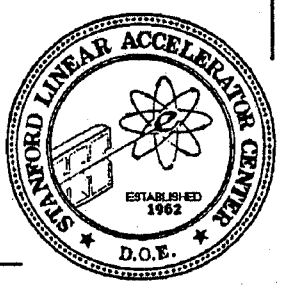
May 1995

NLCTA
Fire Hazard Analysis

Stanford
Linear
Accelerator
Center



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1. Introduction

This document is a Fire Hazard Analysis (FHA) for the Next Linear Collider Test Accelerator (NLCTA) project at the Stanford Linear Accelerator Center (SLAC). Its purpose is to comprehensively assess the risk from fire within individual fire areas in relation to existing or proposed fire protection so as to ascertain whether the objectives of the DOE Fire-Protection Order (5480.7A) are met. The objectives of the DOE Fire-Protection Order are to:

- Minimize the potential for the occurrence of a fire.
- Ensure that a fire does not cause an on-site or off-site release of radiological and other hazardous material that will threaten the public health and safety or the environment.
- Establish requirements that will provide an acceptable degree of life safety to DOE and contractor personnel and that there are no undue hazards to the public from fire and its effects in DOE facilities.
- Ensure that process control and safety systems are not damaged by fire or related perils.
- Ensure that vital DOE programs will not suffer unacceptable delays as a result of fire and its effects.
- Ensure that property damage from fire and related perils does not exceed an acceptable level.

2. Description of Construction

The NLCTA facility, which is partially contained inside End Station B (Building #62), consists of an above-ground beam-line enclosure, banks of instrumentation, controls, and power-supply racks, a 3.33-MW electrical substation (Building #501), and a control building (Building #128). The appended figure shows the layout of the NLCTA buildings.

End Station B (ESB) is a reinforced poured concrete structure completed in 1966. Interior dimensions at floor level are 150 ft (east-west) × 75 ft (north-south) × 50 ft high. The north and south walls have large openings for moving equipment in and out. A 20 ft × 20 ft portion of the south opening has a motorized 2-ft thick concrete door. Other openings in the north, south, and east walls are approximately 12 ft high × 70 ft wide, and are covered with 2-ft thick portable concrete blocks. All walls and the roof are concrete, with minimum thicknesses of 2 ft, varying as required by structural considerations. The roof slabs are supported on steel girders. The floor slab is made of 6-in thick, unreinforced concrete on a 6-in untreated base of coarse graded aggregate. The building is a large single-story concrete structure designed as a rigid frame. There are large sections of uninterrupted walls designed to carry large earthquake-induced shear forces into the sandstone foundation. ESB is ventilated by nine roof-mounted 25,000-cfm exhaust fans.

The above-ground beam-line enclosure was recently constructed from poured, reinforced concrete blocks. The walls are 6 ft thick. The roof is 4 ft thick. The interior measures 10 ft high × 9 ft wide × 170 ft long. Approximately half of the enclosure is contained inside ESB; the rest extends beyond the end station by about 80 ft, to the east. The beam dump, which will consist of iron, lead, and concrete, will be at the east end of the accelerator housing. The interior walls of the enclosure are painted white. The concrete floor is sealed. Access and egress is provided through two radiation mazes: one at the west end, which connects to ESB; and one on the south side, which connects to the outside. Cross-ventilation is provided by the two mazes, and can be assisted by using portable

electric fans, when necessary. Telephones are spaced approximately 50-ft apart inside the enclosure. Figure 2 shows a cross-sectional view of the NLCTA beam-line housing.

Approximately 70 racks of instrumentation, controls, and power supplies for the NLCTA are contained inside ESB. Cables run in overhead trays that enter the beam-line housing through the west maze.

The new 3.33-MW substation (#501) provides power to the NLCTA, to ESB, and to the southern part of the Research Yard. This single-story structure, which measures 20 ft × 39 ft, is made of steel-reinforced masonry-block walls, with a sheet-metal roof, on a four-inch-thick concrete slab foundation.

