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LLNL-TR-411554

Tier-2 Safety Basis Document Building 327

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Change Control Form for Safety Basis Documents

Facility name/number: B327	Change Control Form number: B327-2008-01 Date: August 22, 2008
Preparer's name/ ~~Signature~~: Stanley Fong	Telephone ext: 3-3252
Current classification of facility (check): ☐ LSI ☐ Low ☒ Moderate ☐ High hazard	Current classification of hazard type to be evaluated (check): ☐ LSI ☐ Low ☒ Moderate ☐ High hazard

Describe the proposed change (or other change control entry condition):

Two proposed changes are covered in this form:

#1 - Explosive Hazard Classification

The first proposed change involves the re-categorization of the B327 explosive hazard classification in accordance with the Blue Sheet approved August 16, 2007. This re-categorization reduces the facility classification from Moderate Hazard to Low Hazard. There are no actual changes in authorized operations or inventories involving explosives because those are limited, independent of the SBD requirements, to protect against personnel injury and property damage.

#2 - Update of Facility Description and Operations

The facility drawings in Appendix A are updated to the current revisions.

Step 1 -Check the change control entry condition (i.e: proposed change or discovered condition) that applies.

☐ A proposed change in inventory or operations beyond that authorized in existing SBD.

☐ The discovery that previous analyses were inadequate (e.g., a potential hazard was discovered but not identified or was incorrectly analyzed in the SBE document).

☐ A modification to the safety function of a credited control.

☒ A change in the Work Smart Standard for the safety analysis of non-nuclear facilities or table entries upon which the analysis process is based in the various standards (DOE-S-1027, 40 CFR 302.4, TEEL tables, QD constants, BSL definitions).

☒ The facility hazard classification is being reduced.

If none of these apply, a Change Control Form is not required.

CCF, Rev. 3
12/17/04

Step 2 - Classification Questions

A. Does the entry condition exceed the facility's current classification?

☐ Yes ☒ No

B. Does the entry condition exceed the current classification of the hazard type to be evaluated?

☐ Yes ☒ No

C. Is the facility classification being reduced?

☒ Yes ☐ No

For facilities classified as LSI, go to Step 3.

For facilities classified as Low, Moderate, or High: If Step 2C is marked "Yes", submit this form to original signature authority for approval of facility classification downgrade (Step 7). Prepare and attach new or modified SBD, as required. **If 2C is marked "No", skip to Step 5.**

Step 3 - For LSI facilities:

If answers to all questions in Step 2 are "No", form complete. Go to Step 4.

If Step 2A or 2B is marked "Yes", check one of the following options:

☐ 1. Revise entry condition to meet LSI classification, add new hazard to screening form and go to Step 4.

☐ 2. Update screening form and complete Tier 2 SBD, and perhaps Tier 3 SBD, as required per the Analysis Level Matrix. Also submit this form for approval - Step 4. (NOTE: proposed change cannot be implemented until new SBD is approved)

If Step 2C is marked "Yes", submit this form to original signature authority for approval of facility classification downgrade (Step 4). Add facility to Directorate Office listing.

Step 4. Submit form to facility management for approval.

Facility Management's Name/Title:

____

Signature:______________________________ **Date:** ______

Telephone ext: ______________ **L-code:** __________

This form shall be maintained in file with facility SBD.

Step 7. Submit for approval.

Preparer signature: [signature] **Date:** 8/25/08

ESH&Q Team Leader (or Designee) [signature] FOR T SIMPSON **Date:** 8/2?/08

SB Division Leader (or Designee) David Rinkstra **Date:** 8/29/08

Facility Management Designee Paul K. Deon **Date:** 9-03-08

AD Signature Monya Lane **Date:** 9-16-08

If higher level authority required (per Risk Analysis Matrix):

Name/Title:____________________

Signature:____________________ **Date:**________

Name/Title:____________________

Signature:____________________ **Date:**________

TIER-2 SAFETY BASIS DOCUMENT
BUILDING 327

Prepared by

LLNL Engineering Directorate

Revision 1
September 2008

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Acting Associate Director
LLNL Engineering Directorate

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1.0 Screening Report

LLNL Facility Screening Report (SCR) for B327 (Facility Name)	
Lead Preparer: Stanley Fong	Date Performed: September 2008
Facility Description	
Briefly describe facility use, physical structure, location and attach a building layout: The Nondestructive Evaluation (NDE) Facility, B327, is operated by the Engineering Technologies Division of the Engineering Department and is located near the midpoint of the Laboratory main site between the SE and SW quadrants. It is over 600 meters from the Western site boundary. B327 is of steel frame, reinforced concrete construction, two stories tall (second floor office space), and has two basement floors (see Appendix A). The primary function of this facility is to apply NDE methods to materials, components, and assemblies. Magnetic particles, dye penetrant, ultrasonics, radiography, eddy current, infrared imaging, visual, and X-ray computed tomography are examples of NDE capabilities performed in the facility. The facility supports LLNL programs at the main site, Site 300, the Nevada Test Site, the Tonopah Test Range, other DOE laboratories such as the LBNL, and other non-DOE organizations.	
Define facility type: Check: ☒ Single Structure or Area: (B/Tr/A) B327 ☐ Complex of Buildings: Designation ______ ☐ Segment* of Bldg or Complex: _____ Seg.# _____ *Attach justification for segmentation	**Owner Organization:** Directorate: Engineering Facility AD: Monya Lane
Final Facility Classification: (Check) ☐ LSI ☒ Low ☐ Moderate ☐ High ☐ Nuclear Facility ☐ Accelerator	
Concurrence Signatures for Facility Classified as LSI:** Lead Preparer :______________________ Date: __________ Safety Basis Division Leader or designee: ______________ Date: __________ ES&H Team Leader or designee: ______________ Date: __________	
Approval Signature for Facility Classified as LSI:** Facility Management: ______________ Date: __________	

Supporting Documentation Appended	**Comments:**
Check as appropriate: ☐ Justification for Segmentation ☐ Chemical Hazard List ☒ Radiological Hazard List ☒ Explosive Hazard List ☒ Building Layout ** Signatures are not required on this form for facilities classified as Low, Moderate or High. Approval signatures for these are on the cover of the Tier 2 or Tier 3 SBDs.	– See Section 1.1 for Explosive Hazard List – See Table 1.2 of Section 1.2 for Sum of Ratios of Radionuclides – Building Layout is provided in Appendix A.

Identification of Operations, Inventories, and Hazards

List key operations that are conducted within the facility:

The primary activities performed in this facility are associated with the development and application of NDE methods for the inspection and characterization of materials, components, and assemblies. The activities and operations include the receipt and handling of hazardous and or radioactive materials, maintenance and operation of radiation-generating devices (RGDs), and use of sealed sources, film-processing equipment, ultrasonic and acoustic test equipment, infrared imaging equipment, dye penetrant and magnetic particle equipment, eddy current equipment, visual inspection equipment, support equipment, and related systems.

Did Facility Management receive any notifications of credible external threats from nearby facilities? yes ☒ no ☐

If yes, list the following for each notification:

Source Facility:	Facility Contact(s):	Phone # (s):
B332, Plutonium Facility	Roger R. Rocha	925-423-1743

Describe Hazard(s):

(1) General hazard potential for radiological releases during accident conditions that could entail shelter in place or evacuation. (2) Large Cryogenic liquid nitrogen (60,750-lbs.) and argon (34,950-lbs.) tanks are located to the West side of the Plutonium Facility. Releases from this facility will not adversely affect safe operations in B327.

Hazard Identification Table

Check the hazard types found in the facility.

Not Found	Found		
☐	☒	Biological Hazards	Complete block I, below
☐	☒	Chemical Hazards	Complete block II, below
☐	☒	Explosive Hazards	Complete block III, below
☐	☒	Radiological Hazards	Complete block IV, below
☐	☒	Industrial Hazards	Complete block V, below

I. Biological Hazards

Check — BioHazard Type

☒ **Non-Select Agents**

Check highest group in facility:

- ☐ RG1 Agents
- ☒ RG2 Agents
- ☐ RG3 Agents

☐ **Select Agents**

Select highest group in facility:

- ☐ RG1 Agents
- ☐ RG2 Agents
- ☐ RG3 Agents

☒ Other BioHazards (e.g., nucleic acid, lab animals, contaminated needles/sharps, animal/human tissues & fluids)

☐ Materials covered under OSH Bloodborne Pathogens Standard – 29 CFR 1910.1030**Applicable Control Level for Biohazards**

Check highest Biological Safety Level (BSL) in facility, as applicable:

☐ BSL-1 ☒ BSL-2 ☐ BSL-3 and/or
☐ Bloodborne Pathogens Standard (Note: AB classification = LSI)

II. Chemical Hazards

Check — ChemHazard Type

- ☒ Flammable, volatile or fuming
- ☒ Toxic materials (acutely toxic, toxic, systemic toxin, toxic gases)
- ☒ Corrosives/irritants
- ☒ Reactive materials (e.g., air/water sensitive; pyrophoric; thermally, shock, or friction sensitive; perchlorate)
- ☒ Carcinogens, mutagens, reproductive hazards
- ☒ Pesticides
- ☒ Beryllium
- ☒ Materials of special concern (e.g., alkali metals, fluorine, asbestos, lead, mercury, PCB)
- ☒ Other regulated metals (e.g., chromium, copper, nickel, zinc)
- ☐ Other:______

Do any chemicals exceed LSI classification?

☐ YES ☒ NO

For chemicals that exceed LSI classification, attach maximally planned chemical inventory listing.

III. Explosive Hazards

Check

☒ Primary High Explosives
☒ Secondary High Explosives
☒ Propellants/Low Explosives
☐ Firearms Ammunition

Do any of the explosive types checked above have any of the following associated hazards?

☐ Fragmentation Hazards (Primary Fragments)
☐ Group L Explosives

Attach maximally planned inventory listing for each explosive type checked.

IV. Radiological Hazards

Check **Sum of Ratio**

☒ <1 of RQ thresholds (40 CFR 302.4 Appendix B)
☐ >1 of RQ thresholds < Cat. 3 Thresholds (DOE-STD-1027-92, Table A.1)
☐ >Cat. 3 Thresholds (DOE-STD-1027-92, Table A.1) < Cat. 2 Thresholds (DOE-STD-1027-92, Table A.1)

Does facility contain the following?

Radiation Generating Devices:

☒ Radiation generating devices not covered by DOE O 420.2B (e.g., X-rays, Electron Beams, Radiography Equipment): class <u>III, IV</u>
☐ Radiation generating devices covered by DOE O 420.2B (Accelerators).

Exempted materials:

☐ Radioactive Certified Sealed Sources
☐ Rad. In Type B Containers with current certificates of compliance

☐ Either in quantities>Cat. 3 thresholds (DOE-STD-1027-92, Table A.1)

Attach listing of maximally planned radiological materials inventory.

V. Industrial Hazards

Check if hazard present	**Industrial Hazard**	**Examples of industrial hazard(s) for each general category. (Select Industrial Hazards found.)**	**List industrial hazard(s) that could directly impact the public (fence-line) or co-located worker (100 m).**
☒	Electrical	☐ Battery banks, ☒ Cable runs, ☐ Diesel generators, ☒ Electrical equipment, ☒ Heaters, ☐ High voltage (> 600V), ☒ Motors, ☒ Power tools, ☒ Pumps, ☒ Service outlets, ☐ Fittings, ☐ Switchgear, ☒ Transformers, ☒ Capacitors, ☒ Magnetic fields, ☐ Transmission lines, ☒ Wiring/underground wiring, ☐ Other:______.	None that will impact the public or collocated workers.
☒	Thermal	☐ Boilers, ☐ Bunsen burner/hot plates, ☒ Electrical equipment, ☒ Electrical wiring, ☐ Engine exhaust, ☐ Furnaces, ☒ Heaters, ☒ Lasers, ☐ Steam lines, ☐ Welding surfaces, ☒ Welding torch, ☐ other:______	None

☒	Kinetic	☒ Acceleration/deceleration, ☒ Bearings, ☐ Belts, ☒ Carts/dollies, ☐ Centrifuges, ☒ Crane loads (in motion), ☒ Drills, ☒ Fans, ☒ Firearm ☐ Discharge, ☒ Fork lifts, ☐ Gears, ☒ Grinders, ☒ Motors, ☒ Power tools, ☐ Presses/shears, ☒ Saws, ☒ Vehicles, ☒ Airplane, ☐ Vibration, ☐ Other:______	None
☒	Potential (pressure)	☐ Autoclaves, ☐ Boilers, ☐ Coiled springs, ☐ Furnaces, ☒ Gas bottles, ☐ Gas receivers, ☐ Pressure vessels, ☐ Vacuum vessels, ☒ Pressurized system (e.g., air), ☐ Steam header and lines, ☐ Stressed members, ☐ Other:______	None
☒	Potential (height/mass)	☒ Cranes/hoists, ☐ Elevated doors, ☐ Elevated work surfaces, ☒ Elevators, ☐ Lifts, ☐ Loading docks, ☒ Mezzanines, ☐ Floor pits, ☒ Scaffolds and ladders, ☐ Stacked material, ☒ Stairs, ☐ Other:______	None
☒	Internal Flooding Sources	☒ Domestic water, ☒ Fire suppression piping, ☒ Process water, ☐ Other: _____	None

Hazard Classification	
Select the appropriate hazard level from the dropdown menu:	
Biological	**LSI**
Chemical	**LSI**
Explosive	**Low**
Radiological materials	**LSI**
Radiation generators	**LSI**
Industrial	**LSI**

Controls for LSI classified facilities: (Low, Moderate and High facility controls are addressed in Tier 2 or Tier 3 SBDs.)

