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SAFETY ANALYSIS OF THE EXISTING 851 FIRING FACILITY

June 5, 1986

DISCLAIMER

FGMB

Abstract

A safety analysis was performed to determine if normal operations and/or potential accidents at the 851 Firing Facility at Site 300 could present undue hazards to the general public, personnel at Site 300, or have an adverse effect on the environment. The normal operations and credible accidents that might have an effect on these facilities or have off-site consequences were considered. It was determined by this analysis that all but two of the hazards were either low or of the type or magnitude routinely encountered and/or accepted by the public. The exceptions were the linear accelerator and explosives, which were classified as moderate hazards per the requirements given in DOE Order 5481.1A.

This safety analysis concluded that the operation at this facility will present no undue risk to the health and safety of LLNL employees or the public.

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SECTION 1 - INTRODUCTION

Purpose and Methodology

This safety analysis of the 851 Firing Facility (Bunker 851) provides a comprehensive review of the existing facility and the operations conducted in it, discusses potential accidents, and makes an assessment of risks. Under the auspices of B-Division, this analysis was performed by the Hazards Control Safety Team with considerable help from Bunker personnel. Multiple shot setups, firings, and recoveries were observed to produce this document and the findings described herein. This document was reviewed by B-Division, the Site 300 Resident Manager, and the Associate Director for Plant and Technical Services.

Organization

There are five sections in this report. Section 2 describes Site 300 and the area surrounding it, as well as the environmental factors pertaining to it. Sections 3 and 4 describe the 851 facility and the operation conducted there. Section 5 summarizes the hazards associated with this facility and provides an assessment of the risks involved by operating this facility. Additional information is referenced. Detailed procedures for handling on-site accidents are contained in the LLNL Health and Safety Manual, Emergency Response Plan, Site 300 Safety and Operational Manual, Operational Safety Procedures, the Fire Department Operations Manual, and Self-Help Plans.

Summary of Findings

This analysis determined that some experiments contain depleted uranium and beryllium, which are released during a detonation. However, air samplers indicate that the airborne concentrations of these materials are well below EPA and Bay Area Quality Management District ambient concentration limits. Soil samples show higher-than-normal concentrations of depleted uranium immediately adjacent to the firing facility. This is attributed to the use of these materials in some of the shots. The calculated worst-case off-site radiation dose from a single experiment containing depleted uranium at 851 is 6 mrem. However, most experiments contain zero or only a few grams of depleted uranium. Thus, the off-site dose is well below the 25 mrem effluent annual dose limit specified by the EPA for radioactive materials.

All but two of the hazards are classified as low per DOE Order 5481.1A or are of the type or magnitude routinely encountered and/or accepted by the public. The exceptions are the linear accelerator and explosives. Because these hazards have a potential for significant on-site consequences, Bunker 851 is classified as a moderate hazard facility per DOE Order 5481.1A. Since this facility was especially constructed to handle explosives detonations, is located in a remote area, and personnel have special operating procedures to follow, the linear accelerator and explosives hazards are deemed acceptable risks.

It has been determined from this safety analysis that the operations at the 851 Firing Facility can be conducted according to DOE codes, standards, and regulations as specified in the Site 300 Safety and Operational Manual, the LLNL Health and Safety Manual, and the DOE Explosives Safety Manual; and there will be no undue risks to the health and safety of LLNL employees or the public.

SECTION 2 - SITE DESCRIPTION

Site Location

The Explosives Test Site (Site 300) is located about 15 miles southeast of the Lawrence Livermore National Laboratory in the sparsely populated hills of the Diablo Range. Site 300 occupies an area of 7000 acres. Figure 2-1 show the location of Site 300 in relation to surrounding communities. Figure 2-2 shows the location of the 851 Facility at Site 300 and its proximity to nearby facilities.

The communities nearest to Site 300 are Tracy (6 miles to the northeast) and Livermore (15 miles to the west). Tracy's population is about 25,000 while Livermore's population is about 50,000 people.

Land use adjacent to Site 300 consists of three major users to the south and one major user to the east: 1) Carnegie State Vehicle Recreation Area (SVRA), an outdoor recreational facility for the off-road motorcycle riding, testing, and racing, 2) the Connolly Ranch, which is used primarily for the grazing of cattle, 3) Stanford Research Institute, which operates an explosives test site adjacent to the Carnegie SVRA, and 4) Physics International, which operates an explosive test facility adjacent to Site 300's southeast boundary. Adjacent to Site 300 on the west, north, and east are small farms and ranches that are used primarily for cattle and sheep grazing.

Environmental Factors

The environmental factors pertaining to Site 300 are discussed in detail in the LLNL Final Environmental Impact Statement[2-1] as well as in other documents that it references. Those factors that might impact the safe operation of the 851 facility or create on-site as well as off-site problems from explosive testing are grass fires, overpressures, and the dispersion of depleted uranium and beryllium. These are discussed below.

Grass Fires

Most of the precipitation falls between October and April and causes grass to grow on-site as well as in the surrounding areas. If left unchecked, this grass presents a high fire hazard both on and off the site in late spring, summer and fall. To reduce the risk from grass fires, the Site perimeter on the north, east, and south sides is disked and/or burned annually to prevent and stop plant growth (winds are predominantly from the west). Also, the Fire Department performs controlled burns around the active firing areas (2000 to 3000 acres) so that hot fragments from test operations will not start uncontrolled grass fires. The controlled burns are performed in May and June when the grass is dry so that most of it burns. (Very little growth occurs after this time until the fall rains begin.) The Site 300 Resident Manager suspends explosives testing when fire conditions are critical. Portable fire extinguishers and water hoses are readily available at the firing facilities to put out small fires.

Controlled burn permits are obtained from the San Joaquin County Air Pollution Control District and the Bay Area Air Quality Management District.

