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SAFETY ASSESSMENT DOCUMENT
FOR THE
ENVIRONMENTAL TEST COMPLEX
(BUILDING 834)
AT SITE 300

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Abstract

A safety assessment was performed to determine if accidents occurring at the 834 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. (However, there are a few recommendations to further enhance the structural integrity of these facilities.) Additional lightning protection for these facilities is being installed. These buildings are located high above the dry creek bed so that a flood is improbable.

A criticality or a 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 exceptions to this policy is that explosive actuating devices are sometimes located in assemblies containing fissile materials. However, a planned or accidental actuation will not effect the safe containment of the fissile material within the assembly.) Even though the possibility of an HE explosion involving uranium and beryllium is remote, the off-site lung doses were calculated and found to be below the accepted standards. 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 Environmental Test Complex (Building 334) 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 Environmental Test Complex is used for thermal testing (cycling, shocking, and soaking) 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 Manager of Plant Services with a written, objective analysis of the facility and its operations as well as furnishing him with recommendations for corrective action in any area that appears deficient. It also provides the DOE S&H office with information to permit 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 1 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 DOE-M-0531.

Even in the event of a maximum credible release, the off-site dose would not exceed the 500 mrem amount effluent dose limit specified in DOE 0524.

Risks from the various hazards at this complex vary from low to moderate as specified in DOE Order 5481.1. The only moderate hazard is that involving the handling of high explosives. 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, with a few minor modifications, the operations in the 834 Complex can be conducted according to existing codes, standards, and regulations and that other than explosive handling 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 834 Environmental 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. Specified emphasis is given to the description of the safety control features.

Section 5 describes the operations conducted at the 834 Environmental Test Complex.

Section 6 discusses the potential accidents deemed credible for the 834 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 834 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 lists the findings of this assessment, states what we are going to do to correct any deficiencies, and makes recommendations to further reduce the risks from the operations being conducted at the 834 Complex.

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 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 15 000. 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 three major users to the south; i.e., 1) Carnegie Cycle Park, an outdoor recreational facility for private and commercial off-the-road motorcycle riding, testing, and racing, 2) the Connolly Ranch which is used primarily for the grazing of cattle, and 3) Stanford Research Institute, which operates an explosives test site adjacent to the Carnegie Cycle Park. Physics International 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

LLL 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 (°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 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 interior of Site 300 is apparently simply structured. The dominant feature is the Patterson Pass Anticline that lies in the midst of the Site. The 834, 836, and 854 Complexes are 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 834, 836, and 854 Complexes 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 834, 836, and 854 Complexes at Site 300. The buildings are located on the crest of hills 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.³⁻¹ 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.

Fig. 3-1. Site 300 location

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

References

- 3-1 Inorpe, 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 Laboratory Report UCRL-52006, January 29, 1976.
- 3-2 Peterson, K. R., Site 300 Safety Analysis Report - Meteorology and Air Quality, Lawrence Livermore 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 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 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.

SECTION 4 -- FACILITY DESCRIPTIONS

Introduction

The Environmental Test Group of the Weapons Engineering Division in the Mechanical Engineering Department administers and operates this Test Complex at Site 300. Background data for this section was obtained from References 4-1 through 4-5. The 834 Complex location is given in Fig. 4-1.

The 834 Environmental Test Complex consists of Test Buildings (B-834 E,F,G,H,I,L), Mechanical Equipment Buildings (B-834 B,C,D), Storage Building (B-834K), and Control Building (B-834A) which is located in the center of the complex as shown in Fig. 4-2. The Test Buildings (Test Cells) are located behind large earthen barricades (berms). The Mechanical equipment Buildings are positioned between the Central Control Facility (B-834A) and the Test Cells. The gross area of these buildings is 703 m² and the net area is 407 m².

The 834 Complex is used primarily for thermal testing (cycling, shocking, and soaking) of test specimens which contain hazardous materials (explosives, radioactive, or toxic materials).

Building Descriptions

Control Building (834A)

The Control Building is designed to withstand the overpressures generated from an accidental detonation of up to 90 kg of explosives from any test cell

in the Complex. Its walls, roof and floor are constructed of reinforced concrete. The walls are 0.2 m thick, and the roof is constructed of 0.18-m-thick concrete slabs that are supported by steel girders. The main entrance contains a blast-resistant, reinforced-steel door. An emergency escape route is provided on the opposite side from the entrance. This 0.6 x 0.6 m opening in the west wall is covered by a blast-resistant steel plate that is hinged to open outward.

The electronic rack room (which houses the control equipment for the complex) has a removable, reinforced-steel panel on the south end of the room. This 1.0 x 2.0 m panel is blast resistant. It covers the wall opening that is used for the installation and removal of large equipment. This opening may also be used as a passageway in the event of future construction.

Five concrete pit boxes (puli boxes) are positioned outside and adjacent to the Control Building. These boxes have steel covers, and serve as part of the conduit system for carrying underground electrical cables between the control room, machinery buildings, and the test buildings.

The system of conduits, pipes, and pit boxes are located such that shrapnel will not be projected into the Machinery Buildings and Control building in the event of an accidental explosion in a Test Cell.

A Mechanical Equipment Room is located adjacent to the Control Building. The south wall of the Mechanical Equipment Room has a frame construction to allow for future construction. The Mechanical Equipment Room houses the air conditioning and other mechanical equipment to support the Control Building.

Emergency electrical power is provided automatically to the 834 Complex by the emergency diesel generator located approximately 20 m south of the Control Building.

Test Buildings (334 E,F,G,H,J)

These five Test Buildings (also called test cells) are similar in construction (see Fig. 4-3). Each building has a steel frame with frangible, 39.0-mm-thick cement asbestos panel walls, with low pitched, built-up roofing on 50.8-mm-thick cement asbestos panels. Entry into Test Cell D is through a double door or airlock system (vestibule). Vestibules, in the other test cells, have been incorporated as part of each test cell. Each test building is surrounded on the three sides nearest the control building by earth barricades. Each barricade is high enough to prevent fragments from traveling in a straight line toward the control Building area or toward the adjacent test buildings should an accidental detonation occur.

A system of underground conduits and pipes for carrying electrical instrument and control wiring and various utilities (compressed air, vacuum, water, carbon dioxide, trichloroethylene - a brine process oil, etc.) are provided between the Test Buildings, Mechanical Equipment Buildings, and the control Building. Each Test Building is equipped with lightning antennae.

A vehicle and personnel access driveway connects each test building entrance with the Mechanical Equipment Buildings and Control Building entrances.

Concrete floors, painted with an epoxy-based paint, are the working surfaces in each test cell, and are suitable for this specific explosives work.