Briefly describe controls developed to assure that facility operations do not exceed the facility classification:

LSI Controls are as follows:

1. Chemical inventories are controlled to less than or equal to the LSI Q-list values.
2. Biological operations research allowed are limited to conform with BSL-1 or BSL-2 classification.
3. Industrial hazards are controlled using the applicable documents in the ES&H Manual.
4. Radionuclide inventories are controlled to less than their Radiological Threshold (RQ) values in 40 CFR 302.4 (Ref. 2) for each radionuclide; the sum of the mass present divided by the threshold mass for each radionuclide is controlled to <1.
5. Radiation generating devices used in the facility meet the LSI criteria in ES&H Manual Document 3.1 and are not of the type covered by DOE O 420.2B.

<table>
<tr><td>Other controls?
Briefly describe:

The operational explosive inventory limits adhered to in the facility are based on Table 1.1 and the associated footnotes. These limits, which are designed to protect against personnel injury and property damage, are more restrictive than the safety basis explosive inventory limits, which are based on the "Low" explosive hazard classification and designed to protect against injuries to the co-located worker and public.</td></tr>
<tr><td>List what document(s) through which the controls will be implemented:

All Controls are documented within the Facility Safety Plan and IWS/SPs and carried down to procedures, where appropriate.</td></tr>
</table>

1.1 B327 Explosives Hazards List

In accordance with the classification criteria in ES&H Manual Document 3.1 (Ref. 1), B327 is classified as Low explosive hazard facility. B327 further restricts explosives operations only in the basement and sub-basement areas of B327 and the inventory of explosives to levels below those specified in the classification criteria in order to provide additional protection against personnel injury and property damage. These operational and inventory restrictions are beyond the requirements of ES&H Manual Document 3.1 and do not constitute operational safety requirements (OSRs). The facility/room limits for explosives (i.e., type, quantity, and location) are presented in Table 1.1 and as follows:

The mass limits of 125 grams (net explosives weight) are authorized for TATB based explosives and are allowed if and only if insensitive TATB explosives are NDEd in B169F, B169H, and B273A. There shall be no more than 125 grams of TATB based explosive in the facility at any one time. In addition, the 125 grams of TATB material shall not be stored in B327. After completion of testing, it shall be removed from the facility as soon as possible. When the 125 gram quantity is in the facility, all other explosive materials must be stored in approved containers or in the repository.

The mass limit authorized for the total of all other explosives (1.1D and 1.3C) present in B327 at any one time is 50 grams (net explosive weight).

> **Note:** Explosives classed as 1.4S in approved containers or in a closed drawer approved repository do not count toward this limit. If removed from its packaging, a 1.4S explosive is no longer classed as 1.4S and the inventory must be included in the summation.

The mass limits authorized for single samples of TATB based explosives and all other explosives (1.1D and 1.3C) in B327 are 125 grams and 10 grams (net explosive weight), respectively.

Table 1.1 Locations of Explosives Operations in B327

Room	Net Explosives Weight (Grams)		Referenced Explosives Safety Basis
	TATB- Based Explosives Only[b,c]	**Other types (1.1D, 1.3C & 1.4S Only)[c]**	Author, Subject, Date issued
B100A	Room Capacity[c]	Room Capacity[c]	(Note: Only 1.4S material is allowed in this room)
B169F	125	10	C. Baker, B-327 Room B169F Blast Pressure Analysis-150g TNT, July 1, 1976 (Ref. 6)
B169H	125	10	J. Dotts, Hazards Analysis for B-327 Room B169H, February 5, 1999 (Ref. 7)
B171B	10	10	C.W. Ma, Overpressure analysis for 10 g PETN, B-327, Room B171B, December, 2000 (Ref. 8)
B271K	10	10	C.W. Ma, Overpressure analysis for 10 g PETN, B-327, Room B171B, December, 2000 (by analogy) (Ref. 8)
Z-Cave in B271K	50	10	C.W. Ma, B-327, Overpressure analysis for 50 g of LX-17 or TATB for the Z-Cave in Room B271K, August 16, 2000 (Ref. 9)
Metal 4-Drawer Fire Safe Repository in B271K	50[a]	50[a]	L. Crouch and J. E. Dotts, *Report on Explosives Repository Testing*, January 31, 2001 and H. Hornig, *Containment of Explosions in a Repository,* UCID-19219, April 10, 1981 (Ref. 10, 12)
B273A	125	10	Dotts, J., *B-327 Room B273A for operations with 125 g TATB,* 12/11/2000 (Ref. 11)
B169	10	10	LLNL explosives safety guidelines (Ref. 3, 4)
Total Facility Allowable	125	50 [d]	(Note: There shall be no more than 125 g of TATB and 50 g of other types of explosives in the facility at any one time.)

[a] Limit per drawer, with 10 g in each segment. Explosives are configured in a 10-gram non-propagating array.

[b] TATB is an insensitive high explosive (IHE) as such it is not subject to the normal initiation hazards of friction, electrostatic discharge (ESD) or impact.

[c] For 1.4S material only, there is no limit except that the physical capacity of the room defines the limit for the DOT containers.

[d] When the 125 g TATB explosive is in the bldg., all other explosive materials must be stored in approved containers or in the Fire Safe Repository.

1.2 Radionuclide Inventory for B327

An average or typical radionuclide inventory for the facility is given in Table 1.2, based on a July 2008 inventory snapshot. The radionuclide inventory of the building normally includes about 95 kg of depleted uranium and 0.13 kg of natural uranium. Sealed sources are not excluded from this inventory. Based on these results, the facility is a Light Science and Industry (LSI) facility for the hazard classification of the radiological hazard type.

The maximum inventory of radiological materials in B327 must be less than their Radiological Threshold (RQ) quantities defined in 40 CFR 302.4 (Ref. 2) and the sum of their ratios to the RQs must be <1.

Table 1.2 Typical Sum of Ratios of Radionuclides in B327 to their General Industry Reportable Quantities (RQs) from 40 CFR 302.4 Appendix B

Nuclide	Room	Type /Class	Serial #	Source Activity (Ci)*	40 CFR 302.4 App. B Radiological Threshold (RQ) (Ci)*	Ratio: Source/ Radiological Threshold	LSI Facility?
Sr90	B170J	B/2	100013	3.30E-05	1.00E-01	3.30E-04	Yes
Cs137	B170J	G/3	200502	7.71E-04	1.00E+00	7.71E-04	Yes
Co60	B200	B/3	200610	7.75E-05	1.00E+01	7.75E-06	Yes
Co60	B200	B/3	200611	7.53E-05	1.00E+01	7.53E-06	Yes
Ho166	B200	B/4	300906	2.86E-03	1.00E+02	2.86E-05	Yes
Ho166	B200	B/4	300913	1.41E-03	1.00E+02	1.41E-05	Yes
Am241	B200	G/1	300445	4.75E-06	1.00E-02	4.75E-04	Yes
Depleted uranium	any	NA	NA	95 kg	248 kg	3.83E-01	Yes
Natural uranium	any	NA	NA	0.13 kg	144 kg	9.03E-04	Yes
					Sum of the Ratios:	**3.86E-01**	**Yes**

If the sum of the ratios as shown above, is less than one, the facility may be classified as LSI with respect to radionuclide inventory for Safety Basis purposes.

2.0 Hazard Analysis

This chapter documents a brief hazards analysis, consistent with the provisions of ES&H Manual Document 3.1 (Ref. 1), for those hazards classified above the LSI level. One hazard was classified in Chapter 1.0 as Low: explosives.

The operations examined are simple enough that all controls assumed for ranking in the Analysis Level Matrix are specified up front as initial conditions. Boldface italics on the hazard analysis tables further denote these controls. Other controls listed, while relevant to safe operation in varying degrees, were not considered in ranking.

2.1 EXPLOSIVES

All operations with explosives are conducted according to the requirements of Document 17.1, "Explosives" in the ES&H Manual and applicable sections of the DOE Explosives Safety Manual. These requirements are addressed in the Facility Safety Plan (FSP) that designates the building areas where handling and NDE of explosives materials can be conducted. Explosives operations are conducted only in the basement and sub-basement areas of B327. The designated areas in B327 for NDE explosives handling or storage are rooms B100A, B169, B169F, B169H, B171B, B271K, B271K Z-cave, and B273A. Explosives assembly of R&D models, if conducted in a non-production research or test area or facility, is exempted from the OSHA definition of an explosives manufacturing facility. An explosives manufacturing facility would fall within the Process Safety Management regulations. In B327 explosives are not mixed, blended, extruded, synthesized, assembled, disassembled, or involved in activities such as making a chemical compound, mixture, or device that is intended to explode. Thus B327 is not an explosives manufacturing facility as described in 29CFR1910.119 (Ref. 5).

Trained explosives handlers are responsible for ensuring that the NDE is conducted in rooms authorized for the quantity and type of explosives material undergoing NDE. All explosives are moved in and out of the building under Materials Management controls. Explosives not in use are stored either in a locked fire-safe 4-drawer repository located in Room B271K, or in a DOT shipping container as United Nations Organization (UNO) Hazard/Class Division 1.4S in Room B100A. Procedures and requirements for safe explosives operations are specified in detail in the FSP, Integration Worksheet/Safety Plans (IWS/SPs), and other documents.

2.1.1 Controls

Initial conditions assumed in assessing explosive hazards are based on the ES&H Manual Document 3.1 Low hazard classification criteria as follows:

The total building inventory shall not exceed 5,000 grams for all types of explosives except for UNO 1.4S materials meeting the conditions stated below. The maximum credible event shall be limited to:

- 10 grams of primary high explosives;
- 350 grams of secondary high explosives that are classified as UNO Hazard Class/Division 1.1, 1.5, and 1.6;
- 5,000 grams of UNO Hazard Class/Division 1.3 and 1.4 materials (except UNO 1.4S materials are allowed unlimited quantities if they are placed in segregated and specifically designated areas;
- no UNO 1.2 materials are allowed

The maximum credible event where explosives of different types or hazard classes are located with one another shall be limited to the lowest mass limit shown above. For example, if UNO 1.1 secondary explosives and UNO 1.3 explosives are located together, the amount of explosives present must be limited to 350 grams total of both materials.

Room inventories shall be managed such that the minimum inventory consistent with efficient operations is maintained and the DOE Explosives Safety Manual 3M rule is observed.

2.1.2 Postulated Hazardous Events

The quantity of explosive material in B327 is transient. The mass limits prescribed in Section 1.1, the explosives handling procedures described in the FSP in accordance with the ES&H Manual (Ref. 3) and the DOE Explosives Safety Manual (Ref. 4) are designed to limit personnel injury and property damage. The worst-case consequences (explosion of 125 g of TATB in Room B169F or B169H) have the potential to cause worker injury on the basement floor of occurrence (Dotts, Ref. 7).The mass limits prescribed in Section 2.1.1 for a Low explosives hazards classification are designed to ensure that there are no impacts to co-located workers and the public, which are the receptors of concern for this analysis.

Table 2.1 Explosives Scenario

Event EXS-1: Explosives in a room are initiated, creating blast effects	
Causes	- Human error – explosives are dropped, struck, crushed, exposed to heat or electrical energy (including ESD), or a chemical reaction occurs due to storage with incompatible materials - Spontaneous initiation – decay of stabilizer - Facility initiated fire – heat initiates - Natural Phenomena – seismic, wind or lightning events result in the direct or indirect application of mechanical, electrical or thermal energy - External Events – vehicle/crane accident results in the direct or indirect application of mechanical/electrical/thermal energy
Preventive Features	**Design:** - Facility structure resistant to seismic inputs, vehicle impacts, and spread of fire - Fire suppression system limits potential for fire growth and propagation - Storage in DOT approved containers or in fire-safe, four drawer repository **Administrative:** - Only amounts necessary for NDE are stored in the bldg.; no long term storage - Operations consistent with the requirements of LLNL ES&H Manual Part 17, Explosives, and applicable sections of the DOE Explosives Safety Manual - Explosives handler training/qualification - Limited combustible loading to support fire propagation - Stability review program - ESD controls
Mitigating Features	**Design**: - Building basement/sub-basement structure limits blast effects outside any given room. Facilities underground - Non-propagating storage arrays (4-drawer fire-safe repository in B271K) - DOT approved containers **Administrative**: - ***Facility explosives mass limits based on ES&H Manual Document 3.1 Low hazard explosive classification criteria*** - Facility and institutional emergency response plans - Authorized personnel only in explosives area. Strictly controlled access
Unmitigated consequences	Category C (Ref. Table 8 of Ref. 1) - The maximum credible event is defined as the inventory consistent with the Low explosives hazard classification. Per DOE M 440.1-1A (Ref. 4) theconsequences of this event to co-located workers or the public are acceptable.
Probability:	Expected (Ref. Fig. 3 of Ref. 1) - Based on operational history at LLNL, an event with small amounts of material can be expected to occur during the lifetime of the facility.
Comments:	Accident analysis is not required.

