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SAFETY ASSESSMENT DOCUMENT
FOR THE
DYNAMIC TEST COMPLEX
(BUILDING 836)

Byron N. Odell
and
Harold E. Pfeifer

UCID--19343

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PREFACE

This document was originally drafted to meet the requirements of ERDA Manual Chapter D531 about the time SAN MD 5481.1 was issued. It was agreed by DOE SAN that, with a few minor modifications, the document would meet the intent of SAN MD 5481.1. These modifications have been included.

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Abstract

A safety assessment was performed to determine if potential accidents at the 836 Complex at Site 300 could present undue hazards to the general public, personnel at Site 300, or have an adverse effect on the environment. The credible accidents that might have an effect on these facilities or have off-site consequences were considered. These were earthquake, extreme wind (including missiles), lightning, flood, criticality, high explosive (HE) detonation that disperses uranium and beryllium, spontaneous oxidation of plutonium, explosions due to finely divided particles, and a fire.

Seismic and extreme wind (including missiles) analyses indicate that the buildings are basically sound. Lightning protection for these facilities is adequate. These buildings are located high above the dry creek bed so that a flood is improbable.

The probability of high explosive detonation involving plutonium is very remote since the radioactive materials are encased and plutonium and HE are not permitted concurrently in the same area at Site 300. (The exception to this policy is that explosive actuating devices are sometimes located in assemblies containing fissile materials. However, an accidental actuation will not affect the safe containment of the plutonium within the assembly.)

There is a remote possibility of an HE explosion involving uranium and beryllium since these are permitted in the same area. However, the calculated off-site lung doses were found to be well below the accepted standards. The possibility of a criticality accident is very remote since the fissile materials are doubly encased in stout metal containers. All operations involving these materials are independently reviewed and inspected by the

Criticality Safety Office. It was determined that a fire was unlikely due to the low fire loading and the absence of ignition sources. It was also determined that the consequences of any accidents were reduced by the remote location of these facilities, their design, and by administrative controls.

All recommendations to improve facility safety are summarized in Section 9 of this report.

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SECTION 1 -- INTRODUCTION

This Safety Assessment Document (SAD) for the *Dynamic Test Complex (Building 836)* provides a comprehensive review of individual buildings and the operations conducted in them, discusses potential accidents, makes an assessment of risks, and recommends corrective action. Detailed procedures for handling on-site accidents are contained in the LLNL Health and Safety Manual, Disaster Control Plans, Operational Safety Procedures, and the Fire Department Operations Manual.

The Dynamic Test Complex is used for vibration testing of specimens that contain hazardous materials (explosives, radioactive materials, or toxic materials). The present cost to replace the facility and equipment is over \$7,500,000.

This SAD provides the LLNL Program Leader and the Manager of Plant Services with a written objective analysis of the facility and its operations, approaches them with recommendations for corrective action in any area that appears deficient, and permits their review of whether these operations can be performed without undue risk to the health and safety of the employees as well as the public.

There are nine sections in this report. Section 2 summarizes the information contained in Section 3 through 9. Those appendices referred to by section numbers (such as Appendix 6A) are included at the rear of this document.

This assessment determined that insufficient quantities of radioactive materials could be released during the maximum credible accident to qualify these buildings as *nuclear facilities as defined in ERDA Manual Chapter 0531*.

Routine releases do not occur and the largest off-site doses under accident conditions are calculated to be 0.46 mrem from plutonium and 4.3 mrem from uranium. The safe-guards, which have been developed to minimize the occurrence and consequences of accidental releases of radioactive materials, meet the as low as reasonably achievable (ALARA) criteria established in DOE Order 5480.1 and by LLNL. Even in the event of a maximum credible release, the calculated off-site doses of 0.46 and 4.3 mrem are well below the 500 mrem effluent dose limit specified in ERDAM 0524 and now prescribed in DOE Order 5480.1.

Explosive handling is the only moderate hazard at this complex, the other hazards are low as defined in DOE Order 5481.1A. Since these facilities were especially designed to handle explosives, surrounded by earthen berms, located in a remote area, and considering that special operating procedures are followed, this is deemed an acceptable risk.

It is also determined from this safety assessment that the operations in the 836 Complex can be conducted according to existing codes, standards, and regulations and there will be no undue risks to the health and safety of LLNL employees or the public.

SECTION 2 -- SUMMARY OF SECTIONS 3 THROUGH 9

This section summarizes the major topics discussed in Sections 3 through 9.

Section 3 provides a description of Site 300's location, surrounding population distribution, adjacent land use, geology and seismicity, meteorology, tornado and extreme straight wind, hydrology, and archaeology.

Section 4 provides a description of the 836 Dynamic Test Complex including a brief description of each building, the supplied utilities, lighting, and communication systems, as well as the environmental maintenance features and their controls. Special emphasis is given to the description of the safety control features.

Section 5 describes the operations conducted at the 836 Dynamic Test Complex.

Section 6 discusses the potential accidents deemed credible for the 836 Complex. Accidents due to acts of nature and human error are discussed. Consequences of these accidents are compared to existing standards.

Section 7 discusses the environmental program conducted at Site 300. It summarizes the various sampling methods used to detect any changes in environmental levels on and around the Site.

Section 8 provides an assessment of the risks involved in conducting the operations at the 836 Complex. A matrix lists the potential hazards and exposure, the mitigating features and their possibility of failure, identifies the consequences of such failures, and determines the level of risk.

Section 9 summarizes the findings and recommendations of this safety assessment.

SECTION 3 — DESCRIPTION AND SAFETY ASSESSMENT OF SITE 300

Location, Population Distribution, and Land Use

The Explosives Test Site (Site 300) is located about 16 km southeast of the Lawrence Livermore National Laboratory in the sparsely populated hills of the Diablo Range. This range separates the Livermore and San Joaquin Valleys. The Site occupies an area of 28 km^2 , or a little less than 7000 acres. About one-sixth of the Site, along the western edge, lies in Alameda County. The remainder of the Site is located in San Joaquin County. Figure 3-1 shows Site 300 and the surrounding communities.

The nearest communities to Site 300 are Tracy to the northeast and the city of Livermore to the west. The Tracy city limits are 9 km northeast of the eastern Site boundary. Tracy has a population of about 20,000. Livermore is a community of about 50,000 people with the city limits about 13 km west of the western boundary of Site 300. Figure 3-2 shows the estimated populations by 22.5 degree sectors within 9.6 km of Site 300.

Land use adjacent to Site 300 consists of four major users to the south: i.e., 1) Carnegie Cycle Park, an outdoor recreational facility for off-the-road motorcycle riding, testing, and racing, 2) the Connolly Ranch, which is used primarily for the grazing of cattle, 3) Stanford Research Institute, which operates an explosives test site adjacent to the Carnegie Cycle Park, and 4) Physics International, which operates an explosive test site adjacent to Site 300's north-east side. Surrounding Site 300 on the west, north, and east are small farms and ranches used primarily for cattle grazing.

Geology and Seismicity

Site 300 is located on the eastern side of the Diablo Range. The southern boundary of the Site lies adjacent to the west-east Corral Hollow Valley. The relief of the Site increases rapidly from the valley floor in a north and northwest direction. The lowest elevation is a little less than 150 m at the southeastern edge of the Site, and the highest point is over 510 m in the northwestern sector. The hills are smooth and rounded, and the drainage patterns are well developed by gullies and steep ravines.

Faults have been identified in the vicinity of the Site area -- the Corral Hollow Fault, the Tesla Fault, and the Carnegie-Patterson Pass Fault system. Although some of the faults may be considered active, none of them have had any violent action in historic times.³⁻¹

Meteorology

LLNL has operated a climatological observation station at Site 300 for many years. Station instruments measure and record surface temperatures, pressure, humidity, and precipitation, as well as surface and limited upper air winds. Much of the following data are taken from these records.³⁻²

The mean annual precipitation is about 267 mm, although wide variation occurs from year to year. Most of the precipitation falls between the months of October and April in the form of rain, although a light dusting of snow can occur on the coldest days. Localized thunderstorms with the threat of lightning are infrequent.

Maximum temperatures in the winter months, November to February, average around 13°C . During these months the minimum temperatures are never much below the freezing level. Relative humidity is about 85 to 90% at night, decreasing to 60 or 70% during the afternoon. Winds are predominantly from the west and average about 5 to 7 m/s in the winter months.³⁻³

The dry season extends from May through September. Daytime temperatures in the mid 30's and low 40's ($^{\circ}\text{C}$) are common in the middle of the summer. The relative humidity ranges from about 30 to 50% in the driest part of the year (fall). Persistent westerly winds are characteristic of this area from spring to fall. Marine air flows through the canyons into the San Joaquin Valley and results in moderately strong winds in the afternoon and evening.

Tornado and Extreme Wind

The tornado (extreme wind) assessment for Site 300 is based on the report, "Development of a Design Basis Tornado and Structural Design Criteria for Lawrence Livermore National Laboratory's Site 300" by McDonald, Mehta and Minor.³⁻⁴ Two probabilities were considered for evaluating damage potential to facilities at Site 300; i.e. tornado criteria based on an occurrence of 10^{-6} /year, and extreme wind criteria based on an occurrence of 10^{-4} /year³⁻⁵. The maximum wind speeds associated with these frequencies are 46 m/s and 54 m/s. winds approaching these speeds have not been observed at Site 300; the maximum wind speed recorded at the Site is about 40 m/s.

Hydrology and Flooding

Surface

The drainage divide for the coastal ranges in the area between Livermore and Stockton is the Diablo Range. Since Site 300 lies on the eastern flank of this range, all of the runoff from the Site flows to the San Joaquin Valley. Most of the Site runoff flows into Corral Hollow Creek, which is close to the southern boundary of the Site. Corral Hollow Creek is an intermittent stream carrying water only in the rainy season, and it flows toward the San Joaquin River, which is located approximately 28 km east of Site 300.

Subsurface

In a region (the coast ranges) noted for structural complexity, the geology of Site 300 is apparently simply structured. The dominant feature is the Patterson Pass Anticline that lies in the midst of the Site. The 836 Complex is situated east of the nose of the anticline. Assuming a close similarity between the ground surface topography and the water table configuration, it is inferred that shallow subsurface flow takes place in all directions from the 836 Complex and that flow is generally from north to south. Shallow groundwater flow should generally follow the steepest topographic gradients until it arrives beneath natural drainage ways. From there, subsurface flow will likely continue beneath the surface ravines towards the major drainage way of the area, Corral Hollow.³⁻⁶

Flooding

It is extremely unlikely that flooding of Corral Hollow Creek will affect the 836 Complex at Site 300. The buildings are located on the crest of a hill having an elevation in excess of 260 m. The creek elevation is approximately 150 m and has a wide flood plain.