Test Building F has been modified to include two additional rooms and a large liquid nitrogen storage tank (see Fig. 4-4). Current operating procedures do not allow explosives testing in this building.

All electrical equipment installed as part of each test building conforms to the electrical classification of Class II. Class II locations are those that are hazardous because of the presence or potential presence of combustible dust. Note: When non-Class II electrical equipment is required

for testing, the equipment is evaluated, and modified if required, to preclude the equipment from being a source of ignition.

Thermal Test Building (834L)

The Thermal Test Building (test cell and utility room) is a steel frame structure having a galvanized exterior, ribbed metal siding and roof. The test cell is insulated, and has prefinished sheet metal walls. The floor consists of a 0.15-m-thick reinforced concrete slab. The wall separating the test cell from the utility room has a layered construction, i.e., prefinished sheet metal wall on the test cell side, insulation and a 16-mm-thick gypsum board wall on the utility room side. This wall has a 1-h fire rating. The remaining walls in the utility room are not insulated.

The Test Cell contains both a 0.9 x 2.1 m hollow metal, personnel door and a 3.0 x 4.0 m metal, rollup door. The rollup door is installed on the exterior wall of the building. A pair of 0.9 x 2.1 m hollow metal doors, with full louvers, cover the entrance to the utility room.

Mechanical Equipment Buildings (834 B,C,U)

The Mechanical Equipment Buildings, also referred to as the Machinery Buildings, have identical dimensions and construction. Each building is a butler type building, i.e., steel frame with metal roof and siding positioned on a concrete slab. The roof contains translucent plastic panels for daytime lighting. These buildings are not insulated. Each building is heated by two electric space heaters. Ventilation is provided by three exhaust ventilator fans located in the roof. Each building houses thermal conditioning and/or miscellaneous support equipment (see Fig. 4-5).

Thermal Chambers (834 E,F,H,J)

The use of insulated environmental test chambers inside the main test cells is common to the 834 Complex. Test Cells 834 E,F,H, and J each contain a large fixed chamber that may be heated or cooled from temperature conditioning equipment located in the Mechanical Equipment Buildings.

Several smaller portable environmental chambers are located in the Test Cells (see Fig. 4-6). These small chambers are used for thermal tests; i.e., they contain electric heating devices for raising the chamber temperature. All chambers are electrically controlled.

Each experiment in a cell, or environmental chamber, is instrumented and monitored through the electrical boxes, panels, etc. (see Fig. 4-7) that are connected to the main Control Building. Equipment performance in the test cell is monitored by a system of electrical controls that will automatically open or close valves, or turn switches on or off depending on preset limits. In addition, if an experiment requires off-shift monitoring, equipment controls can also be set to provide a trouble alarm. Normally, this alarm would be received at the Site 300 Police Console, and would be relayed to the Maintenance Machinists.

Storage Building (834K)

The Storage Building is a steel frame structure with metal sides and roof and is positioned on a concrete slab. The building is not heated. Ventilation is provided by two exhaust ventilator fans located in the roof. The building is used for storage of inert materials.

Cooling Tower

A cooling water tower is located approximately 15 m to the south of the Control Building. The unit is designed to provide cooled water at 29 °C maximum with return water from equipment to be at 43 °C. Overflow from the cooling tower drains into a catch basin, part of the storm drain system that drains the 834 Test Complex.

Utilities

Electrical

The electric utilities include:

- Primary electric power supply system
- Emergency power system
- Battery power system

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 834 Complex is served by overhead power lines that go underground approximately 76 m from the distribution transformer pad, which is located approximately 20 m south of the Control Building. Power distribution is underground from the transformer pad to the various facilities.

Emergency Power -- A diesel generator, with a 225 kW rating, provides power when primary sources fail. 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 testing are available from this emergency diesel generator.

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

Piped Utilities

The piped utilities are:

- Water
- Compressed air
- Vacuum
- Liquid nitrogen
- Carbon dioxide
- Trichloroethylene (Brine)

General practices in this Complex are that:

- Reduced pressure backflow preventers are provided on all Site 300 water lines that enter areas of possible contamination (radioactive, toxic, explosives).
- Double check valve backflow preventers are provided on all compressed air lines.
- All branch circuits from the water main are valved in accordance with the best practice in building construction.

Lighting

Each of the Test Cells and the Thermal Test Building contain either mercury vapor or incandescent lamps that meet the electrical classification (Class II, Division II, Group E,F,G) for hazardous locations. The Control, Mechanical, and Storage Buildings have general purpose lighting and convenience outlets.

Exterior lighting is installed for building entrances and pedestrian and vehicular approaches to the Complex. These exterior floodlights provide area illumination and aid perimeter security surveillance.

Communication

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 Test Cells, Thermal Test Building, and the electronic room of the Control Building. These systems meet the electrical requirements for each respective building.

Environmental Maintenance Features and Their Controls

Air Conditioning and Heating

Heating and cooling are provided for operational quality control and human comfort. Air conditioner-1, located in the mechanical equipment room (834A), provides conditioned air to the Control Building. Heating coils in supply ducts are controlled by a space thermostat to achieve the desired temperature. Air conditioner-2, located in the utility room (834L), provides conditioned air to the adjacent test cell. Each of the Test Cells (834E,F,G,H,J) have self-contained air conditioning units located outside and, in addition, use electric radiators or heat pumps for heating.

Ventilation

Each of the buildings in the Complex has a powered ventilation system, with the exception of 834K, which has two vertical gravity relief ventilators. An outside air intake is the source for approximately 10% of the makeup air to the air conditioners that provides recirculating, conditioned air to the Control Building and the Thermal Test Building.

Safety Control Features

General

Test operations conducted in the 834 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

Cells in the 834 Complex are 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 frangible building construction and building locations (far apart with earth barricades between buildings) will prevent or minimize damage to adjacent buildings should an accidental explosion occur.

Fire Safety

Test Cells 834 E,F,G,H,J, and L, and the Electronic Room (834A) contain product of combustion (ionization) smoke detectors. When a detector is activated, an electrical signal is sent to the fire alarm panel located inside the Mechanical Equipment Room in the Control Building 834A. This signal will cause a red "FIRE" light and a zone indicator light to illuminate on the panel. If there is an open or short circuit in the alarm circuit, a trouble light will be lit on the panel. Either the fire or trouble condition cause a buzzer to sound and an alarm signal to be transmitted automatically to the

Fire and Police Stations (8-870). The water flow indicator, located in the Utility Room at 834L, is wired to the fire alarm panel that is located in the Machine Room at 834A. Power to the fire alarm panel is supplied through the battery bank inverter. This feature provides uninterrupted power to the detection systems during the interval when primary power is lost and before the emergency generator comes on.