Overpressures

When explosives are detonated under certain meteorological conditions, overpressures are generated that produce loud noises and pressure waves at considerable distance from the source. To reduce the possibility of generating excessive overpressures in surrounding communities, a meteorolgy center has been established at Site 300. By use of meteorological data, the operators of the center can determine the maximum amount of explosives that can be detonated at any one time without producing excessive overpressures in the populated areas surrounding the Site.[2-2, 2-3] Rarely has a noise or property damage complaint been registered by the local citizens against the Laboratory.[2-4]

Dispersion of Uranium and Beryllium

Each time an explosive is detonated, its products are dispersed into the air, on the firing table, and onto the ground surrounding the bunker. Air and soil samples are routinely taken at Site 300 by the Environmental Quality Verification Program. The air samples show a slightly higher-than-background concentration of depleted uranium and essentially background concentration of beryllium at Site 300. The ^{238}U measurements are well below the EPA limit of 25 mrem annual effluent dose.[2-4] The calculated worst-case off-site radiation dose from a single experiment containing depleted uranium is 6 mrem (see Appendix A). This dose calculation is based on involving 35 kg of ^{238}U in a

single detonation. However, most experiments conducted at this facility contain zero or only a few grams of ^{238}U. The Be measurements are well below the Bay Area Air Quality Management District ambient concentration limit of 0.01 $\mu g/m^3$.[2-4]

The soil samples show a higher-than-normal concentration of depleted uranium and beryllium immediately adjacent to the firing facility. This is attributed to these materials being used in some of the shots detonated on the firing table.[2-4] Soil samples taken elsewhere on Site 300 indicate background levels of uranium and beryllium.

A special study is currently underway to more fully determine the airborne pathways of depleted uranium and beryllium released from experiments conducted on the firing tables at Site 300. Since very few experiments contain these materials, sufficient data cannot be readily obtained. However, the results of this study should be available about January 1987.