3.0 Controls

This chapter formally specifies the credited controls and associated Operational Safety Requirements (OSRs) for B327.

3.1 Explosives

The following are designated credited controls:

The total building inventory shall not exceed 5,000 grams for all types of explosives except for UNO 1.4S materials meeting the conditions stated below. The maximum credible event shall be limited to:

- 10 grams of primary high explosives;
- 350 grams of secondary high explosives that are classified as UNO Hazard Class/Division 1.1, 1.5, and 1.6;
- 5,000 grams of UNO Hazard Class/Division 1.3 and 1.4 materials (except UNO 1.4S materials are allowed unlimited quantities if they are placed in segregated and specifically designated areas;
- no UNO 1.2 materials are allowed

The maximum credible event where explosives of different types or hazard classes are located with one another shall be limited to the lowest mass limit shown above. For example, if UNO 1.1 secondary explosives and UNO 1.3 explosives are located together, the amount of explosives present must be limited to 350 grams total of both materials.

Room inventories shall be managed such that the minimum inventory consistent with efficient operations is maintained and the DOE Explosives Safety Manual 3M rule is observed.

These controls preclude the potential for any significant risk existing beyond the immediate workplace. The inventory limits are specifically identified as part of one General Administrative Control (AC) defining inventory limits.

3.2 OSRs

The controls cited in Section 3.1 are implemented in the B327 OSRs (see Section 4) as one general AC for inventory limits. Additionally, per ES&H Manual Document 3.1 (Ref. 1), four general ACs are specified for deviations from OSRs, training, procedures, and emergency planning.

No Minimum Functional Requirements or associated Testing Requirements are defined.

3.3 Impacts on Nearby Facilities

Based on this safety analysis, B327 does not pose a significant risk to adjacent facilities or the public.

4.0 OSRs

4.1 SPECIFIC ADMINISTRATIVE CONTROLS

No specific ACs are defined as a result of this analysis.

4.2 General Administrative Controls

Five general ACs are defined.

4.2.1 Inventory Limits

Inventory limits shall be established, implemented, and maintained to ensure that explosives inventories remain consistent with the hazard-specific facility classification.

The total building inventory shall not exceed 5,000 grams for all types of explosives except for UNO 1.4S materials meeting the conditions stated below. The maximum credible event shall be limited to:

- 10 grams of primary high explosives;
- 350 grams of secondary high explosives that are classified as UNO Hazard Class/Division 1.1, 1.5, and 1.6;
- 5,000 grams of UNO Hazard Class/Division 1.3 and 1.4 materials (except UNO 1.4S materials are allowed unlimited quantities if they are placed in segregated and specifically designated areas;
- no UNO 1.2 materials are allowed

The maximum credible event where explosives of different types or hazard classes are located with one another shall be limited to the lowest mass limit shown above. For example, if UNO 1.1 secondary explosives and UNO 1.3 explosives are located together, the amount of explosives present must be limited to 350 grams total of both materials.

Room inventories shall be managed such that the minimum inventory consistent with efficient operations is maintained and the DOE Explosives Safety Manual 3M rule is observed.

4.2.2 Deviations from OSRs

The OSRs define the controls needed to ensure that the facility/operation remains within the safety basis established. They shall be formally controlled with all changes requiring approval at the same level as the associated safety basis document.

A.1 Compliance

Facility Management shall ensure that the OSR requirements are met. Compliance is demonstrated by establishing, implementing, and maintaining the ACs identified in this document.

A.2 Violation

Violation of an OSR occurs as a result of failure to comply with an AC statement. Failure to comply with a specific AC constitutes an OSR violation. For general ACs, violation occurs when the failure is of sufficient magnitude that the overall intent of the referenced program is not fulfilled.

A.3 Response to Violations

If an Administrative Control is violated, proceed as follows:

1. Place the facility in a safe condition, and notify the safety basis signature authority.
2. Prepare an Occurrence Report.
3. Prepare a recovery plan, if appropriate, describing the steps leading to compliance with the Administrative Control.
4. Perform and document a technical evaluation, if appropriate, of the Administrative Control violation to determine if any damage occurred.

A.4 Emergency Actions

Emergency actions may be taken that depart from a requirement in the OSR provided that:

- An emergency situation exists;
- These actions are needed immediately to protect health and safety; and
- No action consistent with the OSR can provide adequate or equivalent protection.

Personnel trained and qualified for the necessary equipment or systems shall perform such emergency actions. If an emergency action is taken, the safety basis signature authority should be notified as soon as is practically possible.

4.2.3 Training

Facility-specific training requirements shall be identified and implemented consistent with the appropriate provisions of *ES&H Manual 3.1* for hazards that result in a facility being classified as low hazard or higher. Specifically, workers responsible for generating, maintaining, and ensuring compliance this document shall obtain a facility-specific working-level awareness of the contents and controls of the facility safety basis and the process of document implementation, (e.g., through required reading, on-the-job training, or briefing). The training should include a review of the following:

- Classification level of each facility.
- The type of Safety Basis Document (SBD) associated with each facility and where to obtain a copy.
- Roles, responsibilities, and authority for maintaining and implementing the safety basis.
- Safety basis controls and the associated requirements needed to maintain them.
- The control implementation documents (e.g., FSP, SP, SOPs).
- Reporting requirements.
- Change control process.
- Configuration management as relevant to maintaining facility safety systems to ensure risk reduction and segmentation requirements
- What to do in case of a control nonconformance.

High explosive (HE) handling requires additional specific training.

4.2.4 Procedures

The safety basis document assumptions and controls shall be implemented through facility- and activity-level documents for hazards that result in a facility being classified as low hazard or higher. These assumptions and controls shall flow down from this document to facility implementation documents such as FSPs, SPs, IWSs or facility and/or equipment operating procedures and ES&H guidelines.

4.2.5 Emergency Planning

An emergency preparedness capability shall be established, implemented, and maintained for hazards that result in a facility being classified as low hazard or higher. It should address the following subjects:

- Notification capability to support localized evacuations.
- Specification of knowledgeable individuals for area/room operations.
- Establishment of assembly points.
- Identification of special actions, if any, that need to be taken in the event of an abnormal situation, including those assessed in this document.

Note that knowledgeable individuals are not required to be continuously available. The intent is to demonstrate a baseline understanding of facility hazards.

4.3 Design Features

No design features are defined as a result of this analysis.

5.0 References

1. LLNL ES&H Manual (UCRL-MA-133867), Document 3.1 *Nonnuclear Safety Basis Program*, current version
2. 40CFR302.4, *EPA Designation, Reportable Quantities, and Notification, Designation of Hazardous Substances,* August 24, 2005
3. LLNL ES&H Manual (UCRL-MA-133867), current version
4. DOE Manual 440.1-1A, *DOE Explosives Safety Manual Pantex/LLNL Version*, current version
5. 29CFR1910.119, *OSHA Process Safety Management of Highly Hazardous Materials,* July 1, 2003
6. C. Baker to R. Henry, "B-327 Room B169F Blast Pressure Analysis - 150 gms. TNT," LLNL Internal Memorandum, July 1, 1976
7. J. E. Dotts to K. Dolan, "Hazard Analysis for B-327, Room 169H," Hazards Control Department, LLNL Internal Memorandum, February 5, 1999
8. C. W. Ma to K. Dolan, "B-327, Overpressure Analysis for 10 grams of PETN sample for B-327, Room B171B," LLNL Internal Memorandum, December 4, 2000
9. C. W. Ma to P. Dean, "B-327, Overpressure Analysis for 50 grams of LX-17 or TATB for the Z-Cave in Room B271K," LLNL Internal Memorandum, August 16, 2000
10. Larry Crouch and James E. Dotts, "Report on Explosives Repository Testing," LLNL internal report, January 31, 2001
11. J. E. Dotts to K. Dolan, "Use of Room B273A for Operations with 125 grams of TATB," Hazards Control Department, LLNL Internal Memorandum, December 11, 2000
12. Howard C. Hornig, "Containment of Explosions in a Repository," LLNL UCID-19219, August 10, 1981

Appendix A

Floor Plans for B327

The floor plans for the first floor, second floor and mezzanine, basement, and sub-basement are shown in Figures A-1 through A-4.