The new control building (#128) contains the NLCTA operations control room, a conference room, an office, and a toilet. This single-story, sheet-metal, steel-frame structure measures 26 ft × 42 ft. Entrance/exit doors are located on both the east and west ends of the building. All internal walls are framed with metal studs, filled with 3.5-inch mineral-fiber batting, and surfaced with 5/8" fire-code wallboard. The foundation is stepped concrete slab-on-grade. The control room, which is located over the lower part of the slab, has an elevated access flooring system raised 10" above the concrete subfloor, consisting of 24-inch-square panels of die-formed galvanized sheet steel laminated over plywood. The conference room, office, and hall are finished with nylon carpeting laid directly on the slab. The bathroom floor is sheet vinyl laid on the slab. All interior spaces are covered by a 10'-high acoustical ceiling composed of 2' x 4' panels of 5/8"-thick Minatone tile with Class-1 flame-spread rating.

3. Protection of Essential Safety Class Equipment

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

4. Fire-Protection Features

The beam line enclosure and the NLCTA areas inside ESB are fully protected by automatic sprinkler protection hydraulically designed for Ordinary Hazard Group 2. The beam line enclosure is protected by a Fenwal high-sensitivity smoke-detection system. The Fenwal analyzer is located outside of the enclosure, but inside ESB. The area inside ESB, but outside the enclosure, is protected by ionization-type smoke detectors. All the smoke detectors are tied to the SLAC fire-alarm system.

The substation is protected by ionization-type smoke detectors tied to the SLAC fire-alarm system.

The control room building is protected by automatic sprinklers and ionization-type smoke detectors tied to the SLAC fire-alarm system.

5. Description of Fire Hazards

The fire hazard posed by the cable plant used to conduct power and signals to and from the beam line and microwave components has been mitigated by choosing cables that meet the latest SLAC standards for cable insulation. These standards comply with the current National Electrical Code (NEC, NFPA-70) concerning cable fire resistance. Large DC cables are compact sector aluminum with XHHW insulation. For instrumentation and control systems, a wide variety of coax and multi-conductor cables have been chosen. These cables run in 4-in deep horizontal ladder-type steel cable trays and, with the exception of risers and plenums, comply with the "general use" classification of the NEC (Section 725-51c) for fire resistance of the insulating material.

The electrical fire hazard associated with the transformers and other high-power components in the substation building is mitigated by the presence of smoke detectors and

upstream circuit breakers. Automatic sprinklers are not provided in the substation since the value for this facility is less than $1M.

The fire hazard associated with the electrical power supplies in ESB is mitigated by the presence of smoke detectors and sprinklers.

Each klystron pulse-transformer tank contains approximately 560 gallons of pure, PCB-free, mineral oil, a Type-III-B combustible liquid. However, the probability that an uncontrolled fire might lead to rupture of a pulse-transformer tank and release hundreds of gallons of combustible oil is negligible because of the presence of secondary containment, the lack of combustible material near the tank, and the presence of the smoke-detectors and sprinklers.

6. Life-Safety Considerations

The three buildings (End Station B, Control Building 128, and Substation 501) utilized in this project are in compliance with the Life Safety Code, NFPA #101, 1991 edition. The detailed life-safety considerations in each of the three buildings follow.

6.1. End Station B

- *Occupancy:* Special Purpose Industrial with low to ordinary hazard contents.
- *Means of egress:* This building is provided with 3 exterior exits. The enclosure built for NLCTA has two means of egress and the dead-end travel distance in the beam dump area does not exceed the 20 ft allowed by code. All areas within the building are within the 250-ft maximum allowable travel distance.
- *Emergency lighting and exit signs:* Battery pack emergency lighting units are used for the illumination of all primary exit paths. Illuminated exit signs are installed to indicate the means of egress. The provisions for emergency lighting and the location of exit signs are adequate and provide the level of protection required by NFPA 101.
- *Interior finish:* The interior finish is all Class A within this building.
- *Smoke control:* This 1 = 3 story building is equipped with manual ceiling exhaust fans available for fire department use. Due to the floor to ceiling height there is more than ample time for personnel evacuation before heat or smoke would block egress paths from the building. Reduced ceiling height of 9 ft exists within the NLCTA enclosure, however, both early warning smoke detection and sprinkler protection are provided for this area. Additionally, this area is not occupied when the test accelerator is operating.
- *Fire alarm:* Manual fire alarm pull boxes are located near each exit which are connected to the site master box system. Operation of a manual pull station, one of the smoke detectors, or the automatic sprinkler system will automatically direct the fire department to the facility. Additionally, operation of any of the devices previously mentioned will activate the building evacuation alarm.