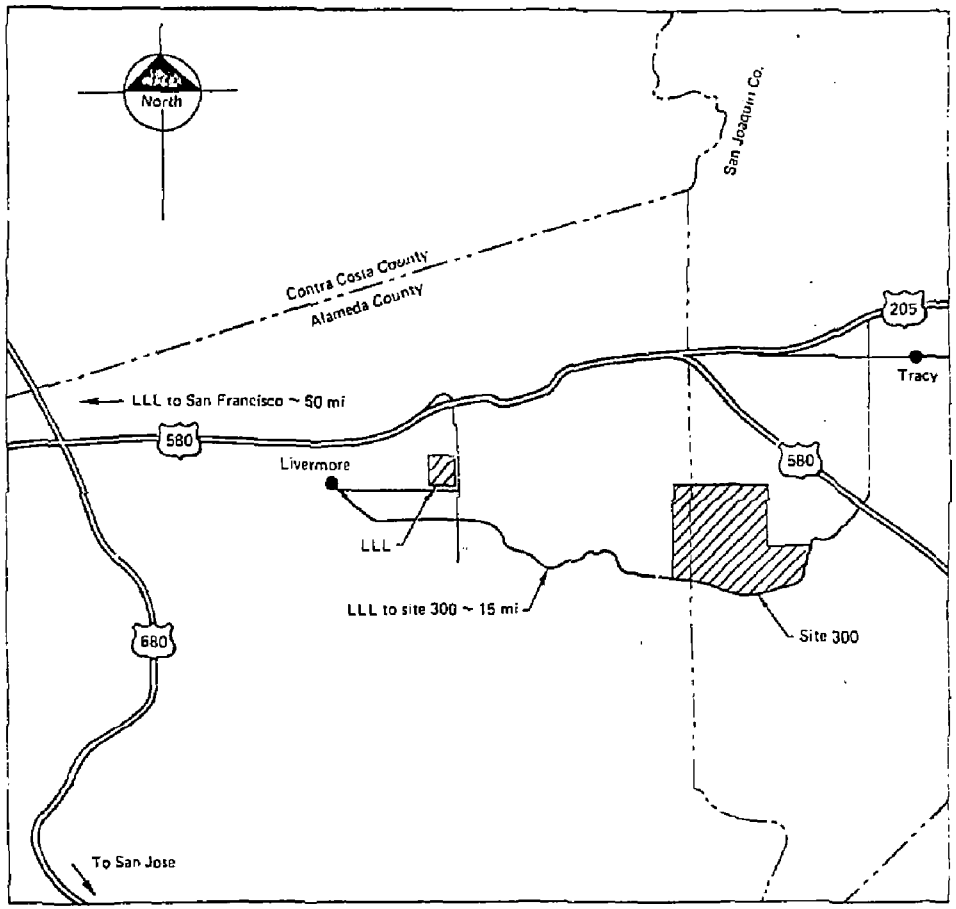

Fig. 2-1. Site 300 Location

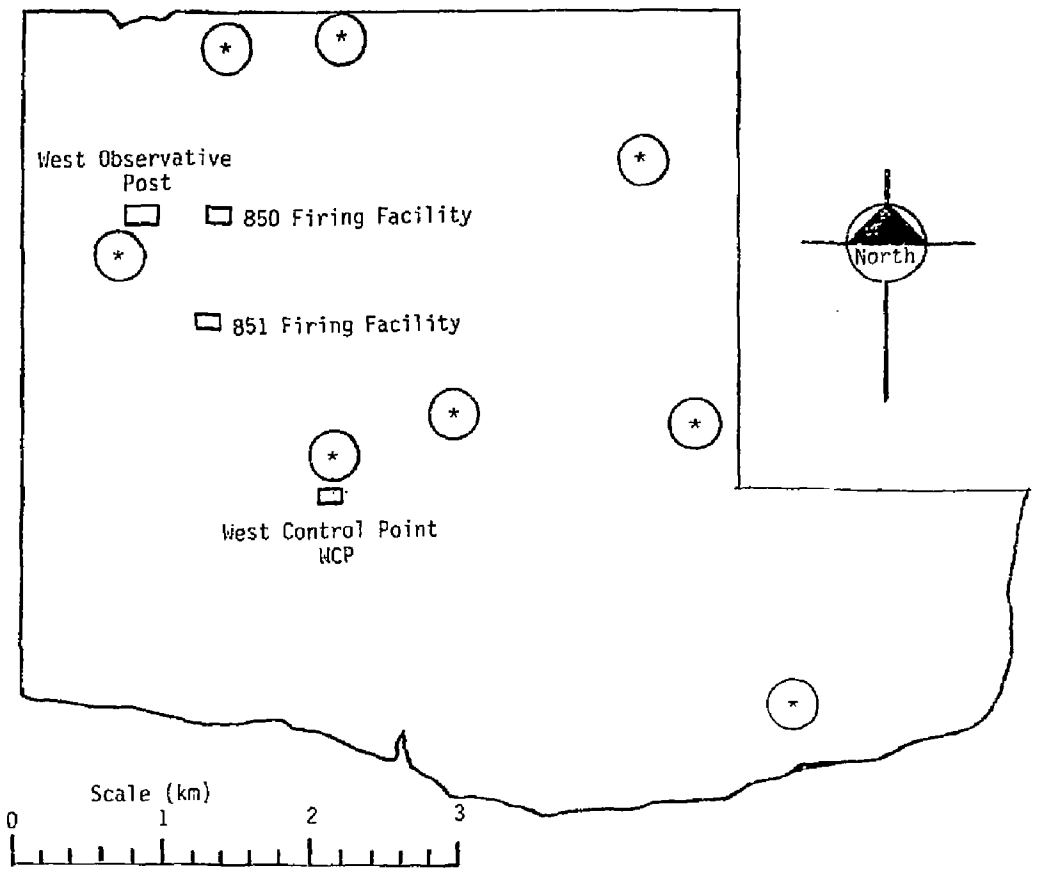

Fig. 2-2. Location of the 851 Firing Facility and Air Samplers at Site 300.

SECTION 3 - FACILITY DESCRIPTION

General

Bunker 851 is a heavily reinforced concrete structure that is located well above the flood plain in the West Firing Area of Site 300 (see Fig. 2-2). The key plan of the facility shows the layout of the buildings (see Fig. 3-1). The bunker is built partially into a hill with the firing table located above the bunker (see Figs. 3-2 and 3-3). Trucks, portable cranes, and forklifts have access to the firing table on the north side. Located slightly downhill from the bunker are two storage buildings, two cooling towers, and a machine shop. Figure 3-4 provides another view of the facility. A Control Post (CP) as well as fencing and gates are provided to restrict access to the area at specified times (musters). Structural calculations performed by Baker and Shay[3-1] as well as actual experience show that the bunker and all the other facilities at the 851 location can withstand the shock waves, overpressures, and missiles generated when explosives are detonated on the firing table. Distance versus elevation curves for placing various charge weights on the firing table are included in the Site 300 Firing Facilities Technicians Reference Handbook. Mechanical, electrical, and research equipment as well as cabinets are secured in accordance with LLNL seismic tie-down standards. Telephones and intercoms are provided.

The electrical systems at the facility conform to DOE and LLNL standards and the National Electric Code. Power supplies, cabling, and related equipment

are insulated, isolated, and totally enclosed. Automatic grounding fixtures and interlocks are provided. The following paragraphs discuss those portions of Bunker 851 that are operationally significant.

Bunker 851 Description

Camera Room (R-105)

Up to eight high-speed cameras (see Fig. 3-5) can be used in unison to film an explosive detonation through viewing ports in the ceiling via turning mirrors previously situated on the firing table. A special exhaust system removes the helium that is exhausted from the cameras. The interior wall and door facing the laser area (R-107) are lined with 1/2-inch thick aluminum to prevent a shattered, high-speed, beryllium camera rotor from escaping from the room if it were to come apart during operation. (Personnel wear respirators when cleaning up the beryllium from the shattered rotor. Swipes are taken to certify that the area is clean.) The door to the camera room is interlocked so that the cameras will shut down if the door is inadvertently opened during operation. An amber light mounted outside the door flashes whenever entry to the camera room is restricted.

Dark Room (R-108)

This room contains equipment for processing film and viewing films and x-rays.

Modulator Room (R-113)

Five enclosed cabinets containing the high voltage modulating circuits for the linear accelerator's klystron tubes are located in this room. Each cabinet door is interlocked so that the voltage shuts off when the door is opened.

Dark Room (R-116)

This room is used to assemble and disassemble the film package for the linear accelerator as well as hand processing x-ray film and high-speed camera film, and various-cut black and white film.

Control Room (R-117)

This large room houses numerous oscilloscopes, polaroid cameras, and the electronics that control the operation of the high-speed cameras and linear accelerator as well as the timing mechanism to synchronize all operations including the firing of the shot (see Figs. 3-6 and 3-7). Two air samples are also located in this room to monitor the air for beryllium, and radioactive contaminants.

Bottle Foyer (R-121)

Various cylinders containing argon and helium are stored in this area, which is open to the atmosphere on one side.

Air Conditioning Equipment (R-122)

Air conditioning equipment for the bunker is located in this room. Single stage HEPA filters with blast covers are provided to filter the bunker air except during a shot. The blast covers are closed prior to a detonation to protect the HEPA filters from overpressures generated by the shot. Just prior to, during and shortly after the shot, the air in the building is recirculated. Otherwise, the outside air enters the building through HEPA filters. At shot time the air pressure in the bunker is slightly positive in respect to the outside air to discourage in-leakage of potentially contaminated outside air.

Accelerator Room (R-215)

This room houses the 100 MeV accelerator. A lead sliding door leading from the Control Room to the accelerator area is interlocked so that the accelerator will shut down if the door is opened while it is operating. Radiation monitors indicate radiation levels produced by the accelerator.

Bunker personnel normally use the passageway alongside the accelerator when going to and from the firing table. Two samplers are located by the door leading to the firing table and just inside the accelerator room to monitor the air for beryllium and depleted uranium. The front end of the accelerator is covered by a thick concrete and steel bullnose that protrudes onto the firing table. Water from the cooling towers is used to cool the accelerator.

Safety Control Features

General

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 on-site and off-site property. This analysis determined that the written safety procedures are appropriate for the operations conducted at the 851 Firing Facility. The B-Division Quality Assurance Plan has been formalized in writing.

