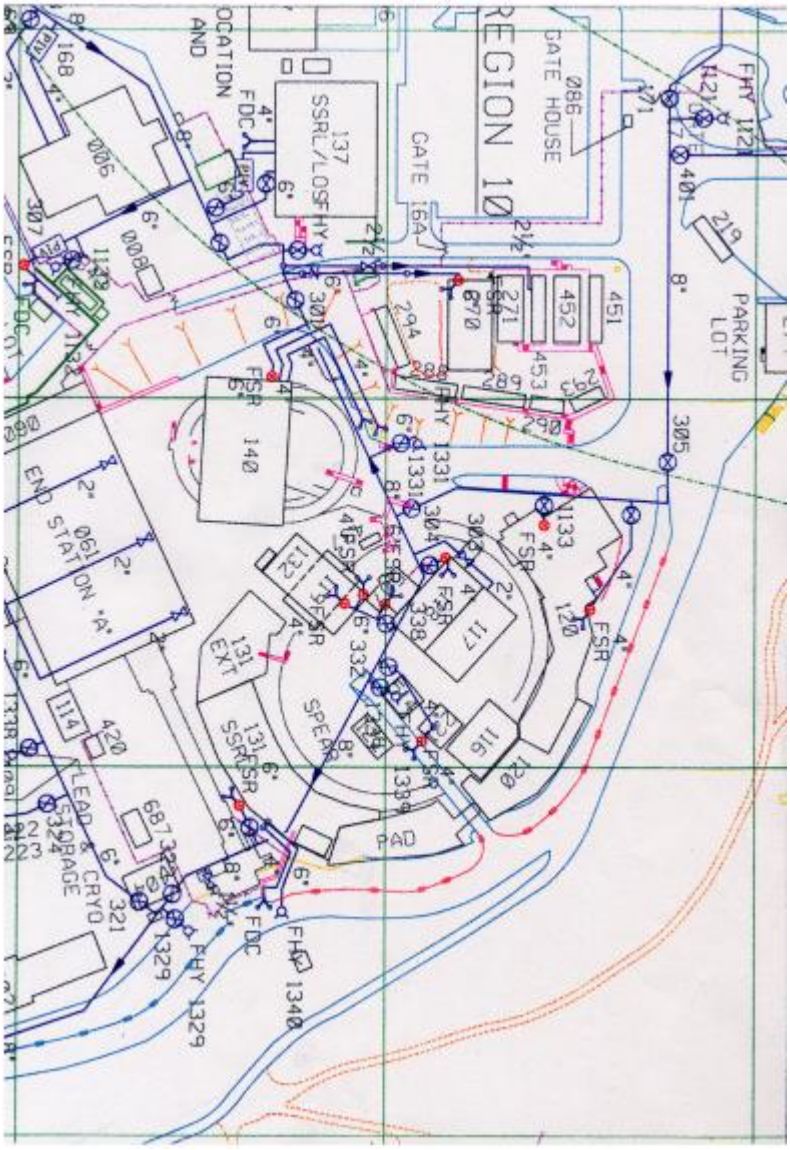


Figure 7-2. Abbreviations and Legend for Figure 7-1

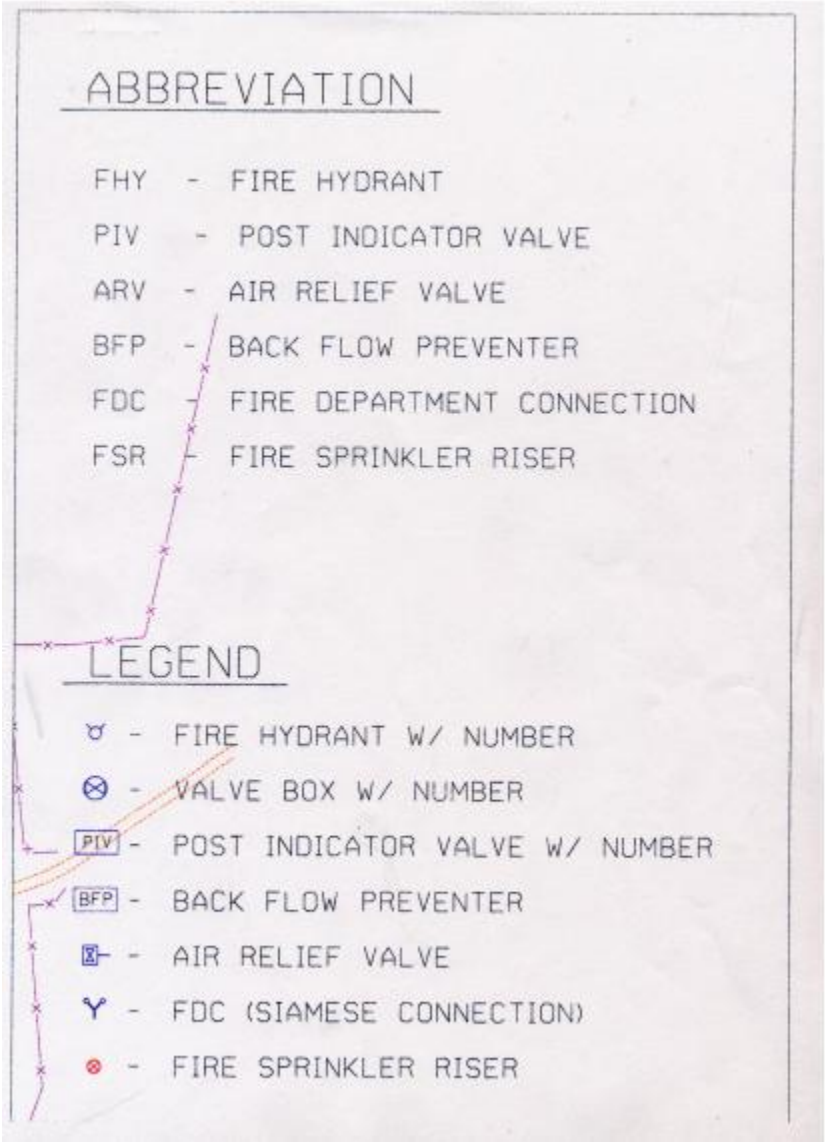
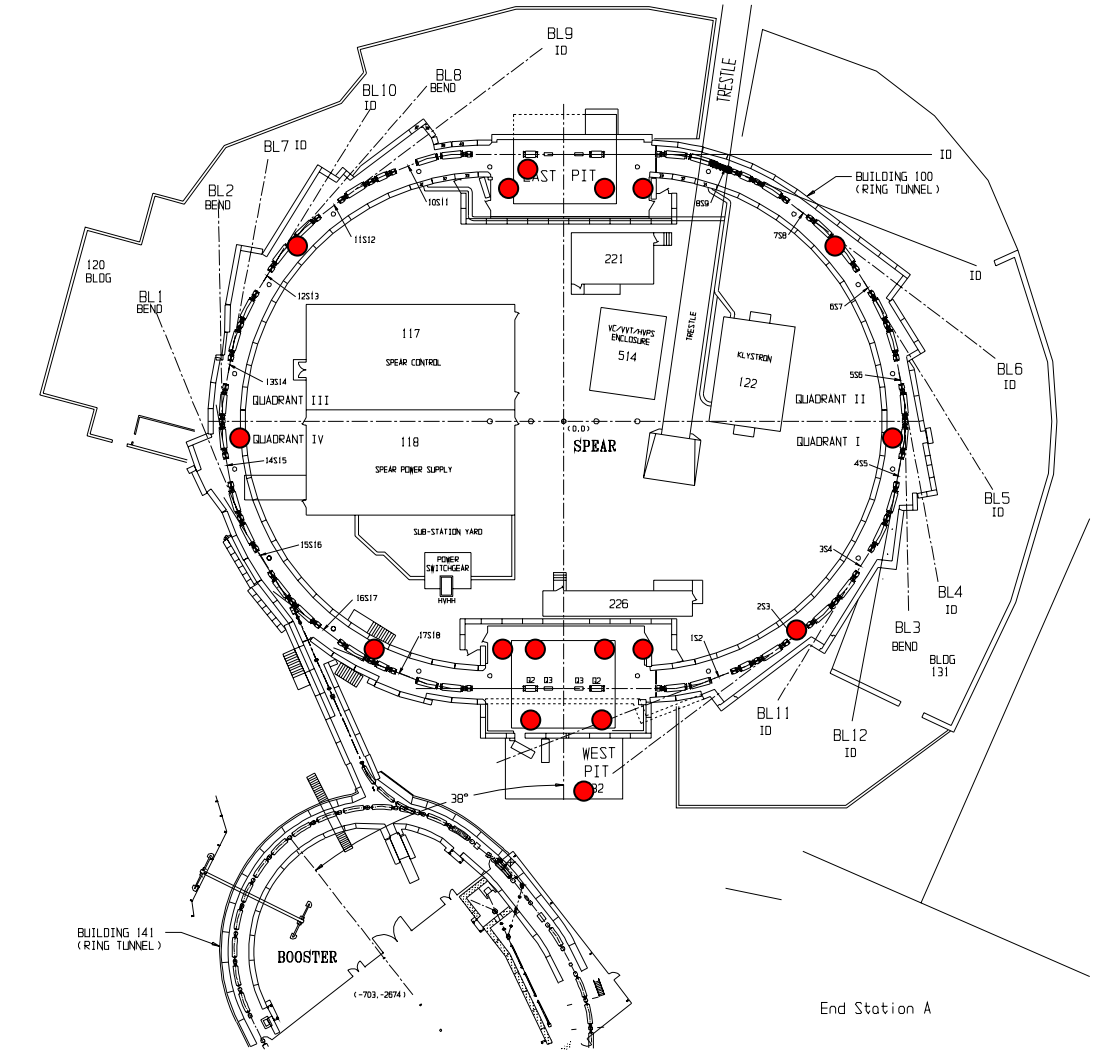


Figure 7-3. SPEAR Accelerator Ring Fire Extinguisher Placement (2/1/00)



[1] SLAC-ER# 96-01

[2] SAN-SU-SLAC-1991-1014
SAN-SU-SLAC-1991-0018
SAN-SU-SLAC-1994-0002
SAN-SU-SLAC-1996-0003

[3] SSRL Facility Emergency Plan, Rev 1999.