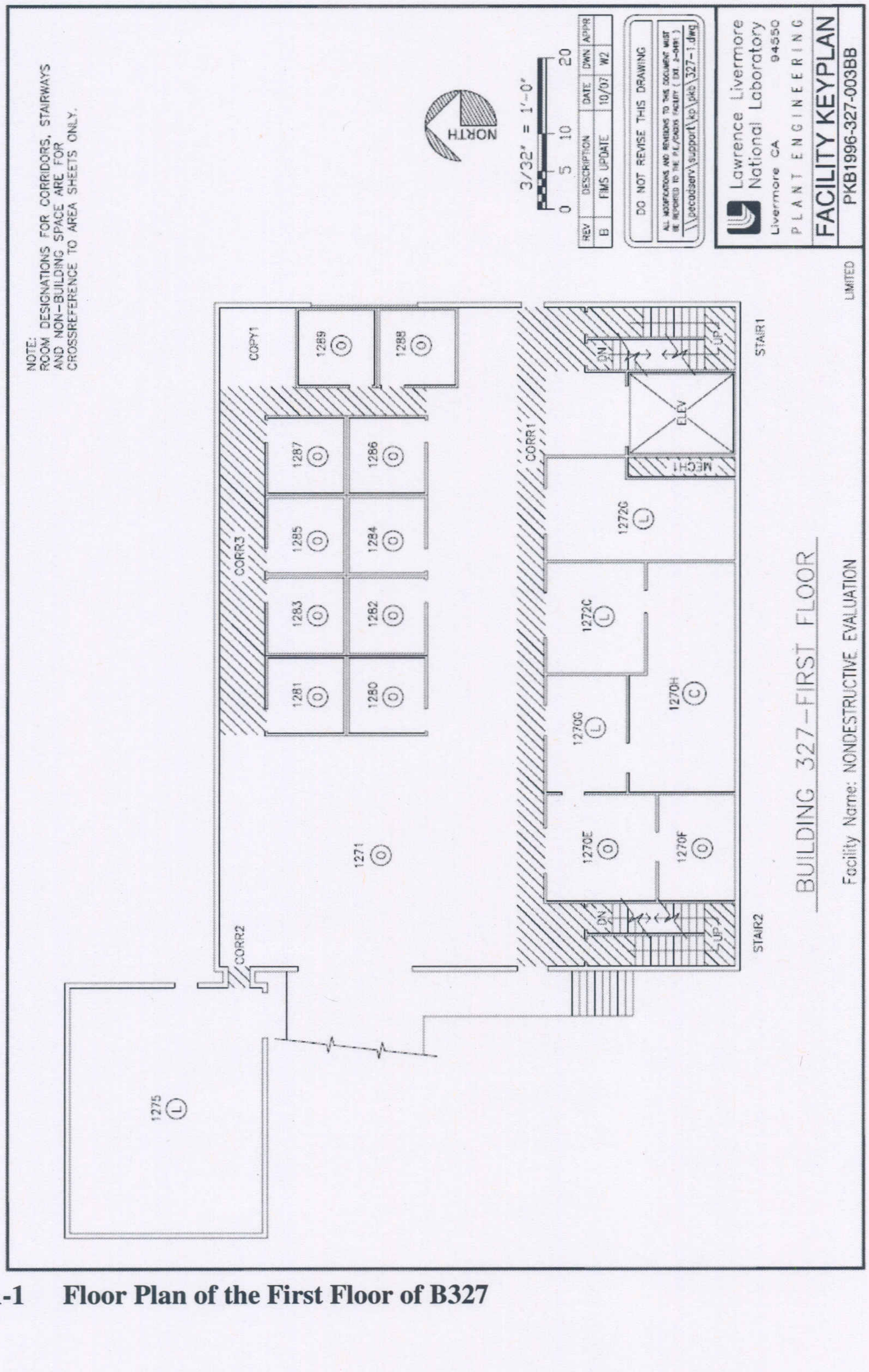


Figure A-1 Floor Plan of the First Floor of B327

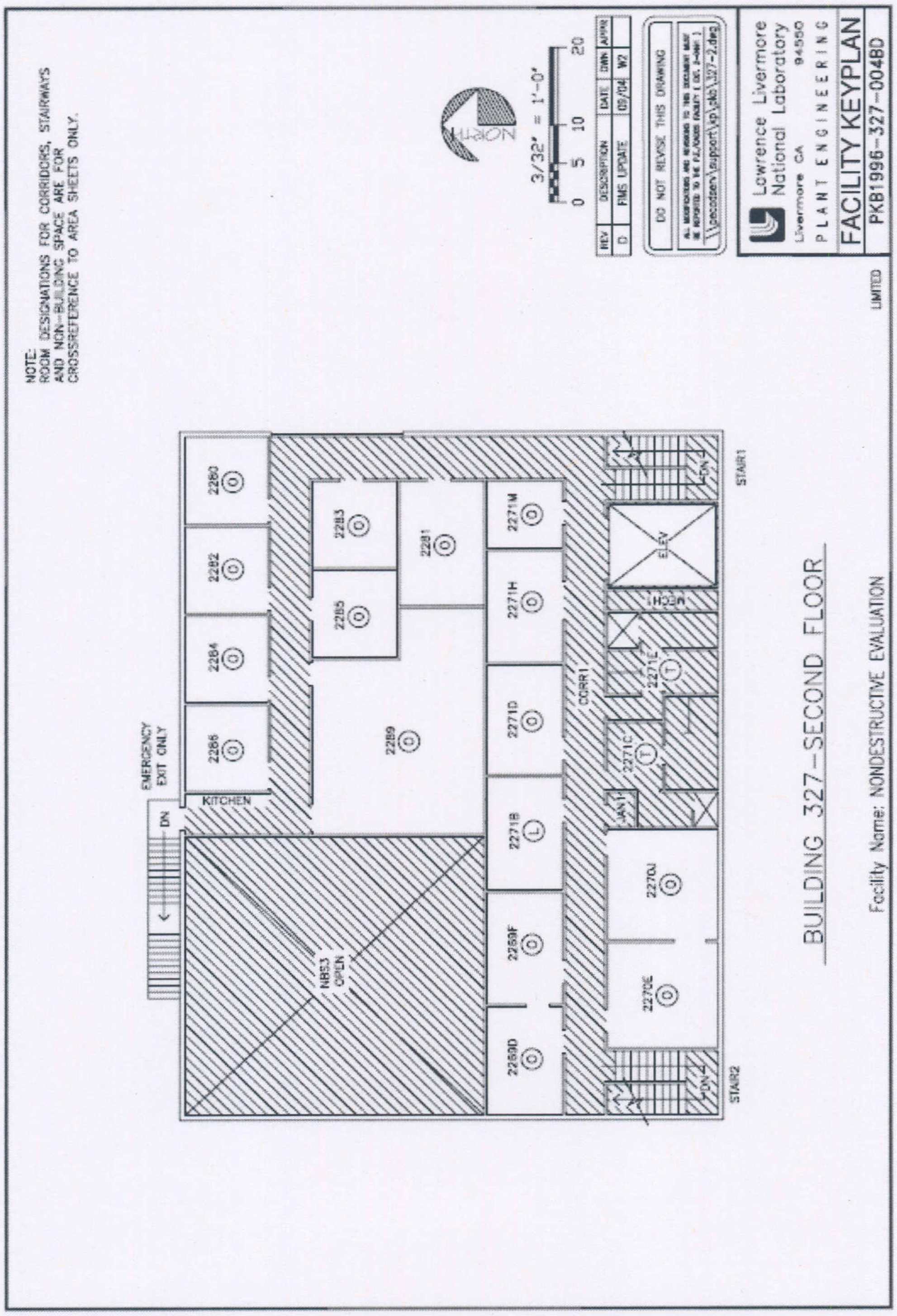


Figure A-2 Floor Plan of the Second Floor and Mezzanine of B327

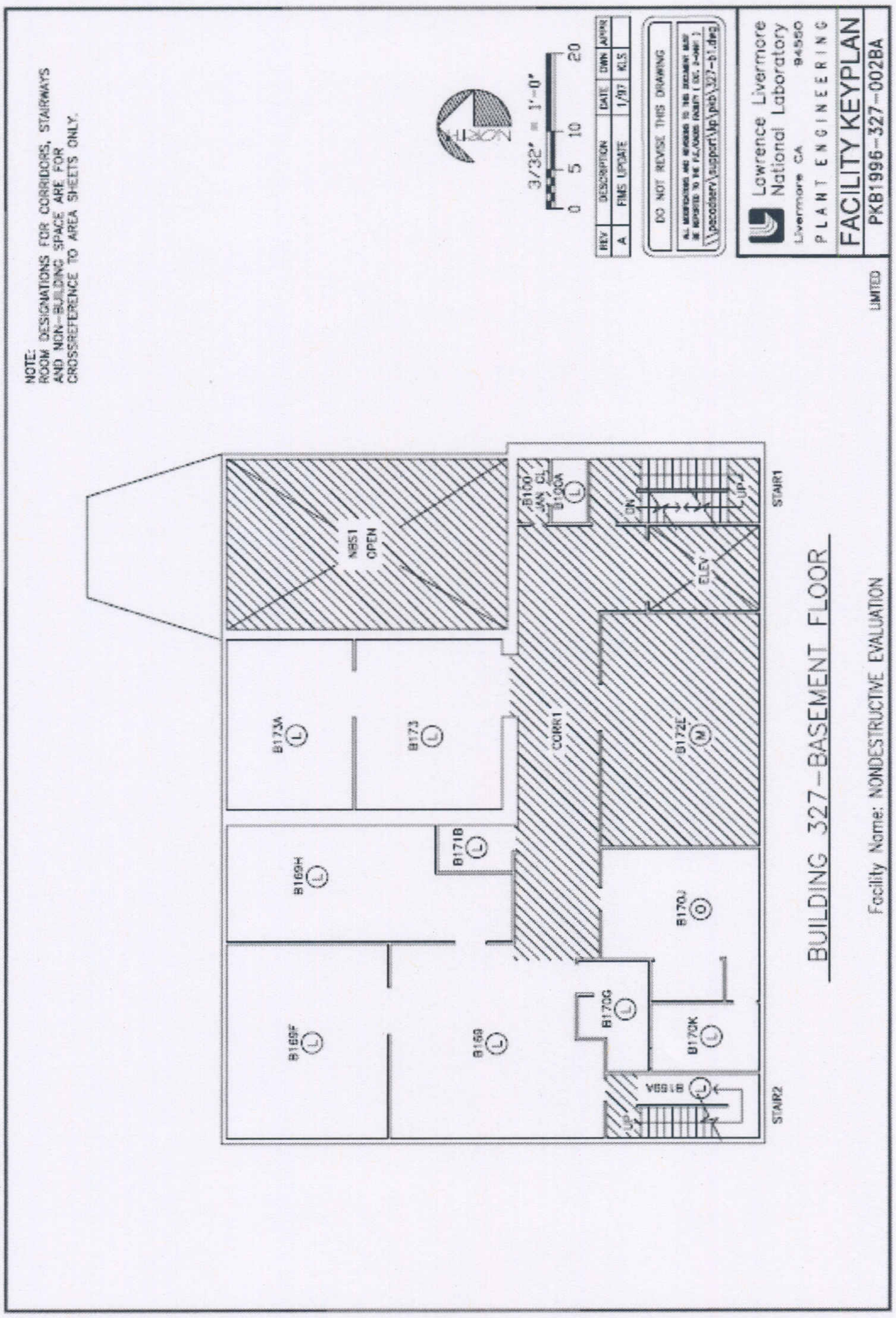


Figure A-3 Floor Plan of the Basement of B327

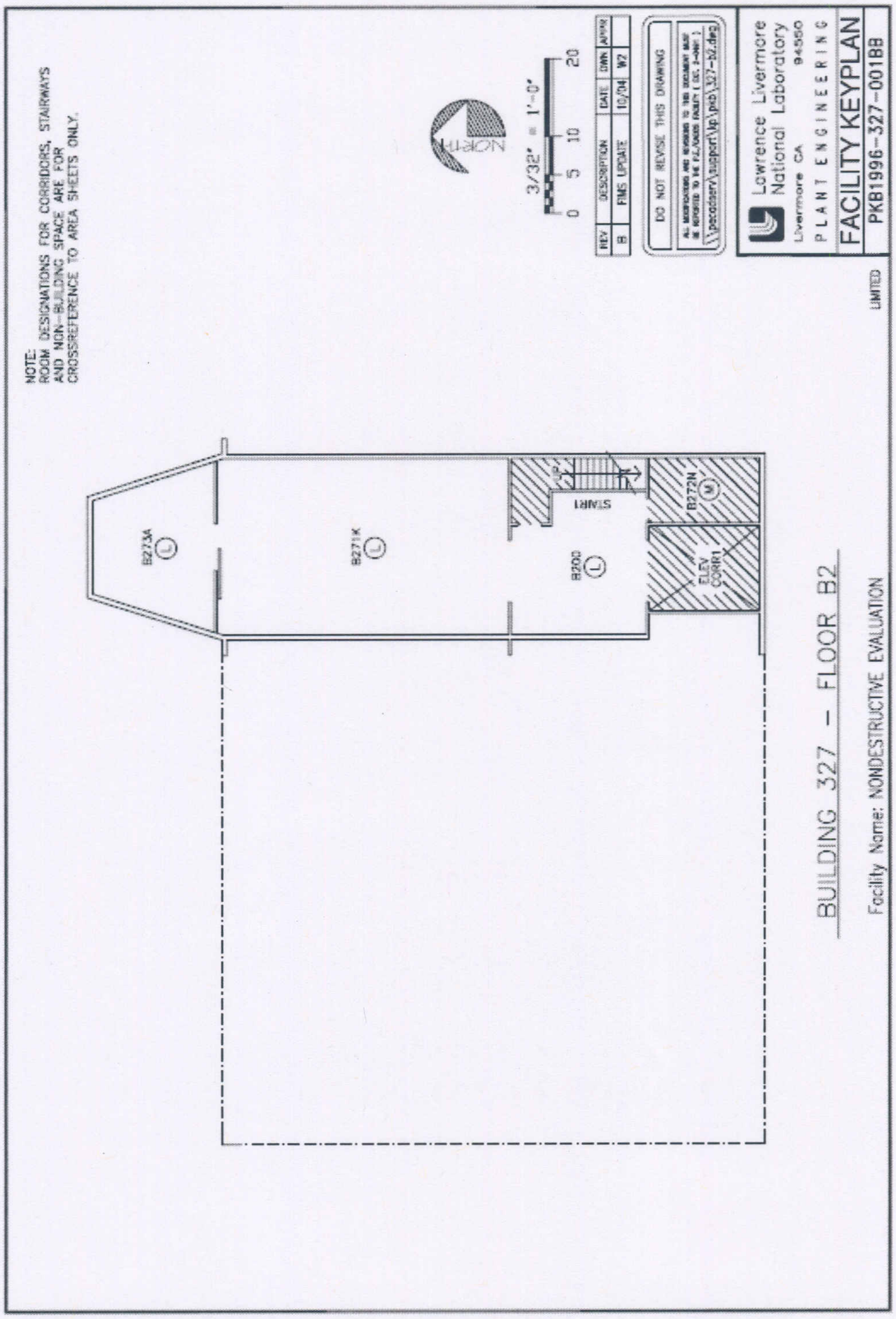


Figure A-4 Floor Plan of the Sub-Basement of B327

Appendix B

Supporting Safety Analyses/Calculations for B327

The following documents are supporting safety analyses/calculations prepared in support of the mass limits in Section 1.1. These mass limits are set to protect against personnel injury and property damage, rather than for protection of the co-located worker and the public, which are the receptors of concern in ES&H Manual Document 3.1. A summary is included. Also included are References 6-11 of Section 5.

Summary of Hazards Analysis for B327 NDE and Explosives Handling Operations

B.1 Explosives use in Room B169H or B169F

Explosives components are nondestructively examined in Rooms B169F and B169H using X-ray imaging techniques. Baker (Ref. B.6.1) analyzed the blast effects of an accidental detonation of 150 grams of TNT in Room B-169F assuming the overpressure from a hemispherical blast. Room B169F is located in the basement of the building. It is about 20-ft-wide by 20-ft-deep and has two interior walls with an entry door in the south end. The other two walls are part of the building foundation. The interior walls are not building structural members. Workers operate the X-ray equipment from outside the room behind an interior wall. This wall is made from 5/8-inch-thick plywood panels with a 1/8-inch-thick layer of lead sheet on both sides. The wall panels protect workers from radiation exposure. In addition, the panels afford some protection from a detonation in the room. The wall panels are bolted to metal struts, with single horizontal struts spaced five feet apart and vertical struts (two struts bolted together) spaced four feet apart. Baker concluded that the wall connections seemed adequate, the door was adequate (if minimum 3/16-in-diameter pins were used to support the door from the rollers), but the framing members of the interior walls were inadequate. The plywood panels or their connections were not analyzed. Based on his analysis, it is assumed that worker injury is possible in case of an explosion.