General procedures for Safety and Operation, Shipping, Receiving, and Storage of Explosives; Hazardous Materials Control; Hazardous Waste Disposal; and Emergencies are described in the Site 300 Safety and Operational Manual.[3-1] These procedures conform to the requirements of DOE Explosives Safety Manual.[3-2] Listed below are the titles and numbers of the main procedures pertaining to firing bunker operations:

Procedure Number	Title
100	Hazardous Work Permits
101	Testing and Inspection Procedure for Lightning Protection Systems
102	Lightning Alerts
103	Protective Clothing and Footwear
105	Site 300 Traffic and Vehicles
106	Working With Explosives
107	Explosives Handling Equipment
108	Operation of Vehicles Transporting Explosives
109	Transferring Explosives and Other Hazardous Materials
110	Shipping and Receiving Explosives
112	LLNL Classification of Explosives
118	Magazines and Explosives Storage

Procedure Number	Title
119	Training and Qualification of Explosives Personnel
120	Approved Type III Meters for Use at Site 300
121	Hazardous Materials Control at Site 300
122	Handling Natural and Depleted Uranium, Natural Thorium, and Beryllium in Metallic Form
123	Warning Devices and Signs
124	Hazardous Operations Status Report
125	Construction and Maintenance Work at Site 300
127	Site 300 Smoking Regulations
128	Maintenance Mechanics Off-Shift Communications Procedures
129	Coffee Pots, Hot Plates, and Portable Electric Heaters
130	Working Alone
131	Site 300 Buddy System
'33	*Replacement of High Efficiency Particulate Air (HEPA)* Filters
134	Nondestructive Field Radiography - Site 300
136	*Hiking/Walking Off Paved Roads at Site 300*
300	Muster Control System
301	*General Firing Facility Operations*
303	Operation of Firing Area Magazines
308	Building 851 Radiation Safety Procedure
309	155 mm Gun Firing - Building 850
E-1	Accident Control Plan
E-2	Emergency Call List
E-3	Handling an Emergency
E-4	Personnel Response to Fire in Areas Containing Explosives
E-5	Accident or Fire With a Vehicle Carrying Explosives at Site 300

Explosives Safety

Personnel are trained in explosives handling. Their qualifications for handling explosives are reviewed annually. All equipment used to handle explosives is certified for explosives use. Fork lifts and hoists are operated and inspected according to the criteria given in the LLNL Health and Safety Manual Supplement 29.04B and Procedure No. 107 of the Site 300 Safety and

Operational Manual, titled "Explosive Handling Equipment".[3-2] Shipping, transferring, and storing explosives on-site and on public highways are in accordance with LLNL Health and Safety Manual Supplement 24.05.

Various physical and administrative controls prevent or significantly reduce the possibility and consequences of an unplanned explosive detonation. Since personnel rely so heavily on administrative controls for operations that involve explosives, they follow these controls rigorously, and supervision rigidly enforces these controls. Adherence to these administrative controls has been observed numerous times by Hazards Control. A badging and muster system (discussed in Section 4) accounts for and controls personnel prior to and during an experiment. Gates are closed, run/safe switches and interlocks are made up, and a muster completed prior to connecting the detonator cables to the Capacitor Discharge Units (CDUs) located inside the bunker. The Facility Supervisor or his designee carries the key to the firing mechanism on his person until the muster is completed and the "fire permission" is granted by the Control Post Operator. Thus, the firing mechanism and x-ray machine are disabled and electrical energy is not available to set off the detonator until the outside area is cleared and all personnel are inside the bunker. The worst that could happen is that a spurious electrical signal might trigger the CDUs and cause a premature detonation that would destroy the experiment before the data can be recorded. No one would be injured by this premature detonation since all personnel would be mustered inside the bunker and out of danger.

All explosives operations conducted at this facility meet the applicable requirements contained in the DOE Explosives Safety Manual.[3-3]

Noise and Overpressure Safety

The Site 300 Meteorology Center forecasts the maximum amount of explosives that can be detonated without producing excessive overpressures off-site that could damage property or produce excessive noise. This is discussed in Section 4.

A series of noise measurements will be taken inside the bunker to determine the level of noise produced by explosives detonation on the firing table. It may take one year to gather sufficient data to make an evaluation of these sound levels since many of the shots are relatively small.

Fire Safety

The water supply for the sprinkler systems is supplied from a line from the Site 300 cold water supply. Electrically supervised shutoff valves are positioned at readily accessible locations. For additional assurance, these shutoff valves are administratively controlled and padlocked open by the Fire Department.

The fire alarm panel is located inside the mechanical equipment room in Bunker 851. This panel has power supplied through the battery bank inverter. If there is an open or short circuit in the alarm circuit, a trouble light will be lit on the alarm panel. The smoke detectors and sprinkler alarms will cause

a red "FIRE" light and a zone indicator light to illuminate on the panel. Both the trouble and fire conditions cause a buzzer to sound and an alarm signal to be transmitted automatically to the Fire and Police Stations (B-870).

Radiation Safety

A local muster must be established by the Facility Supervisor or his alternate prior to operating the accelerator. The Facility Supervisor or his alternate must visually and verbally account for all personnel in the 851 area and confirm the number of people with the West Control Post (WCP) operator, and announce over the public address system that the accelerator is going to be operated, thus producing radiation. The accelerator operator must make a physical sweep of the radiation area, secure gates, and make up the radiation interlock systems. Any interlock not made up or broken after make up will cause the high voltage to the accelerator to shut off. When interlocks are made up, magenta lights come on and a chime is broadcasted. During accelerator operation, a radiation monitor system with remote heads is monitored at the control console. When entering the radiation area, after accelerator operation, the accelerator operator monitors the area with a hand held radiation monitoring instrument. Dosimeters worn by bunker personnel show no radiation exposures from the linear accelerator at Bunker 851.

Radiation run/safe switches are located at all access doors, gates and several places within the radiation area. These switches are highlighted by a yellow light that is on when these switches are made up. The high voltage to the accelerator is secured by actuating any one of the radiation run/safe switches.

Contamination and Effluent Controls

Single stage HEPA filters, mounted in the Bunker air intake system, prevent possible radioactive materials and/or respirable beryllium particles from being introduced into the bunker ventilation system. Solid wastes, including explosives debris that is produced by the detonation, are controlled according to the guidelines outlined in the Site 300 Safety and Operational Manual.

Firing table gravel contaminated with beryllium and/or depleted uranium is removed and dumped in the Site 300 disposal pits. On-site air and soil sampling discussed in Section 2 and special air sampling of the disposal pits[3-4] indicate that wind blowing over the open disposal pits and firing tables does not significantly spread these materials.

Past studies indicate that personnel can be exposed to low levels of airborne beryllium[3-5] and depleted uranium from previous shots while working in the gravel on the firing table. Therefore, the table gravel is monitored monthly for alpha, beta, and beryllium content and is replaced with fresh gravel whenever these readings exceed the following levels:[3-6,3-7]

Alpha	5×10^3 pCi/g of gravel sample.
Beta	1×10^4 pCi/g of gravel sample.
Beryllium	500 µg/g of respirable particles of dust sample.