Archaeology

An archaeological reconnaissance of Site 300 was performed by the Archaeological Consulting and Research Services, Mill Valley, California.³⁻⁷ This study identified seven archaeological sites, or evidences of aboriginal activity, and provided a thorough discussion of each area. None of these sites are located in the vicinity of the buildings discussed in this report.

A Class III cultural resource inventory performed by Basin Research Associates, Hayward, California³⁻⁸ disclosed 24 cultural resource properties and 25 site types. Most of these were located in and around canyon-gully areas. None of these findings were in the vicinity of the R36 Complex.

2-C

Fig. 3-1. Site 300 location

Fig. 3-2. Estimated population within 9.6 km
of Site 300 (1976).

References

- 3-1 Thorpe, R. K. and L. W. Wight, A Geological and Seismological Investigation for the 834, 836, and 854 Building Complexes at LLL's Site 300, Lawrence Livermore National Laboratory Report UCRL-52006, January 29, 1976.
- 3-2 Peterson, K. R., Site 300 Safety Analysis Report - Meteorology and Air Quality, Lawrence Livermore National Laboratory Internal Report UASG78-29, May 1978.
- 3-3 Archibald, P. B. and J. B. Knox, An Analysis of the Winds of Site 300 as a Source of Power, Lawrence Livermore National Laboratory Reports UCRL-51469, October 23, 1973 and April 19, 1977.
- 3-4 McDonald, J. R., J. E. Minor, and K. C. Mehta, Development of a Design Basis Tornado and Structural Design Criteria for Lawrence Livermore Laboratory's Site 300, California, Lawrence Livermore National Laboratory Report UCRL-13667, November 1975.
- 3-5 Revised Tornado, Extreme Wind, and Earthquake Criteria for LLL-Livermore, Site 300, and the 410 Area of NTS, internal letter, J. L. Olsen to C. D. Jackson, July 14, 1976.
- 3-6 Inferred Patterns of Shallow Ground-Water Movement from the 834, 836, and 854 Building Complexes at Site 300, Lawrence Livermore Laboratory, Internal Memo HRG 76-21 from R. Stone to W. J. Silver, September 7, 1976.

3-7 Archaeological Report On Site 300, Appendix 3A in Draft Environmental Impact Statement Livermore Site Livermore, California U.S. Department of Energy Report DOE/EIS-0028-D, September 1978.

3-8 C. I. Busby, D. M. Garaventa, and L. S. Kobori, A Cultural Resource Inventory of Lawrence Livermore National Laboratory's Site 300, Alameda and San Joaquin Counties, California, Lawrence Livermore National Laboratory Report UCRL-15364, May 1981.

SECTION 4 -- FACILITY DESCRIPTIONS

Introduction

The 836 Dynamic Test Complex consists of a one-story, reinforced concrete Control Building (B-836A); a one-story, steel Mechanical Equipment and Storage Building (B-836B), and an earth-covered, reinforced-concrete Test Cell (B-836C) often referred to as the Hydraulic Shaker Building. The Hydraulic Shaker Building is used for testing hazardous materials and houses a large reaction mass plus associated hardware which is used in the testing and evaluating of various weapons systems, mechanical equipment, etc. while they are being subjected to vibration and shock environments. The Weapons Test Group of the Weapons Engineering Division in the Mechanical Engineering Department administers and operates this Test Complex. Background data for this section was obtained from References 4-1 through 4-5. The 836 Complex location at Site 300 is given in Fig. 4-1.

A plan layout of the 836 Complex is given in Fig. 4-2.

Building Descriptions

Hydraulic Shaker Building (B-836C)

The total area of B-836C and the adjacent equipment room is 168 m^2 , divided up as follows:

Shaker Building - 123 m^2

Mechanical Equipment (others) - 45 m^2

The total volume of the Shaker Building (less mechanical equipment room) is approximately 830 m^3 . An external view of 836C is given in Fig. 4-3.

The Shaker Building consists of a large open bay with a reaction mass located below the building with the top surface flush with the floor (see Fig. 4-4). The reaction mass is a large, rectangular, reinforced-concrete block weighing approximately 617,000 kg. The top surface contains provisions for attaching both the hydraulic actuators and specimens to be tested. The hydraulic actuators may be positioned to allow testing in an x, y, or z axis (see Figs. 4-5 and 4-6). The large size and weight of the reaction mass prevents motion to the building during shock and vibration tests.

The exterior walls are 0.46 m-thick reinforced, load bearing concrete, with two retaining walls opening outward in front of the facility (see Fig. 4-3). The building is covered with earth to an approximate depth of 0.9 m above the roof, with a tapering overfill on three of the sides. The retaining walls provide a barrier for the earth overfill, and act as a shield to direct fragments and debris to the open canyon should an accidental explosion occur within the test cell. The entrance wall is constructed of lightweight structural members and frangible wall panels, which are designed to fail and release overpressure in the event of an explosion. The test cell ventilation system is equipped with a recirculating system and a once through, HEPA filter system that is used during dynamic testing of assemblies containing radioactive materials. The filter system is capable of pulling 46 m³/min airflow across the personnel entry door, or an exhaust capability of 113 m³/min from the test cell.

The floor of the test cell is covered with epoxy paint.

The test cell contains a 11,000 kg bridge crane that supports two, 5500 kg hoists. Crane coverage allows movement and placement of test assemblies in all areas of the cell. A 900 kg jib crane mounted on the wall nearest the reaction mass is used to reposition the instrumentation used for data gathering (See Fig 4-4). A mobile crane (450 kg) is available for use in moving other equipment when required.

All fixed electrical installations inside the test cell conform to the electrical classification of Class II, Division I, Group G. Note: Electrical classifications are outlined in the National Electrical Code, NFPA 70-1976, Article 500. Class II locations are those that are hazardous because of the presence of combustible dust. Non-Class II operating equipment is not allowed in the cell unless it provides adequate safety features to preclude being a source of ignition.

The test cell is configured with overhead wet pipe sprinklers. Each sprinkler head is individually activated by a fusible link. A flow indicator on the automatic sprinkler system transmits a fire alarm to the Site 300 Fire Station when there is any flow of water in the system. Audible fire alarms are positioned throughout the test complex to alert personnel that a sprinkler head has opened.

Electrodynamic Shaker Building (836D)

Since the facility has not been constructed yet, a detailed description of it is not included here. However, a description of the planned facility (836D) is contained in "WFP Preliminary Proposal Project No. 81C-03, dated October 1979".

Control Building (B-836A)

The total area of B-836A is 203 m², divided up as follows:

- o Control Room - 115 m²
- o Offices, electronic repair, muster area - 52 m²
- o Others (toilet, closet) - 36 m²

The exterior walls are constructed of reinforced concrete, 0.30 m thick. The flat roof consists of two, 0.2-m-thick, reinforced concrete sections, with the roof above the main control room being supported by six, 0.38 m x 0.56 m reinforced concrete beams. The floor is 0.15-m-thick, reinforced concrete, and is raised in the main control room to allow space below the computer floor. The Control Building is designed to withstand a peak pressure pulse of 3.5 kPa, with a duration of the positive phase from 10 to 12 ms. The Control Building is also designed to withstand a negative pressure pulse of 1.4 kPa with about the same duration. Both magnitude and duration of the pressure pulses were computed on the detonation of 90 kg of explosives at the Shaker Building.

Instrumentation wiring and electrical power is run in raceways below ground from the Control Building to the Shaker Building. The control building is air conditioned for electronics equipment and personnel comfort (see Fig. 4-7). Emergency electrical power is provided automatically to B-836A by the emergency diesel generator. The control room contains product of combustion (ionization) smoke detectors that transmit a fire alarm to the Site 300 Fire Station if activated.

Mechanical Equipment and Storage Building (B-836B)

The total area of B-836B is 455 m² is divided up as follows:

- o Mechanical Equipment Room - 284 m²
- o Storage - 134 m²
- o Utility room - 37 m²

The Mechanical Equipment and Storage Building is a steel frame structure with corrugated metal siding and roof. The storage building is air conditioned and the interior of the building is insulated. The west wall of B-836B is reinforced concrete blocks with all cells filled solid. This building houses the major mechanical and electrical utility systems necessary for the operation of the Complex. The building has a loading dock, a 900 kg monorail crane, and a fire protection sprinkler system. A flow indicator on the automatic sprinkler system transmits a fire alarm to the Site 300 Fire Station when there is flow of water in the system.

A covered utility room and an open area (for diesel generator, motor generator, and electrical substation) are located between the Control Building and the Mechanical Equipment Building. The utility room houses the air conditioning unit for the Control Building; the south wall is constructed of filled concrete blocks, and the north wall has metal siding.

The hydraulic power supply to the Shaker Building consists of 11 individually controlled, pressure-compensated pumps running in parallel (see (Fig. 4-8). Five charging pumps and one circulating pump provide a continuous supply of oil to the high pressure pumps. A fire-retardant synthetic oil (Fyrquel) is used for safety purposes. Hydraulic lines connect the pumps to the actuators positioned atop the reaction mass. The hydraulic supply and return lines are located above ground between the Test Cell and the Mechanical Equipment Building.

Support Facilities

Two support facilities are located approximately 20 m south of the Mechanical Equipment and Storage Building. They are the solvent storage area and water cooling tower. The cooling tower provides cooled water to the air conditioning unit (Control Room), pump oil, and the air compressor aftercoolers located in the equipment room in the Mechanical Equipment Building. Overflow from the solvent storage and the cooling tower drains into a gravel percolation pit located a short distance away.

Utilities

Electrical Utilities

The electrical utilities include:

- o Primary electric power supply system
- o Emergency power system
- o Battery power
- o Motor generator power, B-836A

Primary Power -- Electric power is delivered at 115 kV to the Site 300 power station by PG&E. Power (12 kV) is then delivered by two feeders throughout the Site. The east feeder supplies electricity to the 836 Complex through a combination overhead and underground wiring system.

Emergency Power -- A diesel generator, with a 200 kW rating, provides auxiliary power to the 836 Complex when primary power fails. The emergency diesel generator is capable of starting from rest and delivering rated load within 10 s of primary power failure. Minimum power requirements to continue thermal testing, provide lighting, and operate the control room are available from this emergency diesel generator. It will not provide power for vibration testing

Battery Power -- The fire alarm panel in B-836A has power supplied through a battery bank inverter when there is a power failure and before the emergency generator comes up to power.

Motor Generator Power, B-836A -- The motor generator power system is a special system that supplies power to B-836A (computer and control systems) when uninterrupted power is required for a given test. This alternate power system will provide power up to 42 s or until the emergency power system (diesel generator) reaches full power output. The motor generator also provides power to prevent primary power voltage fluctuations from affecting the instrumentation systems. The motor operation will not provide power for vibration testing.