Buildings 834A, E, H, and L have sprinklers. Each sprinkler head is individually activated by a fusible link. A flow indicator on the automatic sprinkler system transmits a signal to the fire alarm panel (located in the machine room of 834A) when there is any flow of water in the system. An audible fire alarm (horn and bell) is positioned outside Building 834L to alert personnel that a sprinkler head has opened, or a manual fire alarm (pull-box) has been activated.

Two supply and two return air ducts are located in the wall separating the Utility Room and the Test Cell at 834L. These air ducts have fire dampers at the wall penetrations to contain a fire within the Test Cell.

Radiation Safety

Portable alpha survey meters are used by Hazard Control Technicians to determine if there are any leaks of radioactive materials before, during, or after the environmental tests.

Criticality Safety

All operations or proposed operations with fissile material are given an independent safety evaluation, review, and inspection by the LLNL Criticality Safety Office. Approval for all operations must be received from the Criticality Safety Office and line supervision.

Effluent Controls

Airborne Effluents

The Test Cells contain provisions for the control of airborne effluents. HEPA filters are provided at each Test Cell, and are maintained and used for emergency conditions only. The fixed HEPA filters are single systems and do not include spray dampers.

Liquid Effluents

A catchment trench is located in B-834L near the personnel and rollup doors. The trench drains to a retention tank having provisions for cleaning out any and all materials. A dry well at 834L is also provided to catch waste water from the water fountain, dehumidifier, and the air conditioner.

Building 834A has a sanitary sewer leading to an underground septic tank and leaching field. The remaining test cells do not have rest rooms, drinking fountains, or catchment trenches.

Solid Effluents

Solid effluents, 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 Procedure".⁴⁻⁶ Detailed disposal procedures for explosives, radioactive wastes, flammables (liquids, oily rags, etc), plastic wastes, etc, are included in the procedure.

Lightning Protection

Lightning protection is provided for the 834 Complex. Each of the test cells is equipped with lightning rods. External equipment is bonded to the ground system.

The Mechanical Equipment buildings are constructed of metal and provide adequate lightning protection for the equipment they contain.

The Control Building is constructed of heavy reinforced-concrete and does not have lightning rod protection. The electrical and electronic racks are tied to the ground system.

Security and Safeguards

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

The Test Complex is lighted for security purposes and night activities. Security alarms are installed in Test Cells 834 E,F,G,H,J,L and are connected to remote indicators located at the Police Master Console, B-870.

Facility Disposition

The Environmental Test Complex (834 A,B,C,D,E,F,G,H,J,K,L) 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. Environmental Test Complex location B-834.

Fig. 4-2. Plan layout of the Environmental Test Complex.

Fig. 4-3. Earth barricade around test cell (typical).

Fig. 4-4. Liquid nitrogen tank adjacent to B-834F.

Fig. 4-5. Control Bldg center and Mechanical Equipment, JPL Mesa.

Fig. 4-6. Portable environmental chambers, B-8346.

Fig. 4-7. Instrument and control cable panel, B-354F.

References

- 4-1. LLL Plant Engineering Drawings, 334 Complex, 1967-1974-334-111, 112-117.
- 4-2. LLL Emergency Response Drawings, 334 Complex, 1967-1974-334-111, 112-117, 0030.
- 4-3. Review of Preliminary Drawings and Specifications for LLL Environmental Test Complex, April 15, 1969, LLL internal correspondence.
- 4-4. Environmental Test Facility, General Description and Design, April 14, Jan 16, 1969, LLL internal correspondence.
- 4-5. Environmental Test Complex, Equipment Descriptions and Lists, undated, LLL internal correspondence.
- 4-6. Site 300 Safety and Operational Manual, Version 24-111, 1 March 1975.

SECTION 5 -- DESCRIPTION OF OPERATIONS

Introduction

The Environmental Test Complex is administered and operated by the Environmental Test Group of the Weapons Engineering Division in the Mechanical Engineering Department. The principal operation associated with the Test Complex is thermal testing of specimens that may contain explosives, radioactive, or toxic materials. Examples of thermal tests include: 1) storage of a test item at a given temperature for a specified time, 2) cycling between a cold and a hot temperature for a given number of hours or days, and 3) thermal shocking by introducing a hot or cold flow of air over a specimen. The test cells may also be used for testing of pressure vessels at elevated or reduced temperatures.

The Control Building, and primarily the electronic rack room, is the center of activity for this Complex; from here all the test cells, thermal chambers, and miscellaneous equipment are controlled and all the data are recorded.

Quantities and Types of Materials

A variety of materials and equipment have been tested using the facilities available in the B-834 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 30U Safety and Operational Manual.⁵⁻¹ An operating limit of 68 kg of explosives is permitted in 834E, G, H, and J test cells, and 90 kg in 834L.

Fissile material use is outlined in Procedure 121, Hazardous Materials Control at Site 300. Plutonium and explosives are not permitted within a test assembly or within a facility concurrently. 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 334 Complex is controlled by the Facility Supervisor. Within the Test Cell, or thermal chamber inside 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 in the Environmental Test Complex. 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

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

Activities	Two metal containment barriers	Pressure vessels prohibited	HFPA filters required with 150 ft/min	Sprinklers required	Fire loading less than 1 lb/ft ²	DOT approved shipping container necessary
Transportation	Yes	No	No	No	No	Yes
Receiving and inspection	Yes	No	No	Yes	Yes	No
Storage	Yes	No	No	No	Yes	Yes*
Environmental 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 Enclosed Reaction

Activities	Sprinklers required	Fire loading less than 1 lb/ft ²	DOT approved shipping container necessary	Satisfy Procedure 132 (with H.E. present)
Transportation	No	No	No	Yes
Receiving and inspection	Yes	Yes	No	Yes
Storage	No	Yes	Yes*	Yes
Environmental 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 527 A,B,C, and 2 concrete vaults.

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 Environmental Test Complex is governed by Procedures No. 600 and 634^{b-1}.

Changes and modifications to existing procedures are coordinated between the Site 300 Environmental 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.

Frequency of Operations

The frequency of thermal tests at the Environmental Test Complex varies. A biweekly schedule, published by the Environmental Test Group,

provides information on test programs for the B-834 facilities. Some thermal tests may last for a year or more, whereas other tests may last a few days, or weeks, at most. 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:

- Prepare and review test request
- Match Test Cell capabilities with test requirements
- Prepare supplemental DSP (as required)
- Install and check out instrumentation
- Locate specimen in test chamber and attach instrumentation
- Perform test
- 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 m³/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 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 d34 complex. These materials may include trichlorethylene heating/cooling systems, solvents, fumes, liquid nitrogen, and, in a very rare case, beryllium. Occasionally, a pipe leak will allow a small quantity of trichlorethylene to spill on the floor or ground. 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 presently exists for this Complex, it is now in process and should be completed within one year.