Baker used parameters appropriate for a hemispherical TNT surface explosion from (Ref. B.6.4). Since the hypothetical explosion occurs on a table about three feet above the floor, at first glance it seems more appropriate to use parameters for pressure and load duration of a spherical explosion. However, the table stand will impede the blast wave so that the actual blast loading in the room would be between the two types of blast loadings. A hemispherical TNT explosion for the blast assessment is more challenging to the structure and therefore more conservative than assuming a spherical blast model.

Dotts (Ref. B.6.2) analyzed the case of detonating 125-gram samples of TATB and TATB/Kel-F (LX-17) in Rooms 169H and 169F. Using an equivalency conversion factor of 0.93 grams of TNT per gram of TATB or LX-17, 125 grams of TATB or LX-17 is equivalent to about 116 grams of TNT, or 77% of the amount of TNT analyzed by Baker. Because Room B169H is structurally similar to B169F, Dotts concluded that Baker's analysis of Room B169F was applicable by analogy to B169H. The floor, ceiling, and two walls of Room B169F could withstand the blast effects of detonating 150 grams of TNT, but the metal (plywood) walls could not. Either Room B169F or B169H will provide Level II protection (possibility of severe injuries) for the occupants of the basement floor and Level I protection (minimal or no injuries) for all other areas of the building. The proposed operations with 125-gram samples of TATB or TATB/Kel-F formulations are considered allowable activities because both the requirements of quantity-distance and DOE Level of Protection can be met.

B.2 Explosives use in Room B171B

C.W. Ma (Ref. B.6.6) rigorously analyzed the effects of an over pressurization of an explosion involving 10 grams of PETN in B327, Room B171B and concluded that the explosion will be confined within Room B171B.

B.3 Explosives use in Room B271K

C.W. Ma (Ref. B.6.3) analyzed the overpressure from the detonation of 50 grams of LX-17 or TATB in the Z-cave in Room B271K (in the sub-basement of the building). Both types of explosives are considered insensitive high explosives (IHE). LX-17-0 is a mixture of 92.5 wt% TATB and 7.5 wt% Kel-F800. As noted above, these IHEs are slightly less energetic than an equal mass of TNT. C.W. Ma refers to Dobratz and Crawford's observations that these IHEs are among the least sensitive of the high explosives tested. The explosives responses were nearly indistinguishable from inert material up to impact velocities of 1000 m/s. Handling accidents with these explosives would therefore not be expected to result in detonations. Various studies cited by C.W. Ma showed that NDE of IHE by radiography would not lead to a detonation by X-ray heating, or other reactions, with the equipment in B327. It is therefore considered extremely unlikely that the NDE of LX-17 or TATB by radiography would promote an accidental detonation. Nevertheless, C.W. Ma analyzed the blast effects of an accidental detonation of 50 grams of these IHEs in the Z-cave.

The Z-cave is a metal enclosure 8.5-ft wide by 10-ft deep by 8-ft high. The walls are constructed from metal panels bolted together. Each wall panel is made from a 1/8-in-thick lead plate sandwiched between 1/8-in and 1/4-in thick steel plates. The metal frame of the enclosure is bolted to the floor. The top of the enclosure is also metal. During operations, operators may sit outside the enclosure that has a blocked 22-in-wide by 16-in-high window. The postulated peak quasi-static pressure resulting from a detonation of a 50-gram sample of explosives was estimated to be about 2 psig. The analysis of the bolts showed that the metal panels, sliding door, and roof could withstand the overpressure and that any fragments would be confined by the

1/4-in-thick steel panels. It is concluded that worker injury is unlikely in the case of an accidental explosion in the Z-cave.

Howard C. Hornig (Ref. B.6.7) conducted tests on repositories (four-drawer office safe files) to determine safe limits for storing small quantities of explosives. He found that the repository contained the blast from a detonation of 10 g of unconfined explosives. However, a 50 g detonation was poorly contained by the repository. As long as 10 g units were arranged in a non-propagating array, more than 10 g were allowed for storage. LLNL explosives safety guidelines limited each drawer to no more than 50 g.

Larry Crouch and James E. Dotts (Ref. B.6.8) performed additional testing of explosives storage in a repository. They tested a non-propagating array of 12.5 g explosives, to provide for a 25 per cent over test as recommended in DOE M 440.1-1, Chapter II, Sections 13, and 21. They verified that no propagation occurred between array cubicles with 12.5 g. This test result substantiated the decision to allow storage of up to 10 g of explosives in each array cubicle up to the drawer limit of 50 g.

B.4 Explosives use in Room B273A

J. E. Dotts (Ref. B.6.5) reviewed the use of 125 g of TATB explosives in operations for room 273A and concluded that room operators will not be exposed to a hazard greater than that approved for other operations in the facility.

B.5 Explosives use in Room B169

Explosives use in room B169 were limited to 10 g of explosives based upon LLNL explosives safety guidelines.

B.6 References

B.6.1 C. Baker to R. Henry, “B-327 Room B169F Blast Pressure Analysis - 150 gms. TNT," LLNL Internal Memorandum, July 1, 1976

B.6.2 J. E. Dotts to K. Dolan, “Hazard Analysis for B-327, Room 169H,” Hazards Control Department, LLNL Internal Memorandum, February 5, 1999

B.6.3 C. W. Ma to P. Dean, “B-327, Overpressure Analysis for 50 grams of LX-17 or TATB for the Z-Cave in Room B271K,” LLNL Internal Memorandum, August 16, 2000

B.6.4 TM 5-1300 / NAVFAC P-397 / AFM 88-22, “Structures to Resist the Effects of Accidental Explosions," Departments of the Army, the Navy and the Air Force,” June 1969

B.6.5 J. E. Dotts to K. Dolan, “Use of Room B273A for Operations with 125 grams of TATB,” Hazards Control Department, LLNL Internal Memorandum, December 11, 2000

B.6.6 C. W. Ma to K. Dolan, “B-327, Overpressure Analysis for 10 grams of PETN sample for B-327, Room B171B,” LLNL Internal Memorandum, December 4, 2000

B.6.7 Howard C. Hornig, "Containment of Explosions in a Repository," LLNL UCID-19219, August 10, 1981

B.6.8 Larry Crouch and James E. Dotts, "Report on Explosives Repository Testing," LLNL internal report, January 31, 2001

SITE 300

July 1, 1976

EMORANDUM

0: R. Henry

ROM: C. Baker

UBJECT: Bldg. 327 Room B 169F
Blast Pressure Analysis - 150 gms. T.N.T.

s requested an analysis has been performed for the south wall of the ubject room.

'ollowing is a tabulation of the results:

. The wall connections seem adequate.

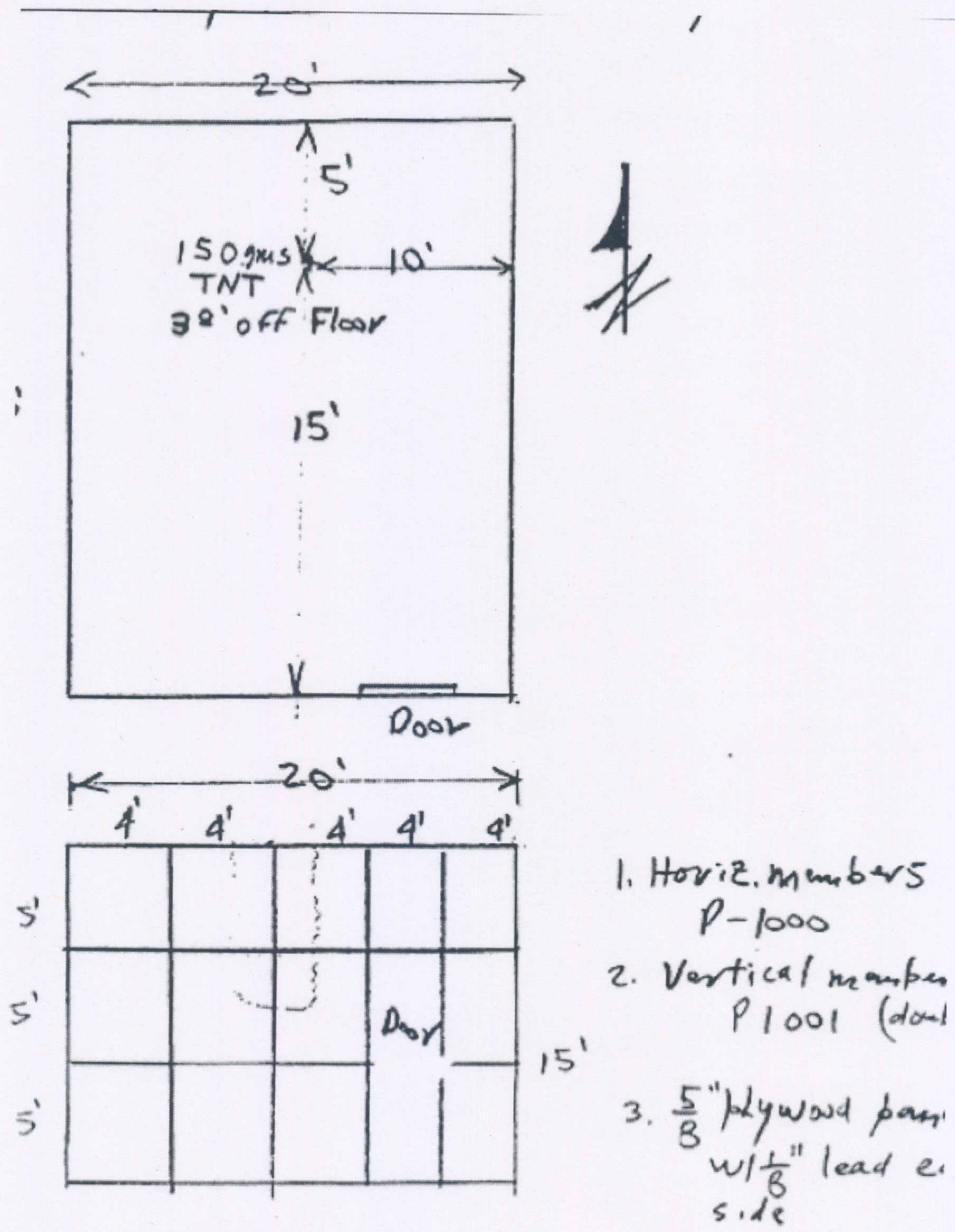
:. The plywood panels and connections were not analyzed.

|. The door is adequate if minimum 3/16" diameter pins support door to top rollers and bottom stay rollers.

|. The horizontal and vertical framing members are inadequate for the charge weight and location analyzed.

C. F. Baker
Site 300 Resident Engineer

:FB:dd


20'
5'
150 gms
TNT
10'
15'
Door
20'
4'
4'
4'
4'
4'
5'
5'
5'
Door
15'
1. Horiz. members
P-1000
2. Vertical
P1001
3. 5/8" plywood
w/ 1/8" lead
side

$R/W^{\frac{1}{3}}$ $\quad w = \frac{150}{4546} = \underline{.33\ lbs}$ [TM 5-130...

$w^{1/3} = .69$

$= \frac{15}{.69} = \underline{21.7}$

...m chart $\quad P_r = 5.7\ psi$

$\frac{t_o}{w^{\frac{1}{3}}} = 3.8 \qquad t_o = (3.8)(.69) = \underline{.0026}$

...ck Vertical beam

$M_p = f_y Z \cong 1.15\ f_y S_x$ $\qquad$ p1001 [ASCE#... p.89...

$M_p = 36{,}000\ 1.15\ (.628)$

$= \underline{26{,}000}$ #in/vert beam.

$S_x = .628\ in^3$
$I = 1.021\ in^4$
$w = 4\#/ft$

$R_y(\text{allow}) = \frac{8\ M_p}{L^2} = \frac{(8)\ 26{,}000}{(15 \cdot 12)^2} = 6.42\ \#/$...