Piped Utilities

The piped utilities are:

- o Site 300 water
- o Compressed air
- o Vacuum
- o Liquid and gaseous nitrogen
- o Refrigerant (R-22)

General practices in this installation are that:

- o Reduced pressure backflow preventers are provided on all Site 300 water lines that enter areas of possible radioactive contamination.
- o Double check - valve backflow preventers are provided on all compressed air lines.
- o All branch circuits from the mains are valved in accordance with applicable building codes.

Lighting

Fluorescent lighting is used in the Control and Mechanical Equipment Buildings. The Control Room lights have separate switches to reduce lighting intensity. The Shaker Building is lighted by 16 mercury vapor lamps, with remote ballast. These lamps meet the electrical classification of Class II, Division I, Group G. Three emergency lights (Class II, Div. I, Gp. G) are also located in the Test Cell, and are connected to the emergency power system.

Exterior lighting is installed for building entrances and pedestrian and vehicular approaches to the Complex. The lights are a combination of outdoor mercury lamps and floodlights used for both area illumination and perimeter security.

Communications

Telephones are located in each of the buildings in the Complex and at several locations in the Control Building. An intercom/speaker system is installed in each of the three main buildings in the Complex.

Environmental Maintenance Features and Their Controls

Air Conditioning and Heating

Heating and cooling are provided for human comfort and operational quality control. Air Conditioner-2, located in the mechanical equipment room adjacent to the Test Cell, provides conditioned air to the Shaker Building, and maintains the temperature at approximately 24°C. Air Conditioner-1, located in the Utility Room adjacent to the Control Building, provides conditioned air to the Control Room. Heating coils in supply ducts (Control Building) are

controlled by space thermostats to achieve the desired temperature and humidity control. Five electric space heaters, each with individual thermostat control, are located in the Mechanical Equipment and Storage Building.

Ventilation

There are two types of ventilation systems in the Test Cell; a recirculating system and a once-through, HEPA filtering exhaust system. The recirculating ventilation system serves the open bay and the air space around the seismic mass during equipment repair, setup and pretest type operations. The once-through system, which is only used during the vibration testing of assemblies containing special nuclear materials, is capable of maintaining below ambient atmospheric pressure to prevent the recirculation of potential contaminants during test.

The ventilation fan for the Test Cell is shut off automatically when the HEPA filter unit is energized. This removes temperature control from the Test Cell. If temperature control is required, a separate thermal chamber is used during the test.

Fresh air is modulated through fan inlet vane dampers and supplied to the return air ducts for each of the air conditioning units located in 836A and C. The modified return (supply) air is then heated or cooled as required.

Two supply fans provide outside air at $300 \text{ m}^3/\text{min}$ each for ventilation of the Mechanical Equipment Building.

Safety Control Features

General

Tests conducted in the 836 Complex have a very low potential for accidents. However, accidents might happen that could cause varying degrees of risk to Laboratory personnel, to the public, and to the environment. The following paragraphs describe both equipment and procedures to protect the health and safety of employees and the public, and to minimize the possibility of damage to Laboratory and off-site property.

Explosives Safety

All equipment used to handle explosives must be certified. Cranes and hoists are operated and inspected according to the criteria given in the LLNL Health and Safety Manual Supplement 29.04B and Procedure No. 107 of the Site 300 Safety and Operational Manual, titled "Explosive Handling Equipment"⁴⁻⁶. Explosive/ignition proof electrical equipment, which meets the requirements of the National Electric Code is used where applicable.

Building 836C is designed for use in testing assemblies containing hazardous materials, one of which is high explosives. Although the possibility of an explosion always exists, the combination of directed irangible front wall construction and building location (far apart with an earth barricade) will prevent or minimize damage to adjacent buildings should an accidental explosion occur.

Fire Safety

The water supply for the sprinkler systems and the HEPA filter automatic

water spray system is supplied from the Site 300 cold water supply.

Electrically supervised shutoff valves are positioned at readily accessible locations. For additional assurance, these shutoff valves are administratively controlled and padlocked open by the Fire Department.

The fire alarm panel is located inside the Control Building. This panel has power supplied through the battery bank inverter. If there is an open or short circuit in the alarm circuit, a trouble light will be lit on the alarm panel. The smoke detectors and sprinkler alarms will cause a red "FIRE" light and a zone indicator light to illuminate on the panel. Both the trouble and fire conditions cause a buzzer to sound and an alarm signal to be transmitted automatically to the Fire and Police Stations (B-870). A remote annunciator panel is also located outside the Security fence adjacent to the road leading to the B-836 Complex.

Electro-Mechanical Safety

Tests routinely conducted at the 836 Complex include the placing of a test package on a shaker table, securing the package to the table, and performing the desired vibration test using a computer to initiate, monitor, and control the test. It is very unlikely that mechanical problems (rupture of attachment bolts, containment package rupture, hydraulic actuator failure) will be encountered during a test. Electro-mechanical systems might be subject to a "run-away" condition; however, computer safety controls, operators monitoring the computer, emergency stop switches for both the computer and hydraulic pumps, and "remote" operation will tend to minimize problems associated with an extreme vibration.

The heart of the vibration test system is a computer that provides electrical wave forms, which in turn are converted into displacements on the

shaker table. Sensors, located in and on the table, monitor table movements, and in turn provide information that is used by the computer to refine or maintain the desired wave input. Three safety constraints (described below) have been installed in the vibration test system to prevent a system "run-away" as a result of signal failure, hose rupture (loss of oil), or unknown problems.

Software programs, for any test series, include many internal safety checks; i.e., input values versus measured. Any deviations from preselected limits will initiate a panel warning light and if the condition is not corrected, the computer will initiate a return to zero amplitude on the wave form. If the unsafe conditions exceed a preset displacement limit, the computer will automatically shutdown the hydraulic actuator pumps.

An operator remotely monitors the sight and sounds within the test cell. He has two emergency stop buttons that can be activated to terminate testing; i.e., one button for the computer, and the other, for the hydraulic pumps. Either button, when activated, will stop the vibration test. Either button could be activated if the operator observed or heard a problem in the test cell during test.

If one of the 1-cm dia. hose ruptured, it may not be heard or observed and the oil pumps would continue to maintain line pressure until the 25 gals of oil in the tank is pumped out. If one of the 5-cm dia. hose ruptured, it would spew oil with a loud gushing sound. Pressure sensors in the oil lines would immediately sense the reduced pressure and automatically send a signal to shut off the hydraulic pumps. Also, a float in the oil reservoir would automatically actuate a switch that would shut off the pump. It is estimated that 55 gals of oil would be sprayed in the cell before the pumps stop working.

Lightning Protection

Lightning protection is provided for the Test Cell (836C). The lightning air terminal is positioned at the highest point and is connected to the building ground system. Neither the Control Building nor the Mechanical and Storage Building contain external lightning protection. A description of the lightning protection afforded the 836 Complex is discussed under the Lightning Analysis in Section 6.

Radiation Safety

The test cell contains a fixed-station alpha detector that will sense any change in the area radiation levels down to the maximum permissible concentration in air (MPC_a) for Pu and transmit a signal to the Control Room, where an audible and visual alarm is located. Any rise in count rate is assumed to be a test item failure unless it can be established otherwise.

Effluent Controls

Airborne Effluents

The HEPA filter system is designed to control and contain radioactive materials if dispersed in the test cell during testing. When a test is being conducted, a special exhaust system will be activated discharging all air from the room and any environmental chamber being used as part of the test, through double High Efficiency Particulate Air (HEPA) filters. The HEPA filtered exhaust system is tested annually and has a maximum allowable penetration of 0.03% for 0.7 micron particles. The system is designed to exhaust air at 113 m^3/min through two banks, with four filters per bank. HEPA filters are protected from fire by automatic water spray dampers and filter face spray protection.

Displacement of oxygen by liquid nitrogen vapors from low temperature testing are detected using portable equipment transported by operating personnel at time of cell entry.

Liquid Effluents

The Test Cell drainage system is designed so there is little possibility of an uncontrolled or unknown radioactive liquid effluent release from the building. A trench is located on the interior of the Test Cell near the personnel and rollup doors. The trench drains to a retention tank that has provisions for cleaning out any and all materials. This trench is designed to contain hydraulic oil in the event of a ruptured line and/or water from from the fire protection sprinkler system. Water from the sprinkler system could wash high explosive particles or radioactive materials into the trench system. Water from the spray dampers is also drained to the retention tank.

Building 836A has a sanitary sewer leading to an underground septic tank and leaching field. Both the Utility Room and 836B contain storm drains that lead to a gravel-filled percolation pit.

Solid Effluents

Solid wastes, which may be generated during operation of the test facility, are handled according to guidelines outlined in Procedure No. 400, of the Site 300 Safety and Operational Manual, titled "Waste Disposal Procedures".⁴⁻⁶ Detailed disposal procedures for explosives, radioactive wastes, flammables (liquids, oily rags, etc.), plastic wastes, etc., are also contained in the procedure.

Security and Safeguards

The 836 Complex is surrounded by a 2.4-m-high security fence. Access to inside the fence is through one set of gates. Personnel access to and from the 836 Complex is controlled by the Facility Supervisor.

The 836 Complex is lighted for security purposes and night activities. A security alarm system is installed in the Shaker Building and is connected to a remote indicator located at the Police Master Console, B-870.

An external TV camera and intrusion alarm are used to detect attempted entry into the test cell.

Building Modifications

The emergency (auxiliary) power unit for the Dynamic Test Complex (B-836A,B,C) has been modified to provide emergency electrical power to the Physical Test Facility (B-833) located a short distance to the west. The auxiliary power unit can supply electrical requirements to both areas in case of emergency.

Analysis of overpressure, produced from 9500 kg of explosives, required for a special test, has shown that some damage (cracking, buckling, spalling) would probably occur to the reinforced concrete Control Building. The weakest portion of the building was determined to be the entrance and exit doors. Sliding protective doors were installed to withstand this increased pressure loading.

Facility Disposition

The 836 Dynamic Test Complex at Site 300 can be readily restored to the public, or future occupants of the Site, if such restoration were to become desirable. Normally these buildings are free of any radioactive or explosive contamination. However, as part of the restoration process, these buildings will be monitored for all hazardous materials just to make sure that they are "clean". If any radioactivity is detected, this contamination will be removed using appropriate methods.