6.2. Control Building 128

- *Occupancy:* Business occupancy with typical conference room, control area with raised floor for running cables and wiring to computers and accelerator control racks.
- *Means of egress:* This building is provided with 2 exterior exits. Travel distance to exits is well below the code permitted 250 ft in this sprinklered building. Ample exit capacity is provided for this 1500 square ft building.

- *Emergency lighting and exit signs:* Battery pack emergency lighting units are provided for the illumination of the two primary exit paths. Illuminated exit signs are installed over both exit doors. The provisions for emergency light and the location of exit signs are adequate and provide the level of protection required by NFPA 101.
- *Interior finish:* Interior finish is a mixture of Class A, B and C within this building which is acceptable since this building is equipped with automatic sprinkler protection.
- *Smoke control:* Not required in this one story building.
- *Fire alarm:* This building is equipped with manual pull stations at each exit which are connected through a fire alarm panel to the site master box system. Operation of a manual pull station, a smoke detector or the automatic sprinkler system will result in the dispatch of the fire department to the facility. Additionally, the operation of any of the previously mentioned devices will activate the building evacuation alarm.

6.3. Substation 501

- *Occupancy:* Special Purpose Industrial with ordinary hazard contents. This building is normally not occupied.
- *Means of egress:* This building is provided with two exterior exits. Since this building is only 20 ft × 39 ft, the travel distance is well below the code permitted 250 ft.
- *Emergency lighting and exit signs:* Battery pack emergency lighting units are provided for the illumination of all exit paths. Illuminated Exit Signs are over both exit doors. The provisions for emergency light and location of exit signs are adequate and provide the level of protection required by the code.
- *Interior finish:* The interior finish is all Class A within this building.
- *Smoke control:* Not required in this one story building.
- *Fire alarm:* This building is equipped with two manual pull stations near each exit door which are connected through a fire alarm panel to the site master box system. Operation of either a pull station or a smoke detector will automatically direct the fire department to the facility and sound the building evacuation alarm.

7. Critical Process Equipment

Critical process equipment is defined as critical equipment that, if damaged or destroyed, would take more than six months to replace. Since all components of the NLCTA can be fabricated in less than six months, the NLCTA contains no critical process equipment by this definition.

Nevertheless, the high-gradient accelerator sections, due to their mechanical complexity and precise tolerances, are the components that might take the longest to replace—almost six months, based on the initial construction experience with single accelerator sections. All of the beam line components, including the accelerator sections, are protected redundantly from fire loss by the presence of smoke-detectors and heat-sensitive sprinklers. Both of these protection systems summon the on-site fire department. The beam line components also are protected indirectly by the lack of sufficient combustible fuel to feed a fire in their proximity.

8. High-Value Property

High-value property is defined as single pieces of equipment that, if damaged or destroyed, would cost more than $1M to replace. There is no high-value property, by this

definition, in the NLCTA project. The most expensive single pieces of property are the klystrons and their associated DC pulse modulators. The NLCTA construction project includes three klystrons and three modulators. Each klystron, and each modulator, costs $0.2M.

9. Damage Potential

The Maximum Credible Fire Loss (MCFL) is the fire loss expected assuming the installed fire protection performs as designed. For the ESB areas of NLCTA, the MCFL is approximately $250k, assuming a fire in an electronics rack. However, based on the early warning detection systems present, and SLAC's past experience with accelerator fire incidents, the expected loss would be less than $100k when the control room is operating, due to human intervention in the fire incident.

The MCFL for the Control Room Facility is approximately $100k, assuming an electrical-failure fire in a control rack resulting in automatic sprinkler activation. This MCFL represents the extreme case since this facility would be occupied during accelerator operations. With the early warning smoke detection provided for this facility, a loss below $50k is the more probable event.

The MCFL for the Substation is $500k, since no automatic fire suppression system is provided for this building. However, early warning smoke detection coupled with the response of the on-site fire department would more likely result in a significantly lower expected loss.

The Maximum Possible Fire Loss (MPFL) is the expected loss assuming no automatic or manual fire suppression occurs. For the NLCTA areas of ESB, the MPFL is $19M. This loss estimate is based on a fire of extended duration which might occur in the event of a major earthquake which could result in substantial delays in fire department response. However, due to the limited amount of combustible fuel, represented predominately by cables, significant smoke and some heat damage would involve equipment, but minimal building damage is expected.

The MPFL for the Control Room Facility is $250k. This loss scenario would only be expected in the event of fire caused by a major earthquake. Since this is a building of non combustible unprotected construction, extensive damage to the building could occur in this scenario.