Swipe samples taken inside the bunker indicate that none of these materials have been detected inside the bunker since sampling began in 1965. Yearly whole-body counts and semi-annual bioassays of bunker personnel indicate only background radiation exposures.

At the present time, photographic processing liquid wastes are put into small containers at the facility. These containers are then transported to the 851 facility and the liquid poured into a retention tank. Hazardous Waste Management pumps the contents of this tank into a tank truck and hauls this waste to the Livermore Site for proper disposal. When plans are approved, the photo processing waste from Site 300 facilities will be released to surface impoundments at the 817 facility where the liquid will be evaporated.

Laser Safety

Laser equipment is installed and engineered to conform to Section 28 of the LLNL Health and Safety Manual. Special operational procedures are written and approved any time the operation does not meet the requirements of the LLNL Health and Safety Manual.

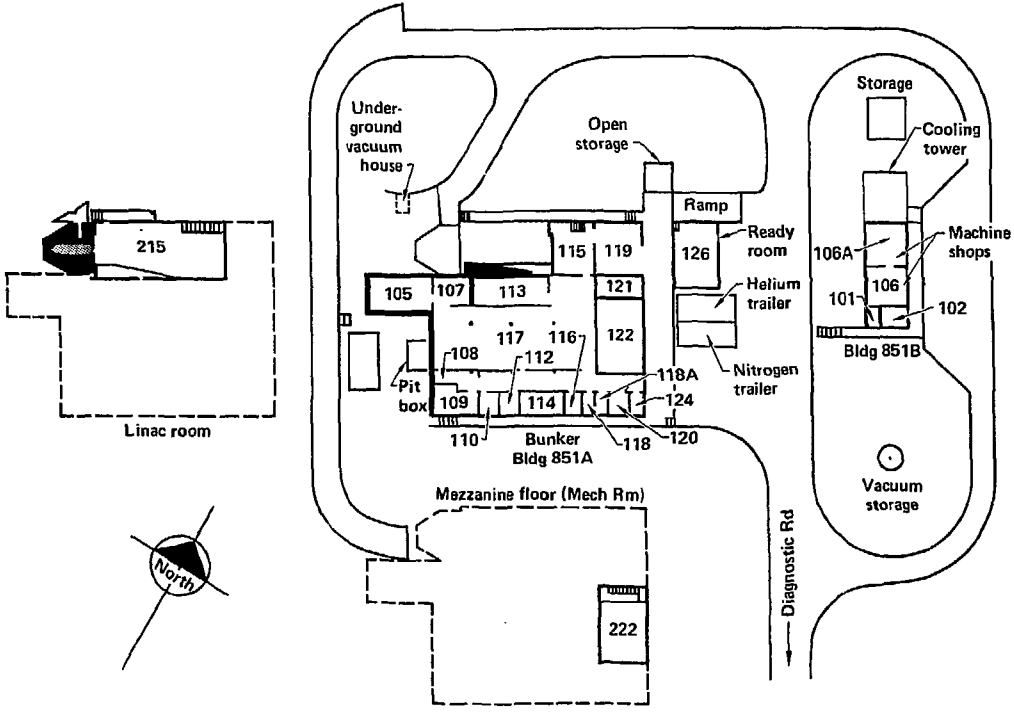

Fig. 3-1. Key plan of 851 Firing Facility.

Fig. 3-2. Top View of 851 Firing Facility

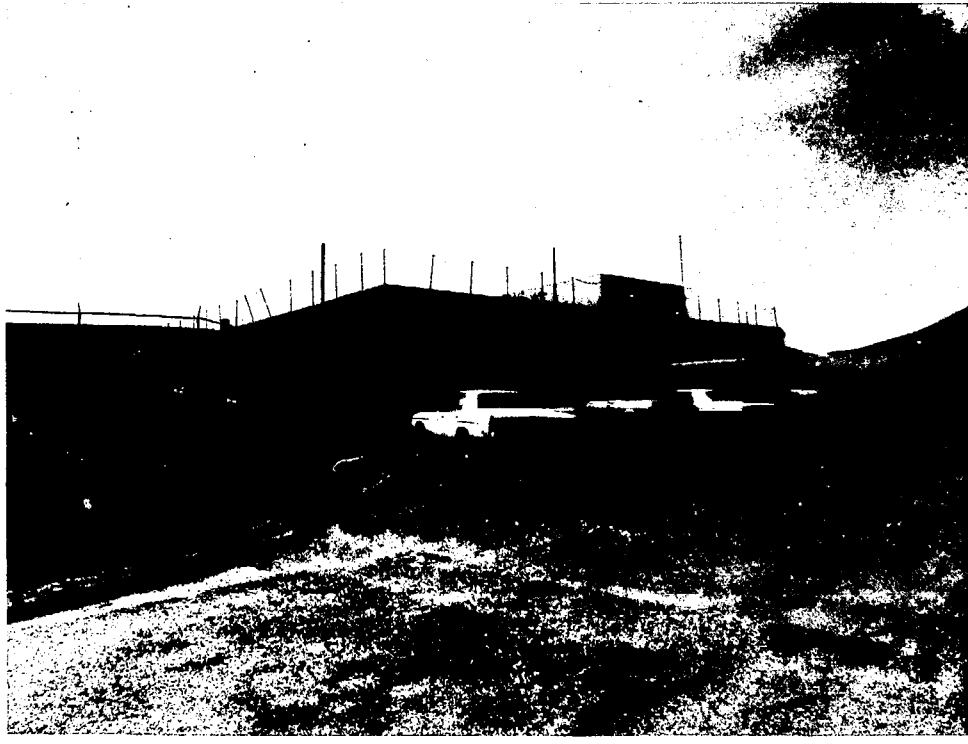

Fig. 3-3. Front view of Bunker 851.