References

- 5-1. Site 300 Safety and Operational Manual, Reprint, M-091, 1 March 1978.

SECTION 6 -- SAFETY ANALYSIS

Introduction

This section presents and analyzes potential accidents deemed credible for the 834 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 834, 836, and 854 Complexes were critical facilities (possible fence-line radiation dose resulting from a maximum credible accident would exceed 500 mrem). Therefore, a seismic, tornado, and extreme wind analysis of these facilities was performed to determine if they could meet the criteria established for critical facilities at Site 300. The results of the analysis indicated that these facilities would not meet this criteria in all cases (see Appendices 6A and 6B). However, recent radiation dose calculation included in this section indicate that the maximum credible accident will not result in fence-line doses greater than 500 mrem. Therefore, these facilities are not required to meet the stringent requirements for critical facilities. With this in mind, D. Coats of LLNL

has scaled down the calculations included in Appendices 6A and 6B. This recent re-evaluation of these facilities is included in Appendix 6C.

The structural capacity of the 834 E, F, G, H, J and L buildings at Site 300 was re-evaluated using the LLNL interim seismic criteria and an extreme wind speed of 100 mph. This interim seismic criteria was felt to be the appropriate level to use for the seismic analysis and consists of 0.25g peak ground acceleration (PGA) with a response spectrum, and design of connections for 1.5 times the loads produced by this level of seismic loading. Uniform building code (UBC) type allowable stresses were used in the analysis. The 100 mph wind speed was selected as this resulted in approximate UBC level wind pressure loadings for Site 300 terrain. The re-evaluation was performed by scaling down the result of the analysis previously performed using a 0.3g PGA and a 121 mph windspeed.

The following recommendations are based on the results of this re-evaluation and would not be significantly different if a UBC evaluation was made instead of using the LLNL interim criteria.

Recommendations for Buildings 834 E, F, G, H, and J

- Replace the 5/8 in. diameter diagonal rod bracing system with a 3/4 in. diameter diagonal rod bracing system having a minimum yield strength of 36 KSI.
- Install a diagonal bracing system equivalent to the above system, in the front face walls of these structures.

- Design connections of all diagonal rod bracing systems to develop a minimum load of 13,000 lbs. (A 2:1 safety factor for turnbuckles may be used).

Recommendations for Building 834-L

- Install a system of X-bracing in the east and west walls equivalent to 1/2 in. diameter rods with a minimum yield strength of 30 ksi.
- Design connections of diagonal bracing rods to develop a minimum load of 5,000 lbs. (A 2:1 safety factor for turnbuckles may be used.)

LIGHTNING ANALYSIS (see Appendix 6D)

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 834 Complex.

Assuming the area of concern (834 Complex) is approximately $7.0 \times 10^{-4} \text{ km}^2$, the recurring interval of a strike in the area becomes

$$\begin{aligned}
 P &= \text{storms/yr} \times 1/2 \text{ day/storm} \times 7.0 \times 10^{-4} \text{ km}^2 \times 0.1 \text{ strikes/km}^2\text{-day} \\
 &= 1.75 \times 10^{-4} \text{ strikes/year or 1 strike in 5700 years.}
 \end{aligned}$$

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 834 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.

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

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 634 Complex is served by overhead power lines that go underground some distance from the transformer pad. The power line is fused and by-passed to ground by lightning suppressors located on the last power pole. Power distribution is underground from the transformer pad to the various facilities.

The test cells in this complex have a steel frame construction with the frames, doors, and all external equipment well bonded to the ground system. These test cells originally provided excellent lightning protection; however, at Test cells E, F, G, and J the addition of security street lights, powered from test cells power panels, has greatly increased the lightning exposure area of the test cells electrical systems. It was suggested by A. Hyne

(Appendix 6D) that improved protection be provided by installing lightning transient suppressors in the street light circuits at Test cells E,F,G, and J power panel boxes.

The mechanical equipment buildings have metal construction and should provide adequate lightning protection for the equipment they contain. Test cell 834L lacks adequate number of lightning arrestors. A request has been generated to upgrade the lightning protection for 834L.

Building 834A, the Control and Instrumentation Building, has 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 circuit installed where they enter the buildings.

With the exception of the security lightning circuits and the lack of lightning arrestors (air terminals) at 834L, the 834 Complex provides good protection against lightning hazards and damage. Air terminals are in the process of being installed at 834L.

FLOODING ANALYSIS

It is extremely unlikely that flooding of any building at the 834 Complex will ever occur. The terrain at Site 300 consists of hills, connecting plateau, and numerous drainage ravines. Test complexes are located at the upper elevations and are isolated from adjacent test facilities by natural terrain barriers. The 834 Complex is situated near the crest of a knoll having an elevation of 260 m. In general, the terrain slopes downward from the 834 Complex in all directions. Runoff from the 834 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 material in any form. Even though a spill involving plutonium is less likely than a uranium spill, both types of possible releases are considered. It must be emphasized that the two postulated releases are considered to be extremely remote. There are no routine (non-accident) releases of radioactivity from the 334 complex. In fact, there are no experiments that plan a dispersal of U-235 or Pu-239 at Site 300. The only possible releases would be from an accident.

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 1.1.132²⁻¹ is that explosive actuating devices are sometimes located in assemblies containing fissile materials. A planned or 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.

For an accident involving plutonium, spontaneous oxidation of the plutonium is postulated as occurring when the containers are breached, resulting in the possible scattering of plutonium oxide throughout a test cell

and to the surrounding environment. One such accident scenario assumes that the metal barriers of a test assembly containing four kilograms of plutonium are 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, 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 100m with a radius of 14m.

Dose Calculations

The modified CPSCT⁶⁻⁵ 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. Three test areas (834, 836, 854) were considered for each of the two types of postulated accidents.

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 exceeded 5% of the time is calculated to occur in summer at the site boundary 210 m north of Test Complex 834:

$$\begin{aligned} \text{Dose} &= (700 \text{ pCi/sec})(8 \text{ hr})(2.3 \times 10^{-3} \text{ sec/m}^3)(0.33 \text{ mrem-m}^3/\text{pCi-hr}) \\ &= 4.2 \text{ mrem, which is well below the maximum value of 500 mrem annual} \\ &\quad \text{effluent dose limit specified in DOE M 0024.} \end{aligned}$$

All doses calculated at or beyond the site boundary from any of the other test areas (836, 854) are less than the site boundary dose north of Building 834 (see Figure 4-1).