The MPFL for the substation is the same as MCFL ($500k) since the substation is not protected by an automatic fire suppression system. Due to limited amounts of combustibles and the concrete block wall construction, only minimal damage to the substation building is expected under this scenario.

10. Fire Department Response

A station of the Palo Alto Fire Department is located on the SLAC site, 2/3 mile from the NLCTA fire area. Driving time is two minutes. The station is manned 24 hours per day by a complement of three people, and maintains one engine at ready. The station is alerted by the automatic and manual smoke- and fire-alarm systems present throughout the NLCTA fire area, and is equipped with telephone and radio communications.

11. Recovery Potential

A significant fire, one with sufficient heat to cause sprinkler activation, could shut down the NLCTA Facility for up to six months. Since this is an experimental test accelerator, there are very few spare parts. The klystrons are specially produced for this project. No spare klystrons are budgeted to be available in the event of damage due to a fire. However, NLCTA does have reduntant fire protection for most areas of the project.

Therefore, the probability for significant fire damage is minimal with protection working as designed.

12. Potential for a Toxic, Biological and/or Radiation Incident due to Fire

There is no potential for a toxic or biological incident due to fire. The cut-off of electricity in the event of a fire will disable all sources of radiation, with the exception of temporarily radiological activated beam line components, such as the beam dump. Any activated components will be safely inside the concrete beam line shielding enclosure.

13. Emergency Planning

The fire department has been involved in the design review for this facility. Prior to startup of this experiment, a walk-through of the facilities will be held with the Palo Alto Fire Department since they are the site emergency responder for fire, hazardous atmosphere, hazardous material incidents and medical emergencies. Evacuation plans and diagrams will be prepared prior to final occupancy.

14. Security considerations related to fire protection

There are no impediments created by security needs that would prevent a timely evacuation from any of the NLCTA facilities.

15. Natural Hazards Impact on Fire Safety

Earthquake provides the only credible natural hazard since the site is located in a Seismic Zone-3 location. Both the sprinkler protection and the facilities have been designed for seismic events, however, a major seismic event could result in impairment to the sprinkler protection. Based on the minimal fire hazards present, the non combustible construction of the facilities and the lack of exposure hazards to the NLCTA facilities the increased fire risk to these facilities from a earthquake is minimal.

16. Exposure Fire Potential

Adequate spatial separation exists between the three NLCTA facilities and neighboring SLAC buildings. Since the NLCTA facilities are located on the interior of the research yard, there is no exposure to grass fires or other flammable or combustible exposures. Therefore, the exposure fire potential is considered negligible for these facilities.

From a fire area standpoint, each of the three NLCTA facilities (ESB, the Control Room, and the Substation) is a fire area based on spatial separation, non-combustible construction and limited combustible contents. Under MPFL conditions, a fire occurring in any one of the three facilities would not be expected to spread to either of the other two facilities. Furthermore, the three NLCTA facilities do not pose an exposure hazard to neighboring fire areas.

17. Conclusion

This analysis of fire hazards for the NLCTA project at SLAC has comprehensively assessed the risk from fire within individual fire areas in relation to existing and proposed fire-protection systems. The design of the NLCTA and its fire-protection systems are sufficient to:

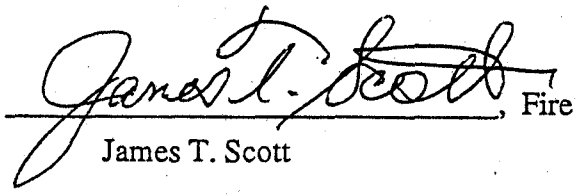
- Minimize the potential for the occurrence of a fire.
- Ensure that a fire does not cause an on-site or off-site release of radiological and other hazardous material that will threaten the public health and safety or the environment.

- Establish requirements that will provide an acceptable degree of life safety to DOE and contractor personnel and that there are no undue hazards to the public from fire and its effects in DOE facilities.
- Ensure that process control and safety systems are not damaged by fire or related perils.
- Ensure that vital DOE programs will not suffer unacceptable delays as a result of fire and its effects.
- Ensure that property damage from fire and related perils does not exceed an acceptable level.

Consequently, this FHA concludes that the objectives of the Fire-Protection Order are met for the NLCTA at SLAC.