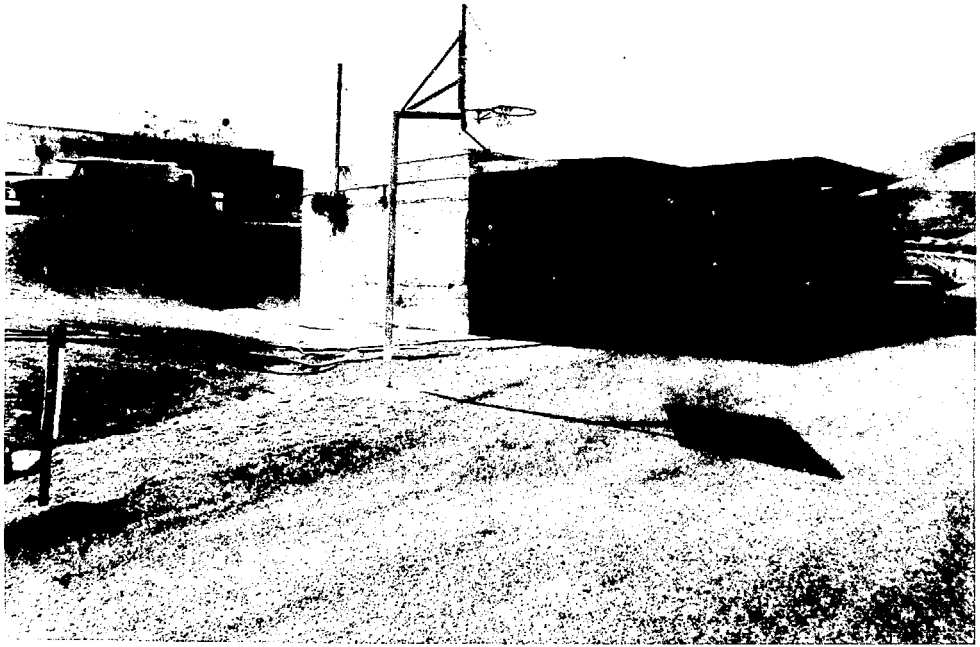

Fig. 3-4. Front view of Bunker 851 and Machine Shop.

Fig. 3-5. Interior view of high-speed camera room.

Fig. 3-6. Interior of Control Room showing Control Panels

Fig. 3-7 Interior of Control Room Showing Raster Cameras and Oscilloscopes

References

3-1 C. Baker and W. Shay, Bunker 851 Structural Calculations, 851 File in Plant Engineering at Site 300.

3-2 Site 300 Safety and Operational Manual.

3-3 DOE Explosives Safety Manual, DOE/EV/06194-3.

3-4 K. Ernst, Letter to J. T. Davis, Beryllium and Uranium in Air Results at Site 300, Pit 7, and the Issue of Daily Covers, November 10, 1983.

3-5 R. K. Yamamoto, Internal Memorandum to A. T. Harris, Beryllium Firing Table Survey, Building 851, November 23, 1983.

3-6 G. E. Williams, Letter to W. E. Keheley dated October 1977.

3-7 R. O. Campbell, A Study of Beryllium Exposures at a High Explosives Assembly Test Facility, Lawrence Radiation Laboratory Report UCRL-6166, February 1961.

References

2-1 Final Environmental Impact Statement Lawrence Livermore National Laboratory and Sandia National Laboratories, Livermore Sites, Livermore, California, U.S. Department of Energy Report DOE/EIS-0028, July 1982.

2-2 B. N. Odell, H. E. Pfeifer, and V. E. Arganbright, Blast Forecasting Guide for the Site 300 Meteorological Center, Lawrence Livermore National Laboratory Report UCID 17822, June 1, 1978.

2-3 H. E. Pfeifer, B. N. Odell, and V. E. Arganbright, "Noise-Abatement Method for Explosive Testing," American Industrial Hygiene Association Journal (41), September 1980.

2-4 K. Griggs, et al., "Environmental Monitoring at the Lawrence Livermore National Laboratory, 1985 Annual Report, Lawrence Livermore National Laboratory Report, UCRL-50027-85, February 1986.

SECTION 4 - DESCRIPTION OF OPERATIONS

General

This facility is used to photograph and x-ray various types, amounts, and configurations of explosive devices while they are in the process of detonating. The diagnostic equipment used includes pins and raster scopes, high-speed cameras, interferometers, and a linear accelerator. The pins, along with the raster scopes, provide quantitative data that can be utilized by a computer to help understand the behavior of the device during an explosion. Optics are used to show qualitatively what is happening to a device during an explosion. Lasers are used to align the turning mirrors, time a portion of the detonation, and provide light timing marks on the high speed camera film. Several high-speed cameras are aimed by way of turning mirrors at the various sides of the device. These cameras are synchronized so as to photograph whatever the physicist wants to see during a certain portion of the explosion. The camera synchronization signal is also used to trigger the start of the explosion, the lighting, and the operation of all the diagnostic equipment as well as the 100 MeV linear accelerator (which is used when a high-energy, deep-penetrating x-ray is required). This x-ray, taken during the explosion, provides a picture of the internal state of the device at a specific time during the detonation.

The Site 300 Firing Facilities Technicians Reference Handbook helps the experimenters in planning the test as well as the Bunker Supervisor in setting

up the equipment for these experiments. By using the same source material, many misunderstandings and costly, time-consuming mistakes are avoided. All operations meet the intent of the LLNL Health and Safety Manual, the Site 300 Safety and Operational Manual, and the DOE Explosives Safety Manual. Special Operational Safety Procedures (OSPs) must be written and approved for any operation that differs from these basic safety documents. The written safety procedures are appropriate for the operations conducted at this facility.

Shot Preparation Work on the Firing Table

Several people are required to accomplish the shot preparation work. The small crater produced by the previous detonation is dug out and back filled with fresh gravel. (The old gravel is sprayed with water to settle the dust before it is handled.) At times, the carpenters build a wood frame tent that is covered with plastic. This tent encloses the firing area to protect the experiment and diagnostics from weather. It keeps that area dark just prior to detonation so that the camera film isn't exposed to light prematurely. A fork lift is used to lift heavy items on the firing table. The bunker crew assists the Bunker Supervisor and physicist in setting up and connecting the various parts. Much of the work (except for final alignment and hose and cable connections) is accomplished before the explosives are placed on the firing table. Turning mirrors are positioned so that the experiment is reflected onto the lens of the high speed camera through viewing ports in the roof of the bunker. Electric cables are connected from various items on the firing table to other cables that are connected to equipment inside the bunker. (These cables transmit timing signals that synchronize the operation; i.e., start the

lighting, start the explosion, and destroy the turning mirrors thus preventing double exposures). Hoses are attached to argon lines for purging the candles with argon gas. (Candles consist of cardboard boxes that are filled with argon. An explosive charge is attached to the rear of each candle. The shock wave from the detonated explosive ionizes the argon, which creates a brilliant light to illuminate the experiment). These candles are positioned around the experiment. Some are positioned in holes dug in the gravel while others are taped to a wooden support structure so that they are above the equipment.