...his beam supports an area 4 ft. wi...
...herefore $\frac{6.42}{(4)(12)} = \underline{R_y\ .1337\ psi}$

From ASCE #42 Page 91

$$T = .64\, l^2 \sqrt{\frac{W}{gEI}}$$

$W_{P1001} = \frac{4}{12}$ =

$g = 38$

$E = 29x$

$I_{P1001} = 1.$

$$T = .64\,(12.15)^2 \sqrt{\frac{.33}{386(29x10^6)\,1021}}$$

$$= \underline{\underline{.1114 \quad secs.}}$$

From ASCE #42 P.108

$$\frac{t_o}{T} = \frac{.0026}{.1114} = .023$$

use $\mu = 5$
Accidental De

$$\frac{P_m}{r_y} = \frac{5.7}{.1337} = 42.63 \text{ reqd.}$$

$\frac{P_m}{r_y}$ from chart
$\cong 38$

$42.63 > 38$

$\therefore$ no good

Now check horizontal Beam

$Mb = f_u\, 1.15\, S_x$

Hori
P-10

$S_x =$

$$y(allow) = \frac{8 M_p}{L^2} = \frac{8\,(9356.4)}{(4.12)^2} = 32.49^{\#}$$

$$y = \frac{32.49}{5(12)} = \underline{\underline{.54\ psi}}$$

$$T = .64\,L^2 \sqrt{\frac{w}{g\,EI}} = .64\,(48)^2 \sqrt{\frac{2/12}{386 \cdot 29 \times 10}}$$

$$= \underline{\underline{.0126\ Secs.}}$$

$$\frac{t}{T} = \frac{.0026}{.0126} = .206 \qquad \text{for } \mu = 5$$

$$\frac{P}{y} \text{ From Chart} = 4.8 \qquad \frac{P_m}{r_{y(actual)}} = \frac{5.7}{.54}$$

$$10.55 > 4.8$$

$\therefore$ No good

<u>Now check Connections</u>

Connection at top of Vertical Column = $(2)\frac{1}{2}$" ...

Flush ...

<u>:heck bottom connection</u>

· Concrete nails

ssume Wire gauge #5 .212"

$\frac{.212^2 \pi}{4}$ = are of one concrete nail = .035 in^2

.035 X 3 = are resisting in she

= .106 in^2

se (1.33) 10,000 psi (single shear) (.106) in^2

= 1408

load = $\frac{5.7 \text{ psi}}{38 \text{ OLF}}$ = .15 psi x (7.5)(4)(144)

648 < 13200 < 1408

∴ Connections are ok

<u>low check Door</u>

40 ft^2 x 144 in^2/ft x .15 psi = 864 # load

$\frac{864}{2}$ = $432^{\#}$ load in shear on bottom pin

$\frac{432}{10,000(1.33)}$ = sq. in. required in 2 pins

= $.032 \text{ in}^2$

each pin should be .016 in^2

$\pi \frac{d^2}{4} = .016$

$d = \sqrt{\frac{4}{\pi} .016} = .14$ in pin diameter required.

on top or bot rollers.

Say 3/16" min pin diameter

Interdepartmental letterhead

Mail Station **L - 143**

Ext: 2-7149

HAZARDS CONTROL DEPARTMENT

Date: February 5, 1999
ES&H Team 3 99-32

TO: Ken Dolan, L-333

FROM: J. E. Dotts, L-143

SUBJECT: Hazard Analysis for Building 327, Room 169H

Currently Building 327 is authorized to store up to 50 grams of H/C 1.1D explosives in an approved modified safe and work on 10-gram samples of all types of explosives excluding primaries.

Request: Provide recommendation on performing non-destructive testing with 125-grams samples of TATB and TATB/Kel-F formulations.

Hazard Analysis: Blast and Fragment calculations were accomplished for room 169F in July of 1976. Memo, attachment 1, provides the results of that Blast/Fragment calculation. The referenced document addresses the detonation of 150 grams of TNT within the room and concludes that the floor, ceiling, and two of the walls would withstand the blast effects but that the metal walls would not. Room 169F is structurally similar to 169H therefore the calculations for 169F will apply by analogy to 169H.

The current request is to increase the facility load limit to allow collection of diagnostic information on 125-gram TATB samples. One Hundred Fifty grams of TNT is equal to 139 grams of TATB using a conversion factor of 1.11 (conversion factor from HEAF). The amount of TATB is only slightly less than that of the TNT for which we have calculations; therefore, the blast effect should be consistent between the TNT and TATB. Should there be a detonation of this quantity of explosive in Room 169H, the effects would not exit building 327, but will cause damage to the equipment in the room of occurrence and to the metal walls of that room. Room 169H will provide Level II protection (possibility of severe injuries) for the occupants of the floor of occurrence, and Level I protection (minimal or no injuries) for all other areas of the facility and for personnel outside the building.

The proposed operation with TATB and TATB/Kel-F is considered a **Class IV** ***operation*** and therefore requires only **Level IV** protection (protection from explosives fire). Class IV *operations* consist of low risk, contact explosive activities with TATB or TATB sub assemblies. These activities *do not* include Class I activities with this material such as machining, pressing, dry blending, dry milling and others.

University of California
Lawrence Livermore National Laboratory

Class I activities are *non-contact* activities that require all personnel be fully protected from the effects of an accidental detonation.

Conclusion: The proposed operation with TATB and TATB/Kel-F formulations can be allowed because both Quantity-Distance requirements and DOE Level of Protection requirements are met in accordance with the DOE Explosives Safety Manual, Chapter VI.

Recommendation: Allow the requested operation using 125 grams of TATB or TATB/Kel F formulations in Room 169H, Building 327.

Restrictions: Operations with **more** than 10 grams of explosive material which are not TATB or a TATB/Kel-F formulation is prohibited without further investigation and an approved Operational Safety Plan (OSP).

Attachment 1 — Bldg. 327 Room B 169F Blast Pressure Analysis – 150 gms. TNT, dtd July 1, 1976

JED

cc:

Becky Failor	L-143
Dave Prokosch	L-384

Memorandum

To: Ken Dolan
From: Chin W. Ma
Subject: Overpressure analysis for 10 grams of PETN sample for Building 327, Room B171B
Date: 12/4/2000

Ken,

Per your request, an overpressure analysis has been performed for Room B171B in Building 327. The analysis indicated that the PETN sample used for radiography must be handled with care to prevent any significant mechanical impact. However, if a sample of 10 grams of this high explosive explodes for whatever unknown reasons, the results of the calculation show that the explosion will be confined within Room B171B.

Chin W. Ma

Chin W. Ma

cc: J. Dotts
G. Schweickert
E. Updike
P. Dean

**Safety Calculation for radiography of PETN
in Building 327 Room B171B**

1. **Hazard:**
Up to 10 g of PETN high explosives (HE) are analyzed by x-ray radiography in Building 327, Room B171B. The PETN is relative sensitive to impact. In the drop-weight test, the dropping height of a weight (2.5 or 5 kg) that may cause an "Explosion" with 50% probability ranges from 0.11 m to 0.20 m (Dobratz and Crawford, 1985; Pages 9-1 to 9-4). Therefore the PETN sample must be handled with care to prevent any significant mechanical impact.

Various studies (Lee, 1987; Back et al, 1997A and 1997B) showed that non-destructive examinations of HE by radiography will not cause an explosion either due to heating of the HE by x-ray dosage, or heating by nuclear (γ, n) reactions, or due to charge buildup by (γ, e^-) and $\gamma(e^-,e^+)$ reactions. The studies concluded that the stored energy which can be generated by a 9-Mev Linatron is many orders of magnitude below what could cause an accident explosion. Note that the dosage with a KCAT x-ray system is many orders of magnitude lower than the peak rate of the Linatron 3000.

The rest of this calculation is to evaluate the overpressure of a postulated HE explosion (for whatever unknown reasons) during the radiography of a PETN sample in Room B171B and to show that the overpressure will be confined.

2. **Overpressure calculation:**
The x-ray radiography in the B171B involves a 10 g sample of PETN. The peak quasi-static pressure resulting from the postulated explosion of this HE sample is conservatively calculated as (see Appendix A for details):

P = 1 psig

The B171B is a 6'W x 10'D x 8'H metal enclosure. The left, front, rear walls are made of 1/4" metal panels. Each metal panel is bolted to the vertical frames which are then bolted to the ground. The right wall is a 10" concrete wall. The roof is made of a 1/4" metal panel. The metal roof panel is bolted to the roof frames that are bolted to the vertical frames which are then bolted to the ground.

An analysis of the force acting on the metal panels and bolts shows that they will be able to withstand the 1 psig overpressure (see appendix A for details). The metal door and the concrete wall will also be able to withstand the 1 psig overpressure. Any fragments resulting from an explosion will be confined within the 1/4" metal panels and the 10" concrete wall.

3. **Conclusion:**
It is concluded that if a PETN sample explodes for whatever unknown reasons, the resulting overpressure and fragments will be confined within Room B171B.

Appendix A Engineering Calculations

1. Room B171B dimension:
The B171B is a 6'W x 10'D x 8'H metal enclosure. The left, front, rear walls are made of 1/4" metal panels. Each metal panel is bolted to the vertical frames which are then bolted to the ground. The right wall is a 10" concrete wall. The roof is also made of a 1/4" metal panel. The metal roof panel is bolted to the roof frames which are bolted to the vertical frames which are then bolted to the ground (see Fig. 1).

2. Overpressure due to HE explosion:
The x-ray radiography in the B171B involves a 10 g sample of PETN HE. The peak quasi-static pressure resulting from the explosion of this HE sample is calculated below:

The detonation energy of PETN and TNT are given as (Dobratz and Crawford, 1985):

PETN	H = 6.90 MJ/kg
TNT	H = 5.90 MJ/kg
Therefore	PETN = 1.2 TNT equivalent

Weight of TNT equivalent:
W = 1.2*10 g TNT equivalent
= 12 g TNT equivalent
= 0.026 lb TNT equivalent

Volume of B171B:
$V = 6' * 10' * 8' = 480\ ft^3$

$W/V = 5.5 \times 10^{-5}\ lb/ft^3$

Using the FRANG code (Wager, 1997), the peak quasi-static pressure following a postulated PETN explosion is calculated as:

P = 0.87 psig

In this calculation, an overpressure of 1 psig is used to study the structure integrity of Room B171B.

3. Force acting on the left wall panel and bolts:
The force acting on the left wall panel is:

$F_{left\ panel} = 1\ psig * 10' * 8' = 1.2 \times 10^4\ lb$

The left panel is bolted to 5 vertical frames which are then bolted to the ground. Following a postulated HE explosion, these bolts will experience a force. For conservatism, we take credit only for the 3 middle vertical frames. The force acting on each of the 3 middle vertical frame is:

$$F_{\text{side vert frame}} = 1.2 \times 10^4 \text{ lb} / 3 = 4.0 \times 10^3 \text{ lb}$$

Each of the 3 middle vertical frames is bolted to the ground with 2 bolts, the force acting on each of these ground bolts is:

$$F_{\text{ground bolt}} = 4.0 \times 10^3 \text{ lb}/2 = 2.0 \times 10^3 \text{ lb}$$

Since the force acting on each bolt is smaller than the ultimate shearing force (3.2 x 10^3 lb, see Appendix B) that the bolt can withstand, therefore the bolts that bolt the vertical frames to the ground will not fail following a postulated HE explosion.

The left wall panel is bolted to each middle vertical frame with 8 bolts. The force acting on these panel bolts following a postulated HE explosion is:

$$F_{\text{panel bolt}} = 4.0 \times 10^3 \text{ lb}/8 = 5.0 \times 10^2 \text{ lb}$$

Since the force acting on each bolt is smaller than the ultimate tensile force (5.7 x 10^3 lb, see Appendix B) that the bolt can withstand, therefore these panel bolts will not fail following a postulated HE explosion.

4. Force acting on the rear wall panels and bolts:
The force acting on the rear wall panel is:

$$F_{\text{rear panel}} = 1 \text{ psig} * 6' * 8' = 6.9 \times 10^3 \text{ lb}$$

The rear panel is bolted to 3 vertical frames and each of them is bolted to the ground by 1 bolt. Following a postulated HE explosion, the force acting on each rear vertical frame and each ground bolt is:

$$F_{\text{rear vert frame}} = 6.9 \times 10^3 \text{ lb} / 3 = 2.3 \times 10^3 \text{ lb}$$

$$F_{\text{rear ground bolt}} = 2.3 \times 10^3 \text{ lb}$$

Since the force acting on each bolt is smaller than the ultimate shearing force (3.2 x 10^3 lb, see Appendix B) that the bolt can withstand, therefore the bolts that bolt the rear vertical frames to the ground will not fail following a postulated HE explosion.