Fig. 4-1 Dynamic Test Complex B-836 Location at Site 300

Figure 4-2 Plan Layout of the Dynamic Test Complex

Figure 4-3 Building B36C showing HEPA filtration system, Mechanical equipment room, and frangible section of the east wall

Figure 4-4 Interior of 836C showing turbine-generator in test position

Figure 4-5 Hydraulic actuator in 836C

Figure 4-6 Hydraulic actuator in 836C

Figure 4-7 Control Room in 836A

Figure 4-8 Hydraulic pumps in 836B

References

- 4-1. LLL Plant Engineering Drawings, 836 Complex, PSZ-66-836-101, et al.
- 4-2. LLL Emergency Response Drawings, 836 Complex, PSH-76-836-001C, 002C, 003C.
- 4-3. Preliminary Proposal for Environmental Test Complex Building 836, Site 300; LLL, Dec. 1968.
- 4-4. Environmental Test Facilities, Building 336 Complex; Safety and Civil Aspects, Sept. 20, 1966.
- 4-5. Environmental Test Facilities, Building 336 Complex; Architectural and Structural Aspects, Oct. 10, 1966.
- 4-6. Site 300 Safety and Operations Manual, Reprint, M-091, 1 March 1978.

SECTION 5 -- DESCRIPTION OF OPERATIONS

Introduction

The Dynamic Test Complex, Buildings 836A,B,C is administered and operated by the Weapons Test Group of the Weapons Engineering Division in the Mechanical Engineering Department. (An additional Shaker Facility B-836U is planned for operation in 1982. A description of the operations to be performed in the proposed facility is contained in "WEP Preliminary Proposal Project No. 81C-03, dated October 1979".) The principal operation associated with the Dynamic Test Complex is vibration testing of units containing hazardous materials; i.e., explosives, radioactive materials, and when authorized, combinations of explosives and radioactive materials. Plutonium and explosives are not permitted concurrently within a test assembly or within a facility. The Complex has also been used for such studies as shock and vibration tests of rocket motors, seismic qualification of a turbine-generator set, and performance analysis of the rock bolts used in mine-tunnel construction.

A large hydraulic shaker can be programmed by a digital computer to perform sine and random vibration, transient pulses, and static load testing. These tests can also be performed at various temperatures in a thermal chamber.

Most of the materials undergoing test pose potential overpressure (HE detonation) and radiological problems if an accident occurred. Operations within the Complex are governed by Site 300 Operational Safety Procedures. These procedures are contained in the Site 300 Safety and Operational Manual,⁵⁻¹ which provides safety instructions to personnel at Site 300. All documents in the Manual have been assigned review or expiration dates to keep them viable.

Quantities and Types of Materials

A variety of materials and equipment have been tested using the facilities available in the B-836 Complex. Nearly all test components are encased.

Authorized materials include explosives, beryllium, radioactive materials, and other items outlined in Procedures No. 121 and 634, Site 300 Safety and Operational Manual.⁵⁻¹ An operating limit of 90 kg of explosives is permitted in 836C.

Fissile material use is outlined in Procedure 121, Hazardous Materials Control at Site 300. Plutonium and explosives are not permitted concurrently within a test assembly or within a facility. Occasionally enriched uranium is tested in the presence of high explosives. This requires special written procedures. Safety requirements for activities involving plutonium and enriched uranium are given in Tables 5-1 and 5-2. Combinations of explosives, radioactive materials, and other hazardous items are rigidly controlled, and may only be assembled and tested when all prescribed guidelines and Operational Safety Procedures have been reviewed and authorized by the Director's Office. Procedure No. 132⁵⁻¹ details the requirements for these assemblies.

Material Flow

Movement of test assemblies and related test equipment in and out of the 836 Complex is controlled by the Facility Supervisor. Within the Test Cell, materials are only moved from one work station to another by an authorized individual under the direction of the Facility Supervisor.

Detailed procedures are required when classified, hazardous, or special materials are being tested and stored in 836C. A Buddy System (part of the LLNL Site 300 personnel assurance program), Procedure No. 131,⁵⁻¹ is used as a precautionary measure to ensure that actions of any one person will not compromise fissile material. This system is used whenever fissile material is present at Site 300, and remains in effect until the material has been turned over to the appropriate agency authorized to transfer the material from the site. A coordinated effort between the Security Department and the Facility supervisor provides positive control for all test units during normal and offshift operations.

Operational Safety Procedures

An Operational Safety Procedure (OSP) is a published guideline for performing tasks safely and is prepared by the participants for special operations. These procedures provide detailed guidance on safety responsibility, permissible operations, material controls, descriptions of the facility's safety systems, personnel controls, etc. All work accomplished within the Dynamic Test Complex is governed by Procedures No. 600 and 636⁵⁻¹.

Changes and modifications to existing procedures are coordinated between the Site 300 Weapons Test Group Representative, Site 300 Hazards Control Safety Team Leader, and the Facility Supervisor.

A supplemental OSP is prepared when a specific, potentially hazardous experiment, material, test, or operation is not covered by an existing OSP. This supplemental OSP is also a coordinated effort between responsible participants. Reviews and approvals are described in the Site 300 Safety and Operational Manual's Safety and Management Program section.

Table 5-1. Safety Requirements for Several Activities Involving Plutonium

Activities	<u>Two metal containment barriers</u>	<u>Pressure vessels prohibited</u>	<u>HEPA filters required with 150 ft/min</u>	<u>Sprinklers required</u>	<u>Fireloading less than 1 lb/ft²</u>	<u>DOT approved shipping container necessary</u>
Transportation	Yes	No	No	No	No	Yes
Receiving and Inspection	Yes	No	No	Yes	Yes	No
Storage	Yes	No	No	No	Yes	Yes*
Thermal Test	Yes	Yes	No	Yes	Yes	No
<u>Dynamic Test</u>	<u>Yes</u>	<u>Yes</u>	<u>Yes</u>	<u>Yes</u>	<u>Yes</u>	<u>No</u>

Table 5-2. Safety Requirements for Several Activities Involving Enriched Uranium

Activities	<u>Sprinklers required</u>	<u>Fire loading less than 1 lb/ft²</u>	<u>DOT approved shipping container necessary</u>	<u>Satisfy Procedure 132 (with H.E. present)</u>
Transportation	No	No	No	Yes
Receiving and Inspection	Yes	Yes	No	Yes
Storage	No	Yes	Yes*	Yes
Thermal Test	Yes	Yes	No	Yes
<u>Dynamic Test</u>	<u>Yes</u>	<u>Yes</u>	<u>No</u>	<u>Yes</u>

*DOT approved shipping container not required for storage at Building 922 A,B,C, and D concrete vaults.

Operations

This particular test complex was designed to vibrate assemblies to check structural integrity and to observe and evaluate the behavior of components when subjected to a simulated operational environment. The large reaction mass allows a great flexibility in the shape, size, weight, etc., of various test assemblies. The test cell is equipped to lift and position test assemblies; a 11,000 kg bridge crane allows the positioning and movement of large test items from handling dollies, trucks, etc. A small, portable, mobile crane is used for lifting and for utility work. A wall-mounted jib crane (adjacent to the shaker) provides an additional capability to position the instrumentation data gathering system.

The frequency of thermal tests at the Dynamic Test Complex varies. A biweekly schedule, published by the Weapons Test Group, provides information on test programs for the B-836 Complex. Some tests may last several weeks, whereas other tests may last one or two days. Since program requirements do vary, some scheduled tests are deferred, and others are inserted.

A typical test program consists of the following plans, test preparations, and data gathering activities:

- o Prepare and review test plan
- o Match Test Cell capabilities with test requirements
- o Prepare supplemental DSP (as required)
- o Attach assembly and actuator to shaker table
- o Attach instrumentation cables as specified
- o Activate HEPA filtered exhaust system (if required)
- o Activate closed circuit television and begin test
- o Provide Test Engineer with recorded data.

If a hazardous condition is anticipated or occurs during testing, a coordinated discussion between the Facility Supervisor, Test Engineer, and Hazards Control will be held to evaluate the situation and develop special procedures.

Equipment and Facility Inspection

Three related inspection programs exist at Site 300 to minimize equipment failure and to review safety procedures. Plant Engineering follows a schedule of inspections. Such items as hoists, emergency generators, filters, lightning detection, etc. are inspected and tested according to written guidelines.

Operating personnel perform inspections of all running equipment prior to and during testing.

Hazards Control personnel follow an inspection schedule to evaluate facility operations, safety guidelines, and regulatory compliance.

Waste Handling and Disposal

Occasionally, scrap and solid waste are left over when testing is completed. The total quantity of waste material is estimated at less than $1 \text{ m}^3/\text{yr}$.

Uncontaminated and decontaminated waste materials are sent to the Site 300 burial pit. Normally, this facility does not generate any radioactive waste; however, if radioactive waste is involved, Hazards Control assists in preparing instructions for disposal according to Procedure No. 400, paragraph D.5-1

Toxic Materials

Toxic (nonradioactive) materials are sometimes encountered in operations at the 836 Complex. These materials may include solvents, fumes, liquid nitrogen, and, in a very rare case, beryllium. Protective clothing and respiratory protection are available for cleanup.

The Industrial Hygiene program for Site 300 includes standards and guidelines for the handling, storage, and control of all toxic materials. In addition, operational checks of ventilation systems, including HEPA filters and local exhaust systems, are conducted periodically.

Quality Assurance

Although no written quality assurance program exists for this Complex, there is an informal QA program that includes on the job training for new personnel, preventative maintenance, and supervision that makes sure that operations are performed as stated in procedures. The Weapons Engineering Division has agreed to formalize the QA Program in writing.

SECTION 6 -- SAFETY ANALYSIS

Introduction

This section presents and analyzes potential accidents deemed credible for the 836 Complex. Some accidents are discussed only to establish that their probability of occurring is very low.

Accidents are divided into two parts: acts of nature (earthquake, tornado, lightning, flood) and those caused by human error (criticality, spill, explosion, fire).

Acts of Nature

Seismic, Tornado, and Extreme Wind Analysis

When the safety assessment was first started, it was thought that the 836 Complex was a critical facility and that the possible fence-line radiation dose resulting from an accident could exceed 500 mrem. Therefore, seismic, tornado, and extreme wind analyses of this facility were performed to determine if it could meet the criteria established for critical facilities at Site 300. The results of these analyses indicated that the 836 facility could meet this criteria in all cases (see Appendix 6A). However, recent calculations (included in this section) indicate that any accident involving radioactive materials at this Complex would not result in fence-line radiation doses greater than 500 mrem (effluent dose limit specified in EROAM 0524 and as prescribed in DOE Order 5480.1). Thus, this is not a critical facility. No structural improvements are recommended for this facility based on the structural analysis and radiation dose calculations.

Lightning Analysis (See Appendix 68)

Thunderstorms occur less than five days per year in the Site 300 area, are not intense, and normally do not last more than one-half day per storm.