After everything on the firing table is aligned, one or more x-rays are taken prior to detonation to make sure that the shot is positioned correctly. The heavy cassette containing that film is moved away from the explosive by the portable crane so that the exposed film can be removed and new film inserted. The cassette is then repositioned behind the explosive. If these x-rays show that the explosives need to be moved slightly to get a better x-ray, the explosive, along with the turning mirrors, candles, cables, and hoses, may be repositioning.

During preshot work, there is much communication via microphones, speakers, intercoms, and portable radios between people on the firing table with people inside the bunker. A TV camera, mounted behind an earthen berm, views the firing table during shot preparation work. It is lowered prior to shot detonation. The TV monitor is located inside the Control Room.

Shot Preparation Work Inside the Bunker

A TV monitor, in the Control Room, allows the people inside the bunker to view the firing table during daylight hours. Prior to the shot, the bunker crew readies the various pieces of equipment for that critical time. The high-speed cameras are placed in position, film is installed in the various cameras, the computer is readied for operation, lasers are aligned, and the linear accelerator goes through a dry run. Before the accelerator can be operated, a muster is called per the Site 300 Safety and Operations Manual. Thus, people in the muster area are accounted for. Local and area musters will be described later in this section. X-rays of the explosives taken prior to detonation are developed by the radiographer in the dark room. After the shot, various films and x-rays are developed in the dark room.

Operations External to Bunker 851

Muster Control System

Procedure No. 300 in the Site 300 Safety and Operational Manual describes the special badging of all personnel entering the firing area, how all personnel in the area are accounted for including the movement of personnel from one location to another, and how to call a local or area muster. It also discusses how the Control Point (CP) Operator gives final permission to fire after he has been assured that all personnel in the firing area are under cover and accounted for.

Lightning Alert System

Procedure No. 102 of the Site 300 Safety and Operational Manual describes how lightning alerts are called and the action to be taken when the lightning warning system indicates that atmospheric conditions are conducive to the generation of lightning. The lightning alert system is normally exercised several times a year.

Blast Forecasting System

The Site 300 Meteorology Center determines the maximum amount of explosives that can be detonated within specific time frames without exceeding the off-site overpressure limits previously established by the Laboratory.[4-1, 4-2]

References

4-1 B. N. Odell, H. E. Pfeifer, and V. E. Arganbright, Blast Forecasting Guide for the Site 300 Meteorology Center, Lawrence Livermore Laboratory, Livermore, California, Report No. UCID-17822 (1978).

4-2 H. E. Pfeifer, B. N. Odell, and V. E. Arganbright, "Noise-Abatement Method for Explosives Testing," American Industrial Hygiene Journal (41), September 1980.

SECTION 5 - RISK ASSESSMENT

The information contained in Sections 1 through 4 of this document provides the foundation for this risk assessment. Of special concern were the risks associated with an explosives detonation. These risks are low due to the combination of physical and multiple administrative controls that are discussed in Section 3 under "Explosives Safety" and in Section 4 under "Muster Control System".

The various hazards associated with acts of nature and human error have been summarized in Tables 5-1 and 5-2. Low hazards are those that present minor on-site and negligible off-site impacts to people and the environment. Moderate hazards are those that present considerable potential for major on-site impacts but, at most, only minor off-site impacts. High hazards are those with the potential for major on-site and off-site impacts to people, facilities, equipment, and/or the environment.

All but two of the hazards are classified as low per DOE Order 5481.1A. The exceptions are the intrinsic hazards associated with the handling of explosives and operating the linear accelerator. Physical sweeps of the radiation area, secured gates, and radiation interlocks reduce risks of operating the linear accelerator to an acceptable level. Even though an accidental detonation is not likely to occur, it could result in major damage to the equipment on and around

the firing table and possibly injuries or fatalities. Thus, there might be considerable on-site impact from a detonation with only a minor off-site impact to the environment. Therefore, Firing Facility 851 is classified as a moderate hazard facility per this analysis and the guidance provided by DOE Order 5481.1A.

Table 5-1. Hazards Related to the 851 Firing Facility

Hazard	Hazard Level Per DOE Order 5481.1A
Fire	*
Chemicals (film processing)	Low
High Voltage	*
Industrial (tools, falls, etc)	*
Lasers (Class IV)	Low
X-ray Radiation (linear accelerator)	Moderate
Beryllium	Low
Depleted Uranium	Low
Noise (result of detonation)	Low
Explosives	Moderate
Acts of Nature (earthquake, flood, etc.)	*

* Hazards are of a type or magnitude routinely encountered and/or accepted by the public.

Table 5-2

Summary of Safety Evaluation for the 851 Firing Facility

Potential Hazard	Consequences of Failure Mitigating Features	of Mitigating Features
Fire	Automatic sprinklers and fire detection. Concrete buildings are fire resistant. Portable fire extinguishers and water hoses readily available; bunker crew ex-perienced in putting out fires on firing table. Site perimeter disked and/or burned on north, east, and south sides to stop or prevent plant growth. Fire Department annually performs controlled burns of grass around active firing areas. Site 300 Resident Manager suspends explosive testing when fire conditions are critical.	Damage to equipment and buildings as well as personnel hazard, including uncontrolled grass fires. Most probable fire loss less than $250,000.
Chemicals (film processing)	Film processor vented to outside; eyewash, personal protective equipment, administrative controls.	Personnel hazard.
High Voltage	Design conforms to DOE and LLNL Standards; National Electric Code. Interlocks. Isolated and insulated power supplies, cabling, and related equipment. Total enclosure. Automatic grounding. Administrative controls.	Damage to equipment. Personnel hazard.