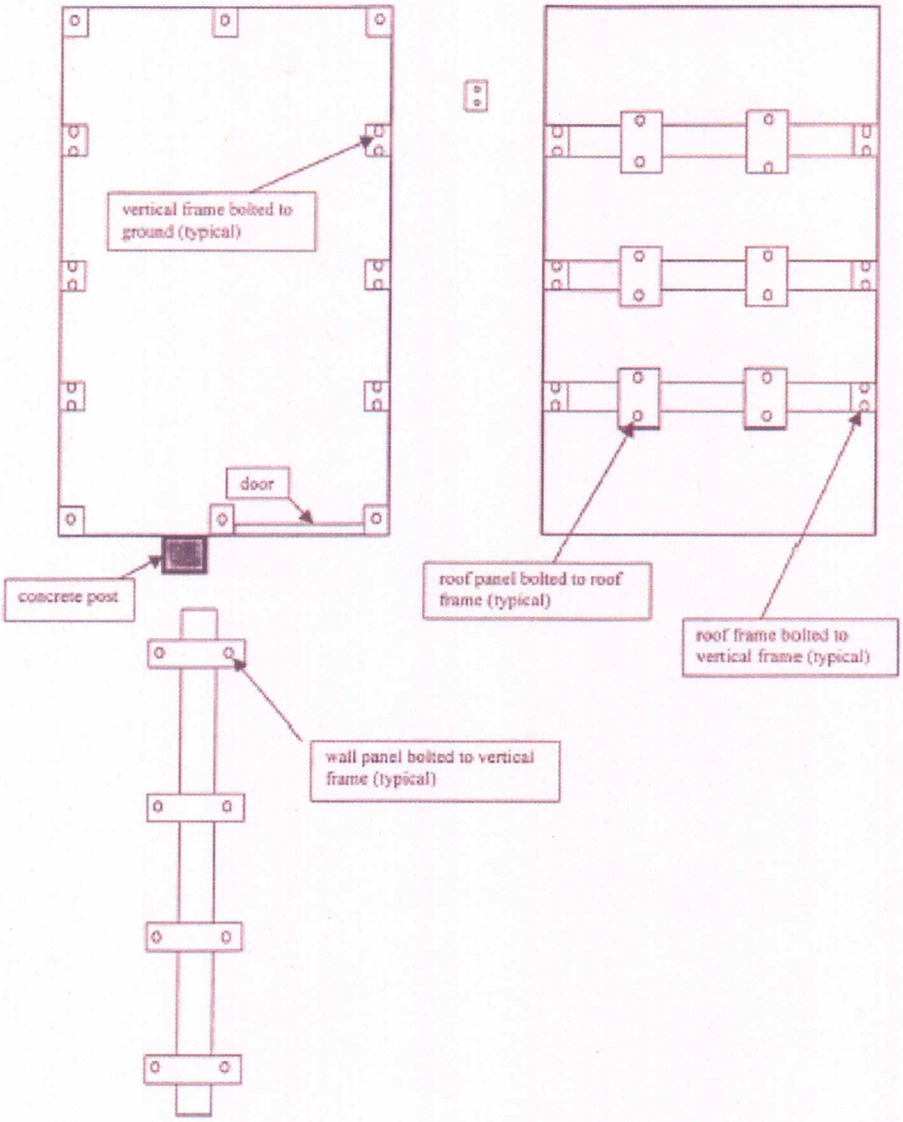


Figure 1 Building 327, Room B171B layout

The rear panel is bolted to the 3 vertical frame by a total of 17 bolts (6 for the left or right rear vertical frame, and 5 for the middle rear vertical frame). The force acting on each of these panel bolts following a postulated HE explosion is:

$F_{rear\ panel\ bolt} = 6.9 \times 10^3$ lb/17 = 4.1×10^2 lb

Since the force acting on each rear panel bolt is smaller than the ultimate tensile force (5.7×10^3 lb, see Appendix B) that the bolt can withstand, therefore these rear panel bolts will not fail following a postulated HE explosion.

5. Force acting on the front wall panels and bolts:
There is a 30" x 80" door opening in the front wall panel, therefore the force acting on the front wall panel is:

$F_{front\ panel}$ = 1 psig * (6' * 8' - 30" * 80") = 4.5×10^3 lb

The front wall panel is sandwiched between 2 front vertical frames inside the room and the concrete post and metal frame outside the room. It is bolted to the concrete post with 6 bolts in addition to other bolts. The outside concrete post and hence the front panel will withstand the 1 psig overpressure.

6. Force acting on the door and bolts:
The 30"x80" door is covered by 1/16" lead sheet on both side. The door is supported by hinges and opened inwardly. Following a postulated HE explosion, the door jamb will prevent the door to open. The door jamb is bolted to the middle and right front frames by a total of 10 bolts. The force acting on each bolt is:

$F_{door\ bolt}$ = 1 psig * 30" * 80" /10 = 2.4×10^2 lb

Since the force acting on each door bolt is smaller than the ultimate shearing force (3.2×10^3 lb, see Appendix B) that the bolt can withstand, therefore these door bolts will not fail.

The right front vertical frame is bolted to the top horizontal frame and the concrete wall with 2 bolts. The middle vertical frame is bolted to the top horizontal frame and the front metal panel with 2 bolts. Therefore the force acting on each bolt is:

$F_{front\ frame\ bolt}$ = 1 psig * 30" * 80" /(2 * 2) = 6.0×10^2 lb

Since the force acting on each bolt is smaller than the ultimate tensile force (5.7×10^3 lb, see Appendix B) that the bolt can withstand; therefore these bolts as well as the 2 front vertical frames will not fail.

7. Force acting on the roof panel and bolts:
The force acting on the roof panel due to the overpressure is:

$$F = 1 \text{ psig} * 10' * 6' \text{ ft}^2 = 8.6 \times 10^3 \text{ lb}$$

The weight of the roof panel (see Table 1) is:

$$W = 6.1 \times 10^2 \text{ lb}$$

Therefore the net uplift force acting on the roof panel is:

$$F_{uplift} = 8.6 \times 10^3 \text{ lb} - 6.1 \times 10^2 \text{ lb} = 8.0 \times 10^3 \text{ lb}$$

The roof panel is bolted to 3 roof frames, the force acting on each frame is:

$$F_{roof\ frame} = 8.0 \times 10^3 \text{ lb} /3 = 2.7 \times 10^3 \text{ lb}$$

Each roof frame is bolted to 2 vertical frames (left and right) by a total of 4 bolts, the force acting on each bolt is:

$$F_{roof\ bolt} = 2.7 \times 10^3 \text{ lb}/4 = 6.8 \times 10^2 \text{ lb}$$

The roof panel is bolted to each roof frame by 4 bolts, the force acting on each roof panel bolt is:

$$F_{roof\ panel\ bolt} = 2.7 \times 10^3 \text{ lb}/4 = 6.8 \times 10^2 \text{ lb}$$

In addition, each of the 6 vertical frames in the middle (left and right) is bolted to the ground by 2 bolts. The total weight of the roof panel and wall panels is 2408 lb (see Table 1). Therefore the uplift force acting on each of these ground bolts following a postulated HE explosion is:

$$F_{uplift\ ground\ bolt} = (8.6 \times 10^3 \text{ lb} - 2.4 \times 10^3 \text{ lb})/(6 \times 2) = 5.2 \times 10^2 \text{ lb}$$

Since the force acting on the three aforementioned bolts is smaller than the ultimate tensile force (5.7×10^3 lb, see Appendix B) that the bolts can withstand, therefore these bolts will not fail following a postulated HE explosion.

8. Force acting on the right concrete wall:
The right wall is a 10" concrete wall, it will be able to withstand an overpressure of 1 psig.

9. Explosion fragments:
A review of the HE radiography setup indicates that there will be minimum fragments as a result of a postulated HE explosion. These fragments will not

penetrate the 1/4" metal panels, the door covered by two 1/16" lead sheets, or the 10" concrete wall of Room B171B.

Table 1 Forces acting on the roof

Roof and Panels weight					
	Density (lb/ft3)	W (ft)	Thick (in)	L (ft)	Weight (lb)
Roof, steel panel	489.7	10	0.25	6	612
Left wall, steel panel	489.7	10	0.25	8	816
Rear wall, steel panel	489.7	6	0.25	8	490
Front wall, steel panel	489.7	6	0.25	8	490
				Total	**2408**

Note:
water density = 1 g/cc = 62.3 lb/ft3
steel density = 7.86 g/cc = 489.7 lb/ft3

```
***** PROGRAM FRANG VERSION 2.1b *****
              *** SEPT 1997 ***

 CAPABILITIES OF THIS PROGRAM INCLUDE:
  1. UP TO FIVE FRANGIBLE PANELS CAN BE TRACKED
  2. INITIAL DISPLACEMENT AND VELOCITY OF PANELS CAN BE INPUT BY USER
NFESC FRANG2


 Bldg 327, Room B171B

Global Parameters
   Charge Weight ........................ 0.03 lbs
   Volume ...... ........................ 480.00 ft^3
   Initial vent area .................... 1.00 ft^2
   Number of frangible panels ........... 0
   Time step ............................ 1.00 msec
   All output will be suppressed ........ false

GAS PRESSURE CALCULATION
   Peak Gas Pressure .................... 0.87 psi
   Gas Load Duration (No Panels) ........ 388.07 msec

REVISED SHOCK IMPULSE ON PANELS
PRESSURE LESS THAN .001*PEAK PRESSURE AT T =   80.00

      ************************** WARNING ************************
        W/V = .0001 < .OO1

      *** CALCULATED IG/W**(1/3) MAY BE LESS THAN ACTUAL VALUE ***

                RESULTS SUMMARY
  GAS      PEAK GAS   TOTAL GAS   CHARGE   TRIANGULAR GAS
DURATION   PRESSURE    IMPULSE    DENSITY  DURATION, Teq
Tg (ms)    Pg (psi)   Ig (psi-ms)   W/V    Ig*2/Pg (ms)
 80.00       0.87       39.86      0.000     91.46

***** END FRANG RUN.
```

Appendix B Ultimate tensile and shearing force of a bolt

The metal panels are bolted to the frames and the frames are bolted to the ground by 3/8x16 UNC, grade 2 bolts. The ultimate tensile force and the ultimate shearing force that will cause a bolt to fail are calculated below.

B.1 Bolt failure due to tensile force:
The tensile stress area of a 3/8x16 UNC bolt is given as (Juvinall, 1983; Table 10.1):

$A_t = 0.0775\ in^2$

The tensile strength for a grade 2 bolt is given as (Juvinall, 1983; Table 10.4):

$S_u = 74\ ksi$

Therefore the tensile force that a 3/8x16 UNC bolt will be able to withstand before failure is:

$$F_t = S_u * A_t$$
$$= 74\ ksi * 0.0775\ in^2$$
$$= 5.7 \times 10^3\ lb$$

B.2 Bolt failure due to shearing force:
The ultimate shearing strength of a bolt can be related to its ultimate tensile strength as (Juvinall, 1983; Eq. 10.16):

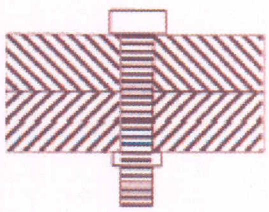
$S_{su} = 0.62\ S_u$

It is conservatively assumed that the tread portion of a 3/8x13 UNC bolt is extended to the shearing plane. Thus the minor diameter of a 1/2x16 UNC bolt is used to calculate the shearing area; the minor diameter is given as 0.2983 in. ((Juvinall, 1983; Table 10.1).

$A_s = \pi/4\ (0.2983\ in)^2 = 0.0699\ in^2$

Therefore the shearing force that a 1/2x13 UNC bolt will be able to withstand before failure is:

$$F_s = S_{su} * A_s$$
$$= 0.62 * 74\ ksi * 0.0699\ in^2$$
$$= 3.2 \times 10^3\ lb$$



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(Juvinall, 1983), R.C. Juvinall, "Fundamentals of Machine Components", 1983

(Lee, 1987), E. Lee to J. West, "Input to Surety Report for LINAC Irradiation of Devices", July 8, 1987.

(Wager, 1997), P. Wager and J. Connett "FRANG User's Manual", Naval facility engineering Service Center, May, 1989. (The code used in this calculation is a 1997 version)

Memorandum

August 16, 2000

To: P. Dean
From: Chin W. Ma
Subject: Building 327, Overpressure analysis for 50 grams of LX-17 or TATB for the Z-Cave in Room B271K

As requested by K. Dolan, an overpressure analysis has been performed for the Z-cave in Building 327, Room B271K. The analysis indicated that it is extremely unlikely that non-destructive examinations of LX-17 or TATB by radiography can lead to an explosion accident. However, if a sample of 50 grams of this insensitive high explosive explodes for whatever unknown reasons, the results of the calculation show that the explosion will be confined within the Z-cave.

Chin W. Ma

cc: K. Dolan
J. Dotts
R. Failor
E. Updike

COPY

Safety Calculation for radiography of LX-17/ TATB at Building 327 Z-cave

1. **Hazard:**
Up to 50 g of LX-17 or TATB high explosives (HE) are analyzed by x-ray radiography in the Z-cave located in Building 327, Room B271K. The LX-17 and TATB are both insensitive HE (IHE), they are among the least responsive of the HEs ever tested in the Susan test (Dobratz and Crawford, 1985; Pages 9-18, 9-20). Their explosive response is scarcely distinguishable from that of an inert material at impact velocities up to 1000m/s. There is no evidence of accelerated burning reactions at the higher impact velocities such as occur with almost all commonly used explosives. Therefore any handling accident, such as dropping the IHE from operators during transfer, will not result in an explosion (note that the terminal velocity of an object dropping from 3 m is only 8 m/s).

Various studies (Lee, 1987; Back et al, 1997A; Back et al, 1997B) also showed that non-destructive examinations of HE by radiography will not cause an explosion either due to heating of the HE by x-ray dosage, or heating by nuclear (γ, n) reactions, or due to charge buildup by (γ, e^-) and $\gamma(e^-, e^+)$ reactions. The studies concluded that the stored energy that can be generated with a 9-Mev Linatron is many orders of magnitude below what could cause an accident explosion (note that the dosage with a KCAT x-ray system is many orders of magnitude lower than the peak rate of the Linatron 3000).