Uranium Lung Dose

Five percent of 35 kg (5% of 35 kg) was used as a source term to calculate dose integrated during puff passage. The U-235 lung dose conversion factor from inhalation, $0.049 \text{ mrem/pCi inhaled}$, was taken from Regulatory Guide 1.109.⁶⁻⁹ The x/Q of $3.0 \times 10^{-4} \text{ s/m}^3$ was obtained from the ISC⁰⁻³ 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 exceeded 5% of the time was calculated to occur in summer 1200 m east southeast of the 834 complex (1200 m was used instead of the nearest site boundary because of the H.E. detonations which caused the release to be above the ground.)

$$\begin{aligned}\text{Dose} &= (3.8 \times 10^9 \text{ pCi})(8.0 \times 10^{-4} \text{ s/m}^3)(2.31 \times 10^{-4} \text{ m}^3/\text{s})(4.9 \times 10^{-2} \text{ mrem/pCi}) \\ &= 34 \text{ mrem.}\end{aligned}$$

This value is well below the maximum value of 500 mrem annual effluent dose limit specified in DOE M 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:

$$\begin{aligned}\text{Dose} &= (8.0 \times 10^{-4} \text{ s/m}^3) \times 10^8 \mu\text{g} \\ &= (.8 \times 10^{-5} \mu\text{g s/m}^3) \times 10^8 \mu\text{g} \\ &= 8 \times 10^4 \mu\text{g s/m}^3 \text{ or } \frac{8 \times 10^4 \mu\text{g s/m}^3}{60 \text{ s/min}} \\ &= 1300 \mu\text{g min/m}^3\end{aligned}$$

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

All operations or proposed operations with fissile material are given an independent safety evaluation, review, and inspection by the LLNL Criticality Safety Office. Approval for all operations must be received

from the Criticality Safety Office and line supervision. During this evaluation, the potential for human error is assessed and controls are established to mitigate that potential. A special Operational Safety Procedure is written, and it states the required controls explicitly.

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 6.0 ft³. A typical test cell in the B-834 Complex has an open volume of approximately 5400 ft³. The ratio of acetone vapor to air volume is about 0.2%. Since the lower explosive limit for acetone (by volume) is 2.6%, it would actually require more than three gallons of acetone to create a hazardous gas - air mixture in a test cell.

Ventilation air would also aid in reducing vapor concentration. Sources of ignition in each cell are minimal since non-sparking tools are used and 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 834 Complex. However, a few milliliters of hydrogen gas are used in this facility as part of a hydrogen embrittlement study. This small amount of hydrogen does not impose a threat to people or structures.

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 834 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 each 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 portions of the building. Debris would be scattered inside the cell, and in an undefined pattern around the facility. No damage, or irreparable damage, would be sustained by adjacent buildings in the Complex.

The Control Building (834A) is designed to withstand the overpressures generated from an accidental detonation of 90 kg of explosives from any Test Cell in the Complex.

A comparison of structural features for Control Building 834A and Control Building 836A shows many similarities; reinforced concrete walls, floors, and roof supported on steel beams. A 1973 study by Baker and King⁶⁻¹² for 836A showed an amount of explosives exceeding 9000 kg could be tested in an adjacent test cell 836C, and only door modifications were required to the basic structure. It is reasonable to assume from analysis of Control Buildings, location of Test Cells, etc. that 200 kg could be tested in the 834 Complex with negligible damage to the Control Room.

In summary, the 834 Complex was designed for testing of hazardous materials. Although the possibility of an explosion always exists, the combination of building locations, types of construction, and methods 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 passive thermal test and pose a threat to an item containing explosives and/or radioactive materials. Electrical equipment (heaters, thermal chambers, sensors, interconnections, etc) 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 834 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 '834' test cells are discussed in Section 4. In addition, the following items also affect fire potential:

- Fuel loading in individual cells is practically non-existent.
- Flammable liquids kept to a minimum and stored in safety cans.
- Minimal external fire exposures to the Test Cells.
- Explosives present during a test.
- Fire extinguishers in each room or outside main entry doors.

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 834 Complex. In addition, test cells are characterized by a low population, 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 834 Complex unless explosives are present. The fire loading is extremely low for each of the facilities. These factors, coupled with the early warning smoke detection (or 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.

$$t = 5.76 \times G_0 / U_a$$

t = Fire duration, in seconds

G_0 = 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 0.5 kg/m^2 (a cardboard shipping box with wood frame), a ventilation rate of 0.4 kg/s , and a cell area of 90 m^2 , the hypothetical fire duration is about 10 minutes. Assuming the failure of the automatic smoke detectors, and sprinklers if installed, the passive containment system (walls, roof, floor) in any Test Cell should remain intact during the short period of the

fire. Each Test Cell has a concrete floor, steel frame, and cement-asbestos or metal walls. It is unlikely that any fire would even occur in any Test Cell at the 834 Complex since the fire loading is practically non-existent, 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 1000 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	R-1	Heavy Duty Rescue

References

- 6-1 Sunde, E. U., Earth Conduction Effects in Transmission Systems, Van Nostrand, N.Y., 1949.
- 6-2 Wick, U. 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 Joy, 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-52045, 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 270, Accession No. Ool-139, Appendix No. Ool-134.
- 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 21,000 lb detonation at Bldg. 836-C, December 3, 1973.
- 6-13 Disaster Control Plan Supplement No. 10 - "Response Plan for Fire in an Explosives Area," Lawrence Livermore Laboratory Internal Report M-014, November 20, 1978.
- 6-14 Harnathy, T. Z., "A New Look at Compartment Fires," Fire Technology, Parts I and II; 8, 196-217, 326-351, Boston, Mass., 1972.

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-50027-79, April 25, 1980.

Sampling

Air Sampling

Airborne radioactivity is measured at ten locations around Site 300 (See Appendix H of UCID-10246. 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 eight 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 ten locations at Site 300. The samples are taken to determine the perturbation to the ^{238}Pu distribution in 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 834 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. A planned or 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 exceed the 500 mrem annual effluent off-site radiation dose limit specified in DOE M 0524 or the 1500 μd 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 a matrix located at the rear of this section. Each of these hazards has been assigned a hazard and risk classification per DOE 5481.1 and SAN MD 5481.

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.