The actual number of lightning strikes per unit area has been approximated by Sunde⁶⁻¹ as $0.1/\text{km}^2$ per thunderstorm day. This can be applied to a calculation of the probability of a lightning strike in/near the 836 Complex.

Assuming the area of concern (836 Complex) is approximately $2.4 \times 10^{-3} \text{ km}^2$, the recurring interval of a strike in the area becomes

$$\begin{aligned} P &= 5 \text{ storms/yr} \times 1/2 \text{ day/storm} \times 2.4 \times 10^{-3} \text{ km}^2 \times 0.1 \text{ strikes/km}^2\text{-day} \\ &= 6 \times 10^{-4} \text{ strikes/year or 1 strike in 1667 years.} \end{aligned}$$

It is interesting to note that four lightning strikes have been recorded at Site 300 in the last ten years; however, none have occurred in the 836 area. Using the above factors and the area of Site 300 (27 km^2), we can calculate the expected number of lightning strikes, and compare with actual strikes to see if the calculation is, at least, conservative.

$$\begin{aligned} P_{\text{theoretical}} &= 5 \text{ storms/year} \times 0.5 \text{ day/storm} \\ &\quad \times 0.1 \text{ strike/km}^2\text{-day} \times 27 \text{ km}^2 \\ &= 6.75 \text{ strikes/year} \end{aligned}$$

which is much higher than observed; i.e.

$$\begin{aligned} P_{\text{observed}} &= 4 \text{ strike/10 years} \\ &= 0.4 \text{ strikes/year} \end{aligned}$$

Thus the predicted value is approximately 17 times more conservative than that observed based on 10 years of observation.

The overhead power lines, which feed this Complex, are protected by fuses and lightning suppressors before they go underground to distribution transformer pad. The transformer, emergency generator, and distribution panel are well grounded. Power cables from the distribution panel run underground to the various buildings of this Complex. The power system is adequately protected from lightning strikes, see Appendix 6B.

Control Building 836A is of heavy reinforced-concrete construction and should provide good lightning protection. Control and instrumentation racks are tied to a heavy ground buss.

Pump and Storage Building 836B is of steel girder construction with every other vertical wall member bonded to the ground system. Being of steel construction and well grounded this building provides excellent protection. Pumps and other mechanical equipment are tied to the ground system.

Test Bunker 836C is of heavily reinforced-concrete construction, is earth covered on the top and three sides, and has a lightning air terminal at its highest point. It appears that building 836C provides excellent lightning protection.

Telephone circuits in this Complex have the usual adequate lightning transient protection.

In conclusion, the 836 Complex will provide good protection against lightning hazards and damage. No further lightning protection is recommended.

Flooding Analysis

It is extremely unlikely that flooding of any building at the 836 Complex will ever occur. The terrain at Site 300 consists of hills, connections, plateaus, and numerous drainage ravines. Test complexes are located at the upper elevations and are isolated from adjacent test facilities by natural terrain barriers. The 836 Complex is situated near the crest of a knoll having an elevation of 250 m. In general, the terrain slopes downward from the 836 Complex in all directions except north. Even though that elevation is approximately 10 m higher, no drainage patterns lead into the 836 Complex, and no pooling of water will occur. Runoff from the 836 area is generally in a southerly direction and ultimately flows into Corral Hollow Creek, which is at an elevation of 150 m.

Human Error

Plutonium, Uranium or Beryllium Spill

A spill, as used here, is any unplanned loss of control of plutonium, uranium, or beryllium in any form. Even though a spill is unlikely, possible releases of these materials are considered. It must be emphasized that the postulated releases are considered to be extremely remote. There are no planned (non-accident) releases of radioactivity from the 836 complex. In fact, there are no planned releases of fissile material experiments at Site 300. The only possible releases would be from an accident. The safeguards, which have been established to minimize the occurrence and consequence of accidental releases of radioactive material, meet the as-low-as-reasonably-achievable (ALARA) criteria established in DOE Order 5480.1A and by LLNL.

Anytime fissile materials or H.E. are to be tested at Site 300, a special Operational Safety Procedure is required.

Accident Scenarios -- Potential accidents believed to be possible at Site 300 that could result in the release of U-235 or Pu-239 are only those involving physical shock to the assembly such as an earthquake caused collapse of a test cell or detonation of high explosives (HE). A plutonium - HE explosion is not considered since plutonium and HE are not permitted concurrently in the same area at Site 300. (The exception to this policy as stated in Procedure No. 132⁵⁻¹ is that explosive actuating devices are sometimes located in assemblies containing fissile materials. An accidental detonation will not effect the safe containment of the fissile material within the assembly.) Also, plutonium is encased in at least two sealed barriers. A major fire is not considered credible due to the very low fire loading and the lack of ignition sources.

An accident that disperses plutonium at the 836 Complex is considered extremely remote due to the low fire loading, the absence of H.E., and the strong structure. However, we have included -- accident involving plutonium to show what the maximum offsite radiation dose could be. In this unlikely accident scenario, it is assumed that the metal barriers of a test assembly containing four kilograms of plutonium are somehow breached, exposing the plutonium to the atmosphere. We then assume it oxidizes at a rate of $0.1 \text{ mg/cm}^2/\text{hr}$, the maximum low-temperature oxidation rate reported in the Plutonium Handbook by Wick.⁶⁻² With respect to the fraction of the oxidized material that becomes airborne, we have chosen the value of 0.05% suggested by Mishima and Schwendiman.^{6-3,6-4} It is further assumed that the accident

causing the plutonium to be exposed to air also destroys the test cell ventilation system. Hence the released particles are available to the environment and are transported by the winds occurring at the time. All of the released particles are assumed to be respirable. Using the above assumptions, the release rate is calculated to be 700 pCi/sec.

At Site 300, it is permissible to conduct experiments involving high explosives (HE) and U-235 but never under conditions that can result in a nuclear yield. An accident involving U-235 assumes that a sufficient mass of high explosives (HE) detonate very close to 35 kg of U-235. Based on the unpublished data of A. J. Toy,⁶⁻⁵ it is assumed that less than 5% of the uranium is finely divided into particles of respirable size, that the roof of the building immediately fails, and that the uranium and HE debris mix thoroughly, forming a puff initially centered at 160m with a radius of 14m.

Dose Calculations -- The modified CPSC⁶⁻⁶ code of Peterson et al was used to calculate Pu-239 doses while the IPSCT code of Peterson was used to estimate U-235 and beryllium doses resulting from a puff generated by a high explosives accident.⁶⁻⁵ Fifty-year dose commitments were calculated for plutonium and uranium inhalation for meteorology conditions that will be exceeded only 5% of the time based on hypothetical releases at each of the test complexes. Dose equals the product of (release) x (atmospheric dispersion factor, x/Q) x (dose conversion factor). Beryllium exposure was calculated using the same 5% worst case meteorology.

Plutonium Lung Dose -- The exposures from a Pu-239 release were time-integrated for 8 hr, the assumed release period. The dose conversion factor ($0.33 \text{ mrem-m}^3/\text{pCi-hr}$) of Bennett (HASL-278⁶⁻⁸) was used. The largest dose, which can be exceeded only 5% of the time from 836, is calculated to occur in summer at the site boundary 610 m southeast of Test Complex 836:

$$\text{Dose} = (700 \text{ pCi/sec})(8\text{hr})(2.5 \times 10^{-4} \text{ sec/m}^3)(0.33 \text{ mrem-m}^3/\text{pCi-hr})$$

= 0.46 mrem, which is well below the maximum value of 500 mrem

annual effluent dose limit specified in ERDAM 0524.

Uranium Lung Dose -- Five percent of 35 kg (5% of 35 kg) was used as a source term to calculate doses integrated during puff passage. The U-235 lung dose conversion factor from inhalation, 0.049 mrem/pCi inhaled, was taken from Regulatory Guide 1.109.⁶⁻⁹ The χ/Q (concentration at receptor/release rate) of 10^{-4} s/m^3 was obtained from the IPSC⁶⁻⁷ code. The specific activity of U-235 is $2.16 \times 10^6 \text{ pCi/g}$. Hence 5% of 35 kg represents $3.8 \times 10^9 \text{ pCi}$. Assuming a breathing rate for an adult of $20 \text{ m}^3/\text{day}$ ($2.31 \times 10^{-4} \text{ m}^3/\text{sec}$),⁶⁻¹⁰ then the largest dose, which can be exceeded only 5% of the time from 836, was calculated to occur in summer 700m east southeast of the 836 complex (700 m was used instead of the nearest site boundary because of the H.E. detonations which caused the release to be above the ground.)

$$\begin{aligned} \text{Dose} &= (3.8 \times 10^9 \text{ pCi})(10^{-4} \text{ s/m}^3)(2.31 \times 10^{-4} \text{ m}^3/\text{s})(4.9 \times 10^{-2} \text{ mrem/pCi}) \\ &= 4.3 \text{ mrem.} \end{aligned}$$

This value is well below the maximum value of 500 mrem annual effluent dose limit specified in ERDAM 0524.

Beryllium Lung Dose -- Based on the unpublished work of A. J. Toy,⁶⁻⁵ it is assumed that less than 0.5% of the 20 kg of beryllium becomes airborne. This was used as a source term to calculate the dose during the puff passage. Assuming the same meteorology and breathing rate used above for the uranium dose calculations, the beryllium calculation is as follows:

$$\begin{aligned} \text{Dose} &= (10^{-4} \text{ s/m}^3) \times 10^8 \text{ } \mu\text{g} \\ &= 10^4 \text{ } \mu\text{g s/m}^3 \quad \text{or} \quad \frac{10^4 \text{ } \mu\text{g s/m}^3}{60\text{s/min}} \\ &= 170 \text{ } \mu\text{g min/m}^3 \end{aligned}$$

This value is less than the maximum value of $1500 \mu\text{g min/m}^3$ total for a 10 to 60 min beryllium exposure recommended by NIOSH.⁶⁻¹¹

Nuclear Criticality

Before starting the discussion of nuclear criticality hazards, two definitions are needed to establish the difference between explosives and explosive accessories. Explosive accessories are explosively actuated devices such as explosive switches, explosive valves, explosive bolts, etc., that are designed and joined with assemblies, devices, or systems containing fissile material such that their planned or accidental actuation will not affect the safe containment of the fissile material within the assemblies, devices or systems.

Explosives or High Explosives are generic terms whose meanings in this Nuclear Criticality section correspond to their usual meanings in technical discourse.

Three classes of assemblies that contain fissile material and explosives or explosive accessories are tested in the Building 836 Complex: (1) U-235/High Explosive, (2) U-235/High Explosive/High Explosive Accessories, (3) Fissile Materials other than U-235/High Explosive Accessories.