Table 5-2

Summary of Safety Evaluation for the 851 Firing Facility

Potential Hazard	Consequences of Failure Mitigating Features	of Mitigating Features
Laser Beams	Enclosed beam. Low-power alignment. Controlled access to laser area by door warning lights and administrative controls. Operations to conform to either LLNL Health and Safety Manual Section 28 or to Operational Safety Procedures.	Personnel hazard. (Loss of sight, burns, electric shock)
X-rays	Restricted Entry Time (RET) procedures that include physical survey of the area before the 100 MeV x-ray machine is turned on. Fences and gates enclose area for local muster.	Personnel exposure to non-ionizing radiation.
Beryllium and depleted uranium (dispersed upon detonation)	Bunker crew dons respirators and booties before ascending to firing table after a shot. HEPA filters installed in air intake system to Bunker. Firing table is monitored monthly, and interior of bunker is monitored weekly for alpha, beta, and beryllium content. Gravel is changed whenever alpha exceed 5×10^{3} pCi/g, beta exceeds 1×10^{4} pCi/g, and/or beryllium exceeds 500 µg/g of dust.	Personnel exposure to very low radiation and beryllium lung doses.
Noise/ Overpressure (off-site)	Site 300 Meteorology Center determines maximum amount of explosives that can be detonated without causing excessive overpressures in surrounding communities.	Excessive noise and minor property damage off-site.

Table 5-2

Summary of Safety Evaluation for the 851 Firing Facility

Potential Hazard	Consequences of Failure Mitigating Features	of Mitigating Features
Explosives	Muster system that keeps track of all personnel in area as well as closing of gates that restrict access to areas prior to planned detonation. Personnel trained in explosives handling. Facilities constructed to withstand explosives detona-tion. Lightning alert system.	Personnel injured and/or killed and equipment damaged or destroyed.
Acts of Nature (Earthquake, Extreme Wind, Missile, Flood, Lightning)	Mechanical, electrical, and research equipment as well as cabinets are secured in accordance with LLNL seismic tie-down standards. Bunker designed to withstand detonation of explosives on firing table. Other facilities continually withstand overpressures and missiles produces by these detonations. Facility located over 250 m above Corral Hollow Creek. Lightning alert system is exer-cised several times a year.	Equipment damage and personnel injured by accidental detonation of explosives.

APPENDIX A

Interdepartmental letterhead

Mail Station L- 383

Ext: 2-5141

February 19, 1986

TO: Byron N. Odell

FROM: T. A. Gibson T. A. G.

SUBJECT: Uranium Lung Dose and Whole-Body Equivalent Dose From Uranium Plus High Explosives Shots

Per your request is attached the lung dose and whole-body equivalent doses following a 35 kilogram (0.01 curie) uranium-238 with 200 pounds of high explosives experiment. The Hot Spot Health Physics Code "EXPLUME" by Steven G. Homann found in LLNL M-161 dated April 1985 was used to generate the dose at various downwind distances.

As you see from the attached printout, we used the following input parameters: atmospheric stability - Category D, wind speed - one meter per second, and 5% of the uranium involved taken to be in the respirable range (this labeled "release fraction" on the printout). These are reasonable and typical conditions and assumptions. The maximum lung dose is seen to be 6 millirem at 0.5 kilometers downwind.

TAG:sh
TAG860219

Attachment

cc: Date File

University of California
Lawrence Livermore National Laboratory

LS

EXPLUME

4/85
U-238: 1.00-02 CURIE
INHALATION CLASS: Y
RELEASE FRAC.= 5.9000-02

STABILITY = D
WIND SPEED = 1.0 M/S
HIGH EXPLOSIVE:200.0 LB
CLOUD TOP= 206 M
CLOUD RADIUS= 26 M

D=0.1 KM
50-YR DOSE COMMITMENT:

LUNG******** 220.-06 REM
EQUIVALENT
WHOLE-BODY** 28.3-06 REM

D=0.2 KM
50-YR DOSE COMMITMENT:

LUNG******** 3.33-03 REM
EQUIVALENT
WHOLE-BODY** 309.-06 REM

D=0.5 KM
50-YR DOSE COMMITMENT:

LUNG******** 6.26-03 REM
EQUIVALENT
WHOLE-BODY** 589.-06 REM

D=1.0 KM
50-YR DOSE COMMITMENT:

LUNG******** 3.59-03 REM
EQUIVALENT
WHOLE-BODY** 333.-06 REM

D=2.0 KM
50-YR DOSE COMMITMENT:

LUNG******** 1.92-03 REM
EQUIVALENT
WHOLE-BODY** 178.-06 REM

D=5.0 KM
50-YR DOSE COMMITMENT:

LUNG******** 1.02-03 REM
EQUIVALENT
WHOLE-BODY** 94.6-06 REM

D=10.0 KM
50-YR DOSE COMMITMENT:

LUNG******** 516.-06 REM
EQUIVALENT
WHOLE-BODY** 47.7-06 REM

D=20.0 KM
50-YR DOSE COMMITMENT:

LUNG******** 267.-06 REM
EQUIVALENT
WHOLE-BODY** 24.7-06 REM

SAFETY ANALYSIS REVIEW SYSTEM DOCUMENTATION FORM

This form records the safety analysis review process required by DOE 5481.1A

1. SAFETY ANALYSIS DOCUMENT TITLE AND DATE: Safety Analysis of the Existing 851 Firing Facility

2. THIS DOCUMENT DESCRIBES:

☐ NEW FACILITY ☒ EXISTING FACILITY ☐ ENTIRE PROGRAM

☐ MAJOR MODIFICATION

3. DOE 5481.1A HAZARD CLASSIFICATION

☐ HIGH ☒ MODERATE ☐ LOW ☐ EXCLUDED

4. CONTRACTOR LLNL

☐ Approval of Safety Documents

☐ Authorization to Operate New/Modified Facility

Reviewed by: Robert O. Godwin
Acting Associate Director for Administration

Date

Approved by: Harry Vantine
Deputy Associate Director for Nuclear Design, Acting

Date

5. FIELD OFFICE SAN

☒ Concurrence with Attached Safety Documents

☐ Authorization to Operate New/Modified Facility

Reviewed by:

Date

Line Program Official

June 23, 1986
Date

6. HQ PROGRAM OFFICE

☐ Concurrence with Attached Safety Documents

☐ Authorization to Operate New/Modified Facility

Reviewed by:

Line Program Official

Date