Risk as defined in SAN MD 5461 is the probability of occurrence times the severity of that occurrence. These are shown in Table 8-1, 8-2, and 8-3. Table 8-3 combines the accident severity categories in Table 8-1 with the accident probability levels in Table 8-2 in a matrix format to define risk levels. The hazards associated with acts of nature as well as those due to equipment failure and human error are summarized in Table 8-4. All but one of these hazards is classified as low per DOE 5461.1. The exception is the intrinsic hazard associated with the handling of explosives. Even though an accidental detonation is not likely to occur, it could cause major damage to the facility and the equipment in it. Thus, there would be a significant on-site impact from a detonation with only a minor off-site impact to the environment.

Therefore, the 634 Complex is classified as a moderate hazard facility.

Table 8-1. Accident Severity Categories

<u>Category</u>	<u>Descriptive Words</u>	<u>Description</u>
I	High, Catastrophic	May cause death or system loss. <i>Potential for major on-site or off-site impacts to people or the environment.</i>
II	Critical	May cause multiple severe injuries, multiple severe occupational illnesses, or major system damage. <i>Potential for major on-site or off-site impacts to people or the environment.</i>
III	Moderate,	May cause few severe injuries, few severe occupational illnesses, or major system damage. Considerable potential on-site impacts to people or the environment, but at most, only minor off-site impact.
IV	Low, Negligible	May cause minor injuries and minor system damage, but not result in occupational illness. Minor on-site and negligible off-site impacts to people or the environment.

Table 8-2. Accident Probability Levels

<u>Level</u>	<u>Descriptive Word</u>	<u>Description</u>
A	Frequent	Likely to occur immediately or within a short period of time.
B	Occasional	Probably will occur in time.
C	Remote	May occur in time.
D	Improbable	Unlikely to occur in time.

Table 8-3. Risk Class

<u>Accident Severity Category</u>	<u>Severity and Probability</u>	<u>Hazard Class</u>
High	IA, IB, IC	High
Critical	ID, IIA, IIB, IIC, IIIA	High
Moderate	IID, IIBB, IIIC, IIID,	Moderate
Low	IVA, IVB, IVC, IVD	Low

Table B-4. Summary of Safety Evaluation

<u>Potential Hazard</u>	<u>Mitigating Features</u>	<u>Consequences of Failed Feature of Mitigation</u>	<u>Level of Risk</u>
Acts of Nature	These facilities are being upgraded to 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 4.2 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 110 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. Farther herms separate facilities. These facilities are located in a remote area.	If an HE explosion occurred due to a human error or equipment failure, the lung dose calculations show a maximum of 34 mrem for uranium and 1300 $\mu\text{g min/m}^3$ for beryllium. The radiation doses are well below the 500 mrem annual effluent dose limit specified in DOE M 0674. The beryllium dose is below the 1600 $\mu\text{g min/m}^3$ recommended by NIOSH.	Low risks for all hazards except the remote possibility of an HE detonation. This might cause a few injuries or even fatalities.
Plutonium Spill	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.		
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 834 Complex.

FINDINGS

- The result of the previous seismic and higher wind analyses was scaled down to the LLNL interim seismic criteria (0-25 G peak ground acceleration) and the UBC wind pressure loadings for Site 300 terrain (100 mph). This re-evaluation was performed because recent radiation dose calculations indicate that the maximum credible accident will not result in fence-line doses greater than 500 mrem. Thus, these facilities do not need to meet the stringent requirements for critical facilities. Recommendations for the 834 E, F, G, H, and J buildings are to replace the 5/8 in. o.d. diagonal rod bracing with 3/4 in. o.d. bracing having a minimum yield strength of 36 ksi. Install a diagonal bracing system in the front facing walls of these structures. Design connections of all diagonal rod bracing systems to develop a minimum load of 13 000 lb. Recommendations for the 834L building are to install a system of x-bracing in the east and west walls equivalent to 1/2 in. o.d. rods having a minimum yield strength of 36 ksi. Design connections of diagonal bracing rods to develop a minimum load of 5000 lb.

- The analysis of the lightning protection systems indicated that the security street lights for Building 834E, F, G, and J need additional lightning protection. This will be provided by installing lightning transient suppressors in the street light circuits located at the bunker power panel boxes.
- A recent inspection of these facilities indicated that Building 834L lacked an adequate number of lightning arrestors (air terminals). These are in the process of being installed.
- The existing fire protection system at these facilities is adequate. No modifications are necessary.
- The design and location of these facilities are adequate for handling explosives.
- Because explosives are handled here, the 834 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 TO FURTHER MINIMIZE RISKS

- Finish writing the Quality Assurance Plan for the 834 Complex.

APPENDIX 6A

SEISMIC, TORNADO AND EXTREME WIND ANALYSIS

OF

BUILDING S34, F, G, H and J SITE-200

SEISMIC, TORNADO AND EXTREME WIND ANALYSIS

OF

BUILDINGS 834E, F, G, H and J SITE-300

by

D. W. Coats, Jr.

INTRODUCTION

Buildings 834E, F, G, H and J are used as an environmental test complex to determine long term temperature and pressure cycle effects on device mock-ups, using high explosives with plutonium mock-up or plutonium with mock high explosive.

These structures were analyzed to determine their ability to withstand the seismic, tornado and extreme wind hazards postulated for Site-300.

SEISMIC, TORNADO AND EXTREME WIND HAZARDS

Seismic - The safe-shutdown earthquake (SSE) for these structures is based on the geological study made by R. K. Thorpe and L. H. Wight entitled, A Geological and Seismological Investigation for the 834, 835 and 854 Building Complexes at LL's Site 300,⁽¹⁾ (UCRL-52006, January 1976).

Based on the proximity of several major faults capable of producing magnitude 6.5 earthquakes, a peak acceleration of 0.8 g has been predicted for the 834, 835 and 854 complexes. Surface faulting and soil liquefaction present no hazards to the critical structures.

⁽¹⁾ The numbers contained in the parentheses refer to the list of references given at the end of this report.

The response spectrum for the safe-shutdown earthquake for these complexes is shown in Figure 1, for values of 2%, 5% and 10% of critical damping.

Tornado and Extreme Wind - The tornado and extreme wind criteria for the site was developed by McDonald, Mehta, and Minor, Consulting Engineers and is presented in a report entitled, Development of a Design Basis Tornado and Structural Design Criteria for Lawrence Livermore Laboratory's Site 301. (2)

The postulated tornado and extreme wind parameters are shown in Table 1.

TABLE 1
Tornado and Extreme Wind Parameters

Tornado	
Rotational Plus Translational Speed	100 mph
Pressure Drop	None
Extreme Wind (straight wind)	
Velocity below 30 ft.	121 mph
Wind Borne Missile	
Wind 2" x 4" x 12', 20 lbs.	10 mph

The tornado criteria were based on a recurrence interval of 1×10^5 occurrences per year, while the extreme wind parameters were determined on the basis of 1×10^4 occurrences per year. This is consistent with ERDA General Design Criteria. The effective velocities given in Table 1 include a 10 per cent increase in windspeed because of the channeling effect of the wind at the site.