U-235/High Explosive assemblies are subjected only to environmental tests in which it is not planned to detonate the high explosive. Environmental testing and movement of U-235/High Explosive assemblies is allowed only after a hazard analysis is made for each specific system, and it has been determined that a nuclear yield cannot possibly occur even if the high explosive detonates (this claim must be certified by the "A" or "B" Division Leader or his designated alternate). Each test plan is reviewed by the appropriate Program Division Leader and approved by that Program's Associate Director.

U-235/High Explosive/High Explosive Accessories assemblies may be subjected to environmental testing with or without actuation of the explosive accessories only after a hazard analysis is made for each specific system and it is determined that (a) a nuclear yield cannot possibly occur even if the high explosive detonates (this claim must be certified by the "A" or "B" Division Leader or his designated alternate), (b) the high explosives in the system will not be detonated by actuation of the explosive accessories. Each test plan is reviewed by the appropriate Program Division Leader and approved by that Program's Associate Director.

Fissile materials other than U-235 may not be assembled with or located in the same cell with high explosives. Subcritical configurations of fissile materials other than U-235 may be assembled with explosive accessories and subjected to environmental testing with or without actuation of the explosive accessories only after a hazard analysis is made for each specific system and it is determined that (a) the fissile material cannot possibly be dispersed by the actuation of the explosive accessory and (b) even if an accidental dispersal should occur, the fissile material will be contained within a secondary container, or in the worst case, within the facility. Each test plan is reviewed by the appropriate Program Division Leader and approved by that Program's Associate Director.

The rules and hazard analyses outlined in the previous three paragraphs serve to prevent explosively assembling a subcritical configuration of fissile material into a supercritical configuration. The probability of changing a subcritical configuration into a supercritical configuration by accidental introduction of moderating materials (e.g. water) is negligible because of a double containment requirement for the fissile materials in a test assembly.

The previous paragraphs discuss generally applicable constraints imposed on testing by nuclear criticality considerations. As a further precaution, each proposed operation with fissile materials is covered by a written Operational Safety Procedure, which is evaluated by members of the Criticality Safety Office

Explosions

Various types of explosions were considered using information in Sections 4 and 5. Among these explosion sources were flammable liquids, flammable gases, combustible dusts, and explosives. The design, location, and operations associated with the buildings in this Complex will tend to minimize the effects of any explosion.

Flammable Liquids -- A possibility exists that a small quantity (pint) of flammable liquid such as acetone, methyl alcohol, or similar volatile solvent would be used for cleaning during the preparation of equipment for test. (All flammable liquids will be removed from the test cell before the test specimen is brought into the test cell.) If the pint of acetone was spilled, and complete evaporation occurred, the vapor would occupy approximately 1.83 m^3 . Building 836 has an open volume of 1650 m^3 . The ratio of acetone vapor to air volume is about 0.1%. Since the lower explosive limit for acetone (by volume) is 2.6%, it would actually require more than three gallons of acetone to create an explosive gas - air mixture in the entire test cell.

Ventilation air would also aid in reducing any vapor concentration. Sources of ignition in each cell are minimal since electrical fixtures and controls use Class II electrical equipment. Thus, it is estimated that an explosion, which could occur as a result of using (or spilling) small quantities of flammable liquids, is highly unlikely.

Flammable Gases -- There are no significant quantities of flammable gases (hydrogen, methane, propane, etc) used in the 836 Complex.

Combustible Dust -- An explosion may occur in a room whenever the concentration of finely divided combustible materials (dusts) exceed their lower explosive limit and some form of ignition source is available. Whether or not a dust cloud will ignite is governed by the size of particles in it, dust concentration, impurities present, oxygen concentration, and the strength of the source of ignition.

None of the operations planned for the 836 Complex will produce dusts. There is a very remote possibility that some substances used in a test program could fail, and produce a finely dispersed lint, dust, metal, etc. Since the test cell is configured with Class II electrical equipment (dust ignition proof), ignition sources are minimal.

Explosives -- If an explosion occurred during a test, damage to a test cell would occur. The magnitude of the damage would vary depending on the quantity of explosives involved. A consequence of any explosion would be the failure of the frangible portion of the building. Debris would be scattered inside the cell, and in a cone shaped pattern away from the frangible wall. No irreparable damage would be sustained by adjacent buildings in the Complex.

The Control Building (836A) was designed to withstand a positive pressure pulse of 3.5 kPa, and a negative pressure pulse of 1.4 kPa. Both pulses were based on a 10-12 ms duration. The quantity of detonating explosives in 836C needed to exceed these design parameters is 9500 kg. A test conducted in 836C, using 9500 kg of explosives, only required door modifications to 836A to prevent failure in the unlikely event that the explosives detonated during testing. 6-12 This was accomplished by installing sliding blast doors on 836A.

In summary, the 836 Complex was designed for testing of certain hazardous materials. Although the possibility of an explosion always exists, the combination of building locations, types of construction, and administration of operation will prevent personal injury and minimize physical damage to facilities.

Fire

General -- It is extremely unlikely that a fire would ever occur during a dynamic test and pose a threat to an item containing explosives and/or radioactive materials. Electrical equipment are configured with redundant cut-off features to limit current and/or voltage, electrical fixtures and wiring in test cells have a rating of Class II (used in the presence of combustible dust), and potential ignition sources are removed/modified to meet safety guidelines.

The overall fire hazard analysis, for each of the test cells in the 836 Complex, considered four areas: (1) fire potential, (2) response to an alarm, (3) problems in fire fighting, and (4) a postulated fire that might occur during the preliminary setup, and checkout of test equipment.

Characteristics Affecting Fire Potential -- Access, building construction, ventilation, and fire alarm systems for the '836' test cells are discussed in Section 4. In addition, the following items also affect fire potential:

- o Fuel loading in the cell is relatively low, the maximum is 4.9 kg/m^2 .
- o Flammable liquids kept to a minimum and stored in safety cans.
- o Minimal external fire exposures to the Test Cell.
- o Contained explosives present during a test.
- o Fire extinguishers in each room (test cell) and mechanical equipment room.

Collectively, these items contribute to a very low fire loading; i.e. the potential for a fire is extremely low.

Fire Department Response -- When a fire alarm is received i.e. automatic, telephone, verbal, etc, the Fire Department at Site 300 responds within 5 min.

A response time of 5 min., or less, by the on-site fire department, augmented by 'first-aid' fire suppression equipment at the cells, ensures a relatively high degree of protection for the 836 Complex. In addition, test cells are characterized by a low population (less than five operating personnel with a test item), affording quick and rapid evacuation in the event of fire. Life safety threats are minimal.

Response levels, and available equipment, are listed in Table 6-1. The Senior Officer may call for additional help after he has evaluated the situation.

Fire-Fighting Problems -- There are no major fire-fighting problems in the 836 Complex unless explosives are present. The fire loading is low for each of the facilities. These factors, coupled with the early warning smoke detection (or wet pipe sprinkler activation) and subsequent response by the Fire Department, make the possibility of a fire extending beyond a single facility very remote.

When explosives are present in a test cell, the firemen will observe the precautions as outlined in the Response Plan for Fire In an Explosives Area.⁶⁻¹³ No reentry will be made into any facility until a cooling off period has been observed. The interim will be used to review all relevant facts associated with the alarm and/or test.

Fire Analysis -- T. Z. Harmathy⁶⁻¹⁴ has developed an equation to describe the duration of a ventilation controlled fire, where duration is defined as the time interval from flashover to when the average gas temperature diminishes to 80% of the maximum gas temperature.

$$t = 5.76 \times G_o / U_a$$

t = Fire duration, in seconds

G_o = Fuel loading, in kilograms (fuel load is paper, cardboard, wood)

U_a = Flow rate of air supply, in kilograms per second

If we assume a hypothetical case where the fire loading is approximately 4.9 kg/m^2 , a ventilation rate of 2.32 kg/s , and a cell area of 123 m^2 , the hypothetical fire duration is about 25 minutes. Assuming the failure of the automatic smoke detectors and sprinklers, the passive containment system (walls, roof, floor) in the Test Cell should remain intact during the short period of the fire. It is unlikely that any fire would even occur in any building at the 836 Complex (or last more than a few minutes) since the fire loading is so low, and sources of ignition are extremely remote.

Table 6-1. Fire Department Response Levels, Site 300

First Alarm	LLL	F-71	1000 gpm pumper
	LLL	F-3	1000 gpm pumper/50 ft. elevating platform
	LLL	Command Car	Chief Officer
Second Alarm	LLL	F-72	750 gpm pumper
	Livermore	E-23	1000 gpm pumper
		C-1	Chief
	Alameda County	E-1	1000 gpm pumper
	Ambulance		Fremont ambulance
Third Alarm	VA Hospital	EZ1	750 gpm pumper
	OES	H-1	Heavy Duty Rescue

References

- 6-1 Sunde, E. O., Earth Conduction Effects in Transmission Systems, Van Nostrand, N.Y., 1949.
- 6-2 Wick, O. J., Plutonium Handbook, 1967, Gordon and Breach, N.Y.
- 6-3 Mishima, J. et.al.; Fractional Airborne Release of Uranium (Representing Plutonium) During the Burning of Contaminated Waste, Battelle Northwest Laboratories Report BNWL 1730, 1973.
- 6-4 Mishima, J. and Schwendiman, L. C., The Amount and Characteristics of Plutonium Made Airborne Under Thermal Stress, Battelle Northwest Laboratories Report BNWL-SA-3379 (Conf.-701101-1) 1970.
- 6-5 Toy, A. J., Lawrence Livermore National Laboratory, unpublished work on the percentage of respirable sized uranium and beryllium dispersed from an explosion.
- 6-6 Peterson, K. R., T. V. Crawford, and L. A. Lawson, "CPS: A Continuous Point Source Computer Code for Plume Dispersion and Deposition Calculations," Lawrence Livermore Laboratory Report UCRL-52049, May 21, 1976.
- 6-7 Peterson, K. R., "IPS: An Instantaneous-Point-Source Computer Code for Puff Dispersion and Deposition Calculations," unpublished manuscript, 1977.
- 6-8 HASL 278, Accession No. 061-139, Appendix No. 061-138.
- 6-9 Regulatory Guide 1.109, USNRC, Office of Standards Development, March 1976, P. 1.109-50
- 6-10 Handbook of Radiological Health, U.S. Dept. of Health, Education, and Welfare, Revised edition, January 1970, p. 215.
- 6-11 Criteria for a Recommended Standard, Occupational Exposure to Beryllium, National Institute for Occupational Safety and Health, NIOSH Report TR-003-72, p.VI-4, Rockville, Maryland, 1972.
- 6-12 Baker, C. F. and C. King, Lawrence Livermore National Laboratory, unpublished study of the attenuation factor of a 21,600 lb detonation at Bldg. 836-C, December 3, 1973.
- 6-13 Disaster Control Plan Supplement No. 15 - "Response Plan for Fire in an Explosives Area", Lawrence Livermore Laboratory Internal Report M-014, November 20, 1978.
- 6-14 Harmathy, T. Z., "A New Look at Compartment Fires," Fire Technology, Parts I and II; 8, 196-217, 326-351, Boston, Mass., 1972.