18. Approvals

This Fire Hazard Analysis is approved by:



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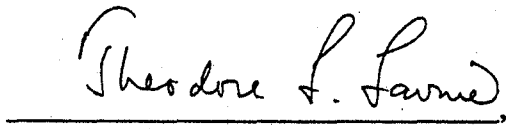

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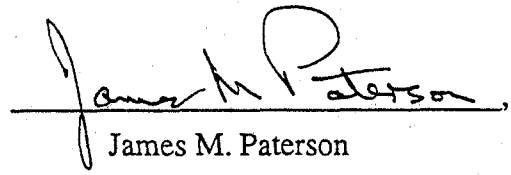

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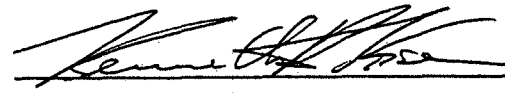

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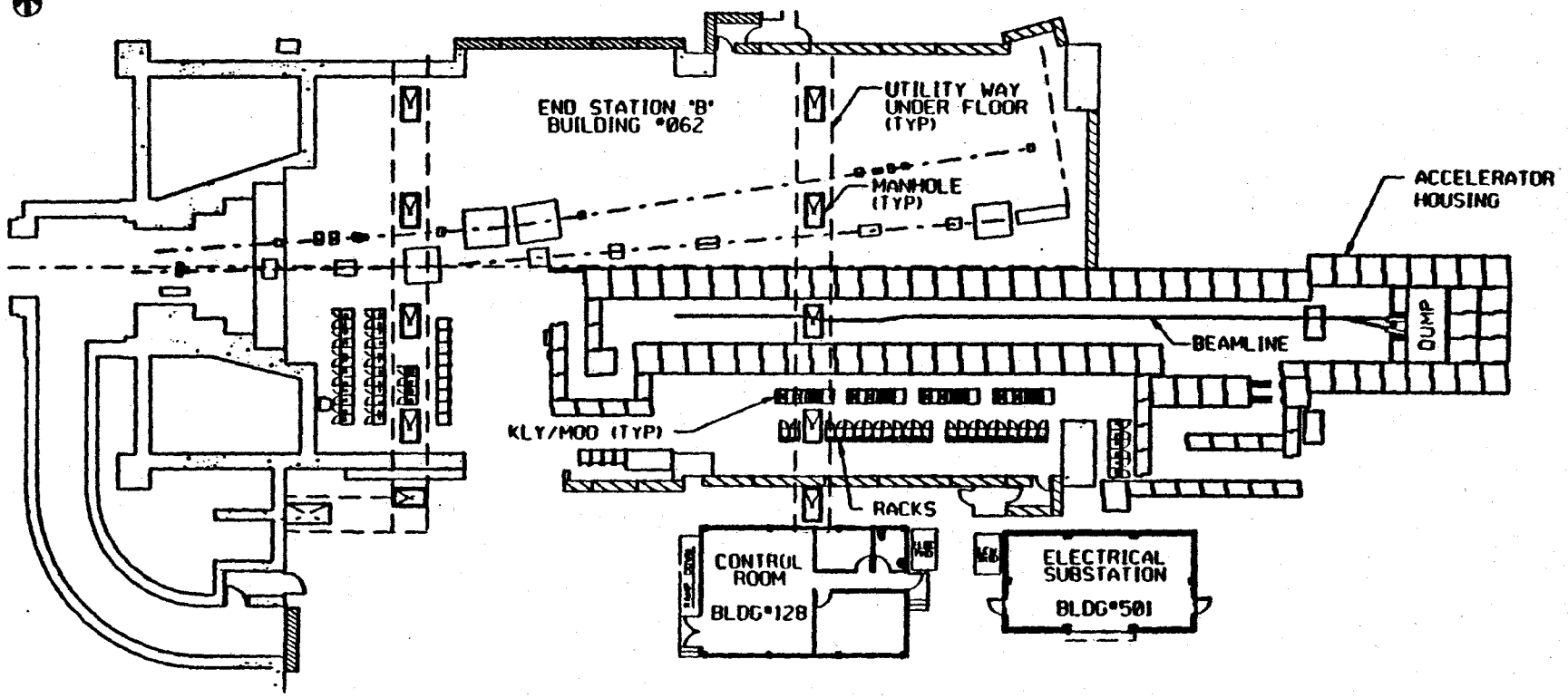

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NLC TEST ACCELERATOR
END STATION 'B'
SITE PLAN

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