For the selected levels of risk, the straight wind parameters dominate. Therefore, the structure was checked for extreme winds only.

Fig. 1. SSE response spectrum for the 834, 836, and 854 complexes.

BUILDING DESCRIPTION

Buildings 834E, F, G, H and J are small one-story, steel-framed structures with plan dimensions of approximately 22' x 26' x 12' high. The exterior walls are constructed of 1-9/16" cement asbestos panels, and the roof consists of 2" thick cement asbestos panels and built-up roofing. The main lateral force resisting system in the structures are 5/8" O.D. diagonal rod bracing in the side walls and back walls of the buildings. Figures 2 and 3 show details of the buildings.

SEISMIC ANALYSIS

Analysis Procedure - Buildings 834E, F, G, H and J were investigated for their ability to resist the safe-shutdown earthquake (SSE) postulated for the 834, 836 and 854 building complexes at Site 300. The response spectrum postulated for the SSE is shown in Figure 1. A value of 1.0 for critical damping was assumed for these structures.

The SSE is defined as that earthquake which produces the maximum vibratory ground motion for which structures, systems and components necessary for safe operation of the facility must remain functional.

An estimation of the fundamental period of the structures was determined on their mass and stiffness characteristics. This estimation resulted in a fundamental period of 0.2 seconds with a corresponding spectral acceleration of approximately 2g.

Because these structures are simple, one-story box systems, the equivalent static method was used for the analysis. In using this method, it is assumed that the east-west building motions are uncoupled from the north-south motions. This requires a separate analysis for each direction.

Results of the Seismic Analysis - The results obtained from the analysis are summarized in tables 2 through 4. These results are based on assuming the

FIGURE 3

worst direction of loading for the designated elements and that a system of diagonal bracing, equivalent to the 5/8" O.D. rods used in the side walls and backface, exists in the front face wall system.

TABLE 2
Factors of Safety of Structural Elements

Description	Location	Factor of Safety*
5/8" O.D. Rods	Exterior Walls	(0.38)
W10x11.5	Roof Chord Members	8.19
W8x10	Roof Chord Members	14.1
W8x10	Roof Supporting Members	(1.0)
Vertical Wall Supports	Exterior Walls	2.11

TABLE 3
Factors of Safety of Structural Connections

Description	Factor of Safety*
W10x11.5 to W8x10	1.23
W8x10 to W10x11.5	2.92
Vertical Wall Support Connections	4.33

TABLE 4
Factors of Safety Against Overturning and Sliding

Description	Factor of Safety*
Overturning	1.48
Sliding	1.62

*Factors of safety based on allowable stresses. When factors of safety based on allowable value are less than 1.0, the factor of safety based on yield stresses are shown in parenthesis.

EXTREME WIND AND TORNADO ANALYSIS

Extreme Wind Analysis - The controlling design basis wind for Site 300 is a 121 mph straight wind at a 1×10^{-4} risk level. Wind effects were investigated based on recommendations made in ANSI A58.1-1972 Standards. Seismic loadings were found to govern in all cases.

Tornado Analysis - Tornado criteria developed for Site 300 is less than the extreme wind criteria. The maximum postulated tornado wind speeds are 102 mph at a risk level of 1×10^{-6} . Therefore, the structure was investigated for straight wind effects only.

Missile Analysis - The postulated missile for Site 300 is a 2 in. x 4 in. x 12 ft. long timber weighing 20 lbs and traveling at 70 mph horizontal velocity. No missile penetration analysis was done, but because the exterior walls of the structure are constructed of cement asbestos panels, 1-9/16" thick, it is highly probable that the postulated missile could penetrate the structure.

CONCLUSIONS AND RECOMMENDATIONS

The results of the seismic analysis indicates that the 5/8" O.D. diagonal bracing used in the side and back walls of the structure is insufficient to resist the lateral forces induced by the postulated SSE. The following recommendations are made:

- Replace the 5/8" O.D. diagonal rod bracing system with a 1" O.D. diagonal rod bracing system, or provide rods with a yield tensile strength of 30,000 lbs.
- Install a diagonal bracing system, equivalent to above system, in the front face walls of these structures.
- Make sure connections can handle larger bracing loads.

Upgrading of the exterior wall systems, with regard to missile penetration problems is required if operational capability during severe winds is necessary.

REFERENCES

1. R. K. Thorpe and L. H. Wight, "A Geological and Seismological Investigation for the 834, 836, and 854 Building Complexes at LLL's Site 300," UCRL-52006, January 29, 1976.
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.

DWC:sac

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APPENDIX 6B

SEISMIC, TORNADO AND EXTREME WIND ANALYSIS

OF

BUILDING 834-L, SITE 300

SEISMIC, TORNADO AND EXTREME WIND ANALYSIS
OF
BUILDING 834-L, SITE-300

by

D. W. Coats, Jr.

INTRODUCTION

Building 834-L is used as an environmental test structure to determine long term temperature effects on device mock-ups, using high explosives with plutonium mock-up or plutonium with mock high explosive.

This structure was analyzed to determine its ability to withstand the seismic, tornado and extreme wind hazards postulated for Site-300.

SEISMIC, TORNADO AND EXTREME WIND HAZARDS

Seismic - The safe-shutdown earthquake (SSE) for this structure is based on the geological study made by R. K. Thorpe and L. H. Wight entitled, A Geological and Seismological Investigation for the 834, 836 and 854 Building Complexes at LLL's Site 300,⁽¹⁾ (UCRL-52006, January 1976).

Based on the proximity of several major faults capable of producing magnitude 6.5 earthquakes, a peak acceleration of 0.8 g has been predicted for the 834, 836 and 854 complexes. Surface faulting and soil liquefaction present no hazards to the critical structures.

The response spectrum for the safe-shutdown earthquake for these complexes is shown in Figure 1, for values of 2%, 5% and 10% of critical damping.

⁽¹⁾The numbers contained in the parentheses refer to the list of references given at the end of this report.

Tornado and Extreme Wind - The tornado and extreme wind criteria for the site was developed by McDonald, Mehta, and Minor, Consulting Engineers and is presented in a report entitled, Development of a Design Basis Tornado and Structural Design Criteria for Lawrence Livermore Laboratory's Site-300. (2)

The postulated tornado and extreme wind parameters are shown in Table 1.