APPENDIX 6A

SEISMIC, TORNADO AND WIND ANALYSIS

OF

BUILDING 836C SITE 300

(performed prior to 1980)

APPENDIX 6A

SEISMIC, TORNADO AND WIND ANALYSIS

OF

BUILDING 836C SITE 300

The seismic, tornado, and wind analysis for Building 836C in this appendix was extracted from the seismic, tornado, and wind analysis of Buildings 836C and 854H written by David Kai Tu. Thus references to facilities other than those in the 836 complex have been deleted.

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- II. SEISMIC, TORNADO AND EXTREME WIND HAZARDS
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- IV. REFERENCES

SEISMIC, TORNADO AND EXTREME WIND ANALYSIS OF BUILDING 836C

I. INTRODUCTION:

Several structures at Site 300 have been identified as critical facilities. A critical facility is defined as a structure which contains material that potentially may become an off-site hazard in the event of certain natural disasters, namely, tornadic or extreme winds and strong motion earthquake. In compliance with the Department of Energy's request, a safety analysis of each of the identified critical facilities is being conducted. As part of that safety analysis study, each of the facilities' structural integrity must be assessed for those extreme geological and meteorological events named.

This report summarizes the analytical investigation of the structural response of Building 836C, subjected to a safe shut-down earthquake and to 10^{-4} probable extreme wind. The purpose of the investigation is to discover deficiencies (if any) within each of the building's lateral force resisting system and its structural components. The study concludes with recommendations for the upgrading of the structure to adequately resist the SSE and extreme wind events.

II. SEISMIC, TORNADO AND EXTREME WIND HAZARDS

Safe-Shutdown Earthquake--The safe-shutdown earthquake (SSE) is based on the geological investigation conducted by Lawrence Livermore Laboratory of the land area surrounding the 834, 836, and 854 Complexes. The investigation is summarized in a report entitled A Geological and Seismological Investigation for the 834, 836 and 854 Building Complexes at LLL's Site 300¹, written by Thorpe and Wight.

The study identifies several major faults and minor faults which are considered active within or around Site 300. These faults are delineated in Figure 1 and Figure 1a. Due to the close proximity of the active faults, a peak ground acceleration of 0.0g was predicted for the area. The characteristic of the worst possible earthquake defined as a safe-shutdown earthquake is that earthquake which produces the maximum vibratory ground motion for which structural systems and components necessary for the safe operation of the facility must remain functional. The response spectra for 2%, 5% and 10% critical damping are shown in Figure 2.

Figure 1. Geologic map of Site 300

Figure 2 SSE response spectra for the 834, 836 and 854 complexes

Tornado and Extreme Wind - The tornado and extreme wind criteria for Site 300 were developed by McDonald, Mehta and Minor, Consulting Engineers. The criteria and the information supporting the criteria are documented in the report entitled Development of a Design Basis Tornado and Structural Design Criteria for Lawrence Livermore Laboratory's Site 300, California².

The postulated tornado and extreme wind parameters are shown in Table 1. The tornado criteria is based on a recurrence interval of 1×10^{-6} occurrence per year, while the extreme wind parameters is determined on the basis of a recurrence interval of 1×10^{-4} occurrence per year. This is consistent with DOE Design Criteria Manual. The effective velocity given in Table 1 accounts for a 10 per cent increase in the wind speed because of the channeling effect of the terrain at Site 300.

TABLE 1

Tornado and Extreme Wind Parameters

Tornado

Rotational Plus Translational Speed 172 mph

Pressure Drop None

Extreme Wind (straight wind)

Velocity below 30 ft. 101 mph

Wind Borne Missile

Wood 2" x 4" x 12', 20 lbs. 70 mph

For the selected levels of risk, the extreme wind criteria dominates; therefore, the structural integrity of Building 0360 and 0340 were checked for extreme wind only. Wind loads are calculated based on recommendations of ANSI A58.1-1972 Standards³.

III. EVALUATION OF BUILDING 83EC

Building description--Building 83EC is a semi-buried experimental structure used for vibration tests of weapon and mechanical hardware. The main structure is a reinforced concrete box system with plan dimensions of 40 ft. long, 30 ft. wide and 28 ft. high. The structure is enclosed with 13 inch thick walls and roof slab. The rear wall, located at the west end of the structure, is also 13 inches thick. The front wall is 12 inches thick with a large opening which is covered by asbestos cement panels. The asbestos cement panels are supported within the opening by steel frames. A roll-up steel door provides access for large equipment.

Extending from the main structure at 45° are two triangular shaped wing walls. These walls act as retaining walls for the fill covering the main structure. The reinforced concrete box structure is covered with a minimum of 3 ft. of soil. The front (east) wall is left exposed.

The floor of the shaker room, inside the main structure, is a massive reaction mass which is supported by a 30 inch thick foundation slab.

The reaction mass is separated from the main structure by an 1 inch gap on all sides. The walls of the main structure are supported by continuous footings which are tied to the walls by steel dowels.

Attached to the south wing wall is a one story steel framed structure. The steel framed structure is enclosed by asbestos panels. The structure houses ventilation and mechanical equipment. The ventilation system is a secondary HEPA filtering system which is attached to the main concrete box structure. Figure 3 thru 5 show details of Building 836C.

Analytical Procedure--The structural systems of Building 836C were evaluated for their ability to resist the safe-shutdown earthquake and the 1×10^{-4} wind which were described earlier. For the concrete box structure, the 18 inch roof slab was taken to be a rigid diaphragm having the ability to transfer lateral and torsional loads to the shear walls.

To accommodate the geological conditions and the dynamic effect of the sloping soil covering, a finite element method of analysis was used to assess the behavior of the reinforced concrete box system under SSE conditions. As recommended in the geological study by Thorpe and Hight¹, the structural analysis included the effects of soil-structure interaction. The soil profile used in the analysis is shown in Figure 6.

The structure was evaluated by a two dimensional finite element procedure² developed by Hwang, Lysmer and Berner. The numerical analysis were conducted by using the computer code FLUSH. PLUS³ is a new finite element soil-structural interaction program developed at the University of California, Berkeley.

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Figure 3: Building 83FC-Plans and Elevations

Figure 6: Soil Conditions at the Critical Structure within the 836 Complex
(No water encountered to 12 m.)

Figure 7 shows the finite element model for shaking in the longitudinal direction of Building 836C. Structural elements running parallel with the direction of shaking were modelled as plate elements. Those structural elements (i.e., columns, walls) perpendicular to the direction of shaking were modelled as beam elements. Certain soil nodes and structural nodes were connected to incorporate the forces transmitted through the soil-structure interface. Energy transmitting boundaries and viscous boundaries were used to simulate the three dimensional response of the soil and the structural.

Since no soil properties were available, the following properties were assumed based upon our experience:

Soil unit weight = 120pcf

Poisson's Ratio = 0.4

The 5th response spectrum (Figure 2) was used for the input to the dynamic analysis.

The results from the dynamic analysis were added to the static load conditions. The superimposed stresses were compared with ultimate stress capacity of the structural elements.

Wind effects were investigated in conjunction with seismic loading. Seismic loadings governed except for suction on the front (east) wall. The one story steel framed structure was not evaluated for either seismic or wind conditions. This structure houses secondary ventilation systems and was not considered to be a critical component of Building 836C.

SOIL MASS ELEMENTS

RETAINING WALL AND SHEAR WALL ELEMENTS

Figure 7: Building 83FC--Finite Element Model

PRELIMINARY
NOT FOR PRODUCTION

Results of the Structural Analysis--The results obtained from the analysis are summarized and tabulated in Table II and III. Table II summarizes the factors of safety for shear stress conditions. Table III summarizes the shear wall transverse bending factors of safety.

TABLE II
Summary of Factors of Safety
for Shear Stress Conditions

Element	Factors of Safety*
North Wall	1.13
South Wall	1.13
East Wall	1.44
West Wall	2.47
Roof	51.13
Foundation	17.42

$$* \text{Factor of Safety} = \frac{\text{Ultimate Shear Stress, } V_{ult}}{\text{Actual Shear Stress}}$$

$$\text{where } V_{ult} = v_c + v_s$$

$$v_c = 2\sqrt{f'_c}$$

$$v_s = \frac{A_v f_y}{b_w s}$$

A_v = area of steel bar

f_y = 60,000 psi

b_w = thickness of wall

s = spacing of steel bars

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Table III

Summary of Transverse
Bending Factors of Safety

<u>Element</u>	<u>Factors of Safety*</u>
North Wall	1.04
South Wall	1.04
East Wall	1.11
West Wall	1.31
Roof	2.50
Foundation	9.06

$$\text{*Factor of Safety} = \frac{\text{ultimate moment capacity}}{\text{actual moment}}$$

The results show that the dynamic stresses induced in the structural members are very low in comparison to the strength of the structural members. Since the configuration of the structure is similar about the principal axes, it was reasonable to determine the stresses due to shaking in the short direction by the results from the longitudinal shaking. The analysis of the structure for shaking in the longitudinal direction is considered to be the worst case because of the larger contribution of the soil mass.

No missile penetration analysis was performed on the front wall. Since portions of the front wall are constructed of cement asbestos panels, 1-9/16" thick, it is highly probable that the postulated missile could penetrate the structure. It is also unlikely the asbestos panels will survive suction loads during extreme wind conditions.

Conclusions and Recommendations--The reinforced concrete shear walls are more than adequate to resist the postulated SSE. The most critical section is the response of the shear wall in transverse bending. Minor cracking and spalling of the concrete would be expected with ground motions as severe as the postulated SSE. No failures of the walls are expected. Therefore no seismic modifications are recommended for this building.

Upgrading the front (east) wall with regard to wind suction loads and missile penetration is required if operational capability during severe wind is necessary.