TABLE 1
Tornado and Extreme Wind Parameters

Tornado	
Rotational Plus Translational Speed	102 mph
Pressure Drop	None
Extreme Wind (straight wind)	
Velocity below 30 ft.	121 mph
Wind Borne Missile	
Wood 2" x 4" x 12', 20 lbs	70 mph

The tornado criteria was based on a recurrence interval of 1×10^{-6} occurrences per year, while the extreme wind parameters were determined on the basis of 1×10^{-4} occurrences per year. This is consistent with DOE General Design Criteria. The effective velocities given in Table 1 include a 10 percent increase in windspeed because of the channeling effect of the wind at the site.

For the selected levels of risk, the straight wind parameters dominate. Therefore, the structure was checked for extreme winds only.

Fig. 1. SSE response spectrum for the 844, 876, and 896 samples.

BUILDING DESCRIPTION

Building 834-L is a small one-story, steel-framed structure with plan dimensions of approximately 34' x 36' x 17' high. The exterior walls and roof are sheathed with 26 Ga. galvanized sheet metal. The main lateral force resisting system in the structure is a rigid steel frame capable of resisting lateral forces in the east-west direction only. In the north-south direction there is no distinct lateral force resisting system. Figures 2 through 4 show details of the building.

SEISMIC ANALYSIS

Analysis Procedure - Building 834-L was investigated for its ability to resist the safe-shutdown earthquake (SSE) postulated for the 834, 836 and 854 building complex at Site-300. The response spectrum shown in Figure 1 with a value of 5% of critical damping was used in the analysis.

The SSE is defined as that earthquake which produces the maximum vibratory ground motion for which structures, systems and components necessary for safe operation of the facility must remain functional.

No estimation of the fundamental period of the structure was made as there is no distinct lateral force resisting system in the north-south direction. To be conservative, the maximum amplification factor of 2, for the 5% damped spectrum was used.

Because this structure is a simple, one-story box type structure, the equivalent static method was used for the analysis. In using this method, it is assumed that the east-west building motions are uncoupled from the north-south motions. This requires a separate analysis for each direction.

Results of the Seismic Analysis - The results obtained from the analysis are summarized in Tables 2 and 3. Sliding and overturning are not a problem

NOTES:

ENGINEERING PROPERTIES OF FRAMING MEMBERS
IN ACCORDANCE WITH THE 1962 EDITION OF THE
AISI SPECS FOR DESIGN OF LIGHT GAUGE
COLD-FORMED STL STRUCTURAL MEMBERS.

FIGURE 3

NORTH WALL FRAMING, SECTION SHEET 1
SCALE: 1/4" = 1'-0"

FIGURE 4

with this structure.

TABLE 2
Factors of Safety of Structural Elements

Description	Factor of Safety*
East and west walls (north-south loading)	< 1.0
Rigid Frame (east-west loading)	0.8
North and south walls (east-west loading)	---
Roof purlins	> 1.0

TABLE 3
Factors of Safety of Structural Connections

Description	Factor of Safety*
3/4" O.D. Anchor Bolts (rigid frame)	2.1
3/8" O.D. Anchor Bolts (purlins)	> 4.0
Moment connection of rigid frame	0.8

EXTREME WIND AND TORNADO ANALYSIS

Extreme Wind Analysis - The controlling design basis wind for Site-300 is a 121 mph straight wind at a 1×10^{-4} risk level. Wind effects were investigated based on recommendations made in ANSI A58.1-1972 Standards.

*Factors of safety based on yield stress.

Tornado Analysis - Tornado criteria developed for Site-300 is less than the extreme wind criteria. The maximum postulated tornado wind speeds are 102 mph at a risk level of 1×10^{-6} . Therefore, the structure was investigated for straight wind effects only.

Missile Analysis - The postulated missile for Site-300 is a 2" x 4" x 12' long timber weighing 20 lbs and traveling at 70 mph horizontal velocity. No missile penetration analysis was done because the penetration resistance of the hollow metal door, the louver doors, the roll-up door and the exterior sheathing is not known.

Results of Wind Analysis - The results of the wind analysis are summarized in Tables 4 and 5.

TABLE 4

Factor of Safety of Structural Elements

Description	Factor of Safety*
East and west walls (north-south loading)	< 1.0
Rigid frame (east-west loading and uplift)	> 1.0
North and south walls (east-west loading)	---
Roof purlins (uplift)	> 1.0

TABLE 5

Factors of Safety of Structural Connections

Description	Factor of Safety*
3/4" O.D. Anchor Bolts (rigid frame)	1.33
3/8" O.D. Anchor Bolts (purlins)	3.9
Moment Connection of rigid frame	> 1.0

*Factors of safety based on yield stress.

CONCLUSIONS AND RECOMMENDATIONS

The results of the seismic and wind analysis for building 834-L indicate that a lateral force resisting system is required in the east and west walls and that the bolted joints connecting the rafter and column members of the rigid frame need to be strengthened.

Because of the complexity of the framing of the north and south walls and the uncertainties in the lateral force capacities of the framing members and exterior sheathing, a strengthening of these walls is recommended. The following recommendations are made:

- Install a system of X-bracing in the east and west walls equivalent to 1/2" O.D. rods with a minimum yield strength of 36 ksi.
- Make sure connection details can handle bracing loads.
- Increase moment capacity of bolted joints connecting rafter and column members of rigid frame.
- Strengthen lateral resistance of north and south walls with knee-bracing, K-bracing, etc.
- Determine missile penetration resistance of the hollow metal door, louver doors, roll-up door and exterior sheathing from full scale tests if operational capability is required during severe winds.

REFERENCES

1. R. K. Thorpe and L. H. Wight, "A Geological and Seismological Investigation for the 834, 836, and 854 Building Complexes at LLL's Site-300," UCRL-52006, January 29, 1976.
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.

APPENDIX 6C

RE-EVALUATION OF SITE 300 BUILDINGS 834 F, F, G, H, J, AND L

Recommendations for Building 834-L:

- o Install a system of X-bracing in the east and west walls equivalent to 1/2" ϕ rods with a minimum yield strength of 36 ksi.
- o Design connections of diagonal bracing rods to develop a minimum load of 5,000 lbs. (A 2:1 safety factor for turnbuckles may be used.)

If you have any questions regarding this information or these recommendations, please feel free to call me.

DWC/mw
2/12j

cc: C. F. Baker
R. C. Murray
S. N. Shukla

APPENDIX 6D

SITE 300 LIGHTNING SAFETY SURVEY

Interdepartmental letterhead

Mail Station L 154

Ext 8318

June 9, 1976
FTS 76-6-6

To: B. H. 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 rused 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.

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