IV. REFERENCES

1. R. K. Thorpe and L. H. Wight, "A Geological and Seismological Investigation for the 834, 636 and 254 Building Complexes at LLL's Site 300", UCRL-52706, January 26, 1975.
2. McDonald, Mehta and Minor, "Development of a Design Basis Tornado and Structural Design Criteria for Lawrence Livermore Laboratory's Site 300, California", report prepared for LLL, UCRL-13667, November, 1975.
New Orleans, Louisiana, Dec. 8-10, 1975.
3. ANSI, 1972: American National Standard: Building Code Requirements for Minimum Design Loads in Buildings and Other Structures, ANSI 458-1-1972, ANSI, New York.
4. "A Simplified Three Dimensional Soil-Structure Interaction Study," J. Lysmer, E. Berger, and R. Huang, ASCE Specialty Conference on Structural Design of Nuclear Power Facilities.
5. PLUSH is a to-be-released computer program based on the Program LUSH. "LUSH--A Computer Program for Complex Response Analysis of Soil Structure Systems," by J. Lysmer, T. Udaka, and H. B. Seed, Earthquake Engineering Research Center, Report No. EERC 74-4, University of California, Berkeley, April 1974.

APPENDIX 68

SITE 300 LIGHTNING SAFETY SURVEY

June 9, 1976
FTS 76-6-6

To: B. N. Odell

From: A. D. Hyne

Subject: Site 300 Lightning Safety Survey (5-5-76)

Lightning Frequency at Site 300

The isokeraunic level for this area is five or less thunder storm days per year. Site 300 records indicate an average of two observed flashes per year and an average of ten alerts per year from the atmospheric potential gradient sensors. There have been three recorded strikes to ground in the last ten years, one to a fence in 1966, a lightning started grass fire in 1969, and the meteorology tower took a strike which damaged instrumentation in 1973.

Site 300 bunkers are located in the canyons and on the hillsides well below the peaks and ridges and so are not the prime lightning targets in the area. From the above it can be seen that the odds of a Site 300 bunker being struck by lightning is very low.

834 Complex Site 300

The 834 complex is served by overhead power lines which go under ground some distance from the distribution transformer pad. The power line is fused and bypassed to ground by lightning suppressors located on the last power pole. Power distribution is under ground from the transformer pad to the various facilities.

The bunkers in this complex are of steel frame construction with the frames, doors, and all external equipment well bonded to the ground system. These bunkers originally provided excellent lightning protection; however at bunkers E, F, G, and J the addition of security street lights powered from bunker power panels has greatly increased the lightning exposure area of the bunker electrical systems. It is suggested that improved protection be provided by the installation of lightning transient suppressors in the

University of California

Lawrence Livermore
National Laboratory

June 9, 1976

street light circuits at the bunker power panel boxes.

The mechanical equipment buildings being of metal construction should provide adequate lightning protection for the equipment they contain.

Building 834A, the Control and Instrumentation Building, is of heavy reinforced concrete construction and should provide excellent lightning protection. The electrical and electronic racks are tied to the ground system.

Telephone circuits have the normal telephone company transient suppressor circuits installed where they enter the buildings.

In conclusion it appears that, with the exception of the security lighting circuits mentioned above, the 834 complex provides good protection against lightning hazards and damage.

836 Complex Site 300

The overhead power lines which feed this complex are protected by fuses and lightning suppressors before they go under ground to distribution transformer pad. The transformer, emergency generator, and distribution panel are well grounded. Power cables from the distribution panel run underground to the various buildings of this complex. The power system is adequately protected from lightning strikes.

Control Building 836A is of heavy reinforced concrete construction and should provide good lightning protection. Control and instrumentation racks are tied to a heavy ground buss.

Pump and Storage Building 836B is of steel girder construction with every other vertical wall member bonded to the ground system. Being of steel construction and well grounded this building provides excellent protection. Pumps and other mechanical equipment are tied to the ground system.

Test Bunker 836C is of heavily reinforced concrete construction, is earth covered on the top and three sides, and has a lightning air terminal at its highest point. It appears that building 836C provides excellent lightning protection.

Telephone circuits in this complex have the usual adequate lightning transient protection.

In conclusion, the 836 complex should provide good protection against lightning hazards and damage.

June 9, 1976

General Comments

Lightning can cause large currents to flow through interconnecting cables and pipe running between scattered buildings such as exists in complexes 834 and 836. These currents can develop voltage drops capable of damaging instrumentation but are unlikely to cause sparking if conduits and pipes are well bonded. Because of the extremely small chance of a strike to a Site 300 complex it seems unnecessary to provide special lightning protection for instrumentation.

A. D. Hyne

A. D. HYNE

Electronics Engineering Department

ajp

Copy to:

W. C. Conner, L-871
W. Gieri, L-154
R. E. Henry, L-871
E. A. Lafranchi, L-151
R. K. Mullins, L-871
H. E. Pfeifer, L-871

SECTION 7 -- ENVIRONMENTAL MONITORING PROGRAM

Introduction

General

A monitoring program is continually maintained at Site 300 to detect and document changes in environmental levels of radioactive and nonradioactive materials. Environmental monitoring consists of: (1) air sampling at perimeter locations, (2) vegetation collection on and in the vicinity of Site 300, (3) collection of water samples from wells, surface sources, and rainfall, and (4) collection of soil samples from locations near the firing bunkers. The results of these programs are contained in the Lawrence Livermore National Laboratory Annual Environmental Monitoring Report UCRL-50027-80.

Sampling

Air Sampling

Airborne radioactivity is measured at ten locations around Site 300. The samplers use Whatman 41 cellulose filters and are operated at an average flow rate of 700 L/min. Air filters are changed on a weekly basis. These samples are analyzed for gross alpha and gross beta activity. A monthly composite is counted for specific gamma-emitting radionuclides by Ge(Li) spectroscopy. A monthly composite, by location, is also analyzed for beryllium using atomic absorption. Plutonium and uranium analyses are made on the monthly composite using radiochemical methods.

Vegetation Sampling

Vegetation samples are collected at monthly intervals from seven locations on and around Site 300. These samples are freeze dried, and selected material intake is determined by liquid scintillation counting.

Water Sampling

The water sampling program consists of several sources: surface water, rainfall, and deep wells. The surface water (creeks) are sampled on a quarterly basis as available; the wells are sampled quarterly; and the rainfall is sampled on a monthly basis. All water samples are analyzed for gross alpha and beta activities using a gas proportional counter.

Soil Sampling

Soil samples are taken annually at twelve locations at Site 300. These samples are taken to determine the perturbation in the $^{235}\text{U}/^{238}\text{U}$ ratio of the soil. These measurements are made by mass spectrometry. Gamma spectroscopy on these samples also provide data on other radionuclides. Plutonium and cesium-137 analyses are also performed.

SECTION 8 -- RISK ASSESSMENT

The information contained in Sections 3 through 7 of this document provide the foundation for this risk assessment. Credit is taken for all mitigating features. Of major concern at the 836 Complex were the possibility and consequences of large releases of radioactive materials and beryllium. However, it was determined in the Accident Analysis Section that:

- 1) a plutonium - HE explosion is not credible since plutonium and HE are not permitted concurrently in the same area at Site 300. (The exception to this policy as stated in Procedure No. 132⁵⁻¹ is that explosive actuating devices are sometimes located in assemblies containing fissile materials. An accidental detonation will not effect the safe containment of the fissile material within the assembly.)
- 2) a major fire involving plutonium, uranium, or beryllium is not credible due to the very low fire loading and the lack of ignition sources.
- 3) An accidental HE detonation would not disperse enough uranium or beryllium to result in a radiation lung dose greater than 4.3 mrem or a beryllium lung dose exceeding 170 $\mu\text{g}/\text{min}/\text{m}^3$. This is well below the 500 mrem annual effluent off-site radiation dose limit specified in ERDAM 0524 or the 1500 μg per min/m^3 off-site limit for beryllium as specified by NIOSH.

The various hazards associated with Acts of Nature and Human Error have been summarized in Table 8-1. Low hazards are those that present minor on-site and negligible off-site impacts to people in the environment. Moderate hazards are those that present considerable potential on-site impacts to people or the environment, but at most only minor off-site impacts. High hazards are those with the potential for major on-site or off-site impacts to people or the environment.

All but one of the hazards listed in Table 8-1 is classified as low per DOE Order 5481.1A. The exception is the intrinsic hazard associated with the handling of explosives. Even though an accidental detonation is not likely to occur, it could result in major damage to the facility, the equipment in it, and even a few injuries or fatalities. Thus, there would be considerable on-site impact from a detonation with only a minor off-site impact to the environment.

Therefore, the 836 Complex is classified as a moderate hazard facility per this analysis and the guidance provided by DOE Order 5481.1A.

Table 8-1. Summary of Safety Evaluation

<u>Potential Hazard</u>	<u>Mitigating Features</u>	<u>Consequences of Failure Feature of Mitigating</u>	<u>Level of Risk</u>
Acts of Nature	These facilities can withstand hazards due to the acts of nature that are postulated for Site 300.	If structure or equipment fail due to an act of nature, a small amount of radioactive material might be released. Lung dose calculations show up to 0.46 mrem for plutonium.	Low
Earthquake	Steel frame buildings,		
Tornado	electronic racks bonded to ground systems, and lightning suppressors on light and telephone circuits provide lightning protection.		
Extreme Wind	These facilities are located 100 m above Corral Hollow Creek.		
Missile			
Lightning			
Flood			
Human Error	Pu and HE not permitted in same area. Pu doubly encased in sealed containers. Facilities are sprinkled, have low fire loading, lack ignition sources, and have dust ignition proof electrical fixtures. Earthen berms separate facilities. These facilities are located in a remote area. Only small quantities of flammable liquids are permitted in tests cells and no flammable gases are present. None of the operations produce dust. Signs are posted and administrative controls are enforced.	If an HE explosion occurred due to a human error or equipment failure, the lung dose calculations show a maximum of 4.3 mrem for uranium and 170 $\mu\text{g min/m}^3$ for beryllium. The radiation doses are well below the 500 mrem annual effluent dose limit specified in DOE 0524. The beryllium dose is below the 1500 $\mu\text{g min/m}^3$ recommended by NIOSH.	Low risks for for all hazards except the remote possibility of an HE detonation. This might cause a few injuries or even fatalities.
Plutonium Spill			
HE Detonation Involving Uranium and/or Beryllium			
Nuclear Criticality			
Explosions			
Fire			

SECTION 9 -- SUMMARY OF FINDINGS AND RECOMMENDATIONS

This section summarizes the finding and recommendations of this safety assessment for the 836 Complex.

Findings

- o The results of the seismic and wind analyses indicated that the 836 Facility is structurally sound. No structural improvements are necessary.
- o The analysis of the lightning protection systems indicated that it is adequate.
- o The existing fire protection system at these facilities is adequate. No modifications are necessary.
- o The design and location of these facilities are adequate for handling explosives.
- o Because explosives are handled here, the 836 Complex is classified as a moderate risk facility by DOE Order 5481.1. This means that these facilities may present significant on-site impacts to people and the environment, but at most only minor off-site impacts.

Recommendations

- o Formalize the existing Quality Assurance Program in writing.