It is therefore concluded that it is extremely unlikely that non-destructive examinations of LX-17 or TATB by radiography at B327 can lead to an explosion accident.

The rest of this calculation is to evaluate the consequences of an postulated IHE explosion (for whatever unknown reasons) during the radiography of LX-17 or TATB in the Z-cave.

2. **Explosion calculation:**
The x-ray radiography in the Z-Cave involves a 50 g sample of LX-17 or TATB HE. The peak quasi-static pressure resulting from the postulated explosion of this HE sample is calculated as (see Appendix A for details):

$$P = 2.0 \text{ psig}$$

The Z-cave is an 8.5'W x 10'D x 8'H metal enclosure (see Fig. 1). The left and right walls each consists of 3 bolted metal panels, the back wall consists of 2 bolted metal panels, the front consists of a metal panel and a metal sliding door. The metal frame is bolted to the ground, there is also a metal roof.

An analysis of the force acting on the bolts shows that the metal panels, the front metal sliding door, and the metal roof will be able to withstand the 2 psig overpressure (see appendix A for details). Any fragments causing by the explosion will also be confined by the 1/4 in. steel panels.

3. **Conclusion:**
It is concluded that it is extremely unlikely that non-destructive examinations of LX-17 or TATB by radiography at B327 can lead to an explosion accident. However, if the IHE explodes for whatever unknown reasons, the results of the calculation show that the explosion will be confined by the Z-cave.

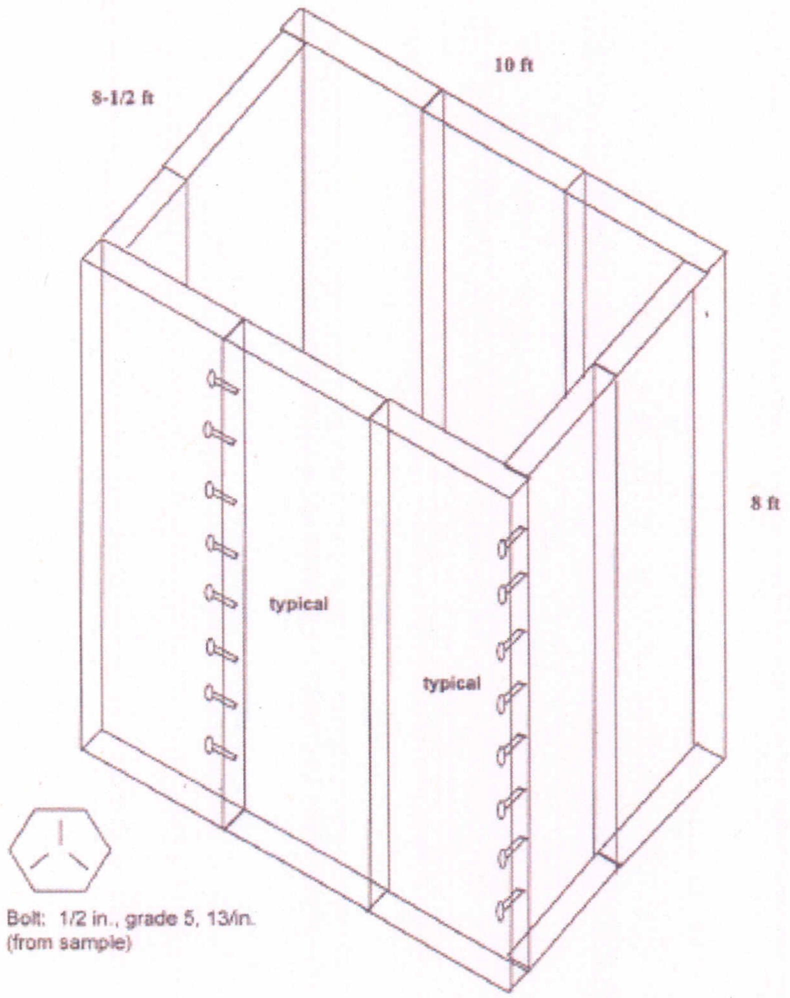


Figure 1 Building 327 Z Cave Schematic Drawing (not to scale)

Appendix A Engineering Calculations

1. Z-cave dimension:
   The Z-cave is an 8.5'W x 10'D x 8'H metal enclosure (see Fig. 1). The left and right walls each consists of 3 bolted metal panels, the back wall consists of 2 bolted metal panels, the front consists of a metal panel and a metal sliding door, both are 5 ft wide. There is also a metal roof.

   Each wall and roof metal panel is made of a 1/8" lead plate sandwiched between two 1/8" steel plates. The sliding door is made of a 1/8" lead plate sandwiched between a 1/8" steel plates and a 1/4' steel plate. The Z-cave frame is bolted to the ground. During operation the operators may sit outside the left wall which has a blocked 22"W x 16"H window.

2. Pressure due to HE explosion:
   The x-ray radiography in the Z-cave involves a 50 g sample of LX-17-0 HE that consists of 92.5% TATB and 7.5% kel-F800. The peak quasi-static pressure resulting from the explosion of this HE sample is calculated below:

   The detonation energy of LX-17-0 and TNT are given as (Dobratz and Crawford, 1985):

LX-17-0	H = 5.48 MJ/kg
TNT	H = 5.90 MJ/kg
Therefore	LX-17-0 = 0.93 TNT equivalent

   Weight of TNT equivalent:
   W = 0.93*50 g TNT equivalent
   = 46.5 g TNT equivalent
   = 0.102 lb TNT equivalent

   Volume of Z-cave:
   $V = 10' * 8.5' * 8' = 680\ ft^3$
   $W/V = 1.5 \times 10^{-4}\ lb/ft^3$

   Using the FRANG code (Wager, 1997), the quasi-static pressure following a postulated LX-17 explosion is calculated as:

   P = 2.0 psig

3. The ultimate tensile force and shearing force of a bolt:
   The metal panels of the Z-cave are bolted to each other by 1/2x13 UNC, grade 5 bolts (see Fig. 1). The ultimate tensile force and the ultimate shearing force that will cause a bolt to fail are calculated below.

3.1 Bolt failure due to tensile force:

The tensile stress area of a 1/2x13 UNC bolt is given in Table 10.1 (Juvinall, 1983) as:

$A_t = 0.1419\ in^2$

The tensile strength for a grade 5 bolt is given as (Juvinall, 1983; Table 10.4):

$S_u = 120\ ksi$

Therefore the tensile force that a 1/2x13 UNC bolt will be able to withstand before failure is:

$$F_t = S_u * A_t$$
$$= 120\ ksi * 0.1419\ in^2$$
$$= 1.7 \times 10^4\ lb$$

3.2 Bolt failure due to shearing force:

The ultimate shearing strength of a bolt can be related to its ultimate tensile strength as (Juvinall, 1983; Eq. 10.16):

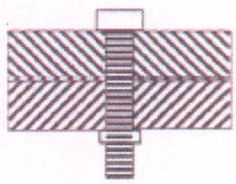
$S_{su} = 0.62\ S_u$

It is conservatively assumed that the tread portion of a 1/2x13 UNC bolt is extended to the shearing plane. Thus the minor diameter of a 1/2x13 UNC bolt is used to calculate the shearing area, the minor diameter is given as 0.4056 in. ((Juvinall, 1983; Table 10.1).

$A_s = \pi/4\ (0.4056\ in)^2 = 0.129\ in^2$

Therefore the shearing force that a 1/2x13 UNC bolt will be able to withstand before failure is:

$$F_t = S_{su} * A_s$$
$$= 0.62 * 120\ ksi * 0.129\ in^2$$
$$= 9.6 \times 10^3\ lb$$



4. Force acting on the bolts of the walls:

Each side wall consists of 3 panels, the force acting on each side panel is:

$F_{sp} = 2.0$ psig * 10' * 8' * 0.333 = 7.7×10^3 lb

The back wall consists of 2 panels, the force acting on each back panel is:

$F_{bp} = 2.0$ psig * 8.5' * 8' * 0.5 = 9.8×10^3 lb

The force acting on the front panel is:

$F_{fp} = 2.0$ psig * 5' * 8' = 1.2×10^4 lb

Each panel frame is bolted to the frames of its neighboring panels and the roof (see Fig. 1).

Following a postulated HE explosion, some bolts will experience a shearing force and some will experience a tensile force. The bolts along the center line of the back wall will experience the largest force. There are 8 bolts and the force acting on each bolt is:

$F_{center\text{-}bolt} = (0.5 * 9.8 \times 10^3 \text{ lb} + 0.5 * 9.8 \times 10^3 \text{ lb}) / 8 = 1.2 \times 10^3$ lb

Note that the above calculation conservatively neglects the load shared by the 3 top bolts fastened to the roof. Since the force acting on each bolt is much smaller than the ultimate tensile force and shearing force that the bolt can withstand, therefore the bolts of the Z-cave walls will not fail following a postulated HE explosion.

5. Force acting on the roof panel:
The roof panel dimension is

$A = 10' \times 8.5' = 85 \text{ ft}^2$

The force acting on the roof panel due to the overpressure (see Table 1) is:

$F = 2\text{psig} \times 85 \text{ ft}^2 = 24{,}480$ lb

The weight of the roof panel (see Table 1) is:

W = 1657 lb

Therefore the net uplift force acting on the roof panel is:

$F_{up} = 24{,}480 \text{ lb} - 1{,}657 \text{ lb} = 22{,}823$ lb

The roof panel is bolted to the frame by 29 bolts, thus the force acting on each bolt is:

F_{bolt} = 22,823 lb/29 = 787 lb

Since the force acting on each bolt is much smaller than the ultimate tensile force that the bolt can withstand, therefore the bolts of the roof will not fail following a postulated HE explosion.

6. Force acting on the Z-Cave frame:
The force acting on the roof panel due to the overpressure (see Table 1) is:

$F = 2\text{psig} \times 85\ \text{ft}^2 = 24{,}480\ \text{lb}$

The total weight of the Z-cave (see Table 1) is:

W_{cave} = 7,300 lb

Therefore the net uplift force acting on the Z-Cave frame is:

F_{up} = 24,480 lb - 7,300 lb = 17,180 lb

The frame is bolted to the ground by 24 bolts, thus the force acting on each bolt is:

F_{bolt} = 17,180 lb/24 = 716 lb

Since the force acting on each bolt is much smaller than the ultimate tensile force that the bolt can withstand, therefore the bolts of the frame will not fail following a postulated HE explosion.

7. The force acting on the front sliding door:
The top of the front door is fixed on 2 sliding wheels hanging to a rail. The stem of the wheels is 1" in diameter, the rail is fastened to the front top frame by four 1x8 UNC bolts.

The sliding door dimension is

$A = 5' \times 8' = 40\ \text{ft}^2$

The force acting on the sliding door due to the overpressure (see Table 1) is:

$F = 2\text{psig} \times 40\ \text{ft}^2 = 11{,}520\ \text{lb}$

Thus the force acting on each 1x8 UNC bolt of the rail is:

F_{bolt} = 11,520 lb/4 = 2880 lb

Since this force is much smaller than the ultimate tensile force that a 1/2x13 UNC bolt can withstand, and a 1x8 UNC bolt is much stronger than a 1/2x13 UNC bolt, therefore the bolts of the rail will not fail following a postulated HE explosion. In addition, the motion of the front door (when it is closed) is further restricted by a 7' steel clamp bolted to the front frame (by 3 bolts) and a 7' floor stop bolted to the ground (by 5 bolts).

8. Explosion fragments:
A review of the HE radiography setup indicates that there will be minimum fragments as a result of a postulated HE explosion. These fragments will be confined by the 1/4" steel panels and the 1/8" lead panels of the Z-Cave.

Table 1 Forces acting on the roof

Force acting on roof vs. roof weight					
	Density	W	D	H	Weight
	(lb/ft3)	(ft)	(in)	(ft)	(lb)
Right wall, steel panel	489.7	10	0.25	8	816
Right wall, lead panel	704	10	0.125	8	587
Left wall, steel panel	489.7	10	0.25	8	816
Left wall, lead panel	704	10	0.125	8	587
Back wall, steel panel	489.7	8.5	0.25	8	694
Back wall, lead panel	704	8.5	0.125	8	499
Roof, steel panel	489.7	10	0.25	8.5	867
Roof, lead panel	704	10	0.125	8.5	623
Front wall, steel panel	489.7	5	0.375	8	612
Front wall, lead panel	704	5	0.125	8	293
Front doorl, steel panel	489.7	5	0.375	8	612
Front door, lead panel	704	5	0.125	8	293
				Total	**7300**
	pressure (psi)	W(ft)	H(ft)		Force (lb)
Force acting on roof	2	10	8.5		24480

Note:
water density = 1 g/cc = 62.3 lb/ft3
steel density = 7.86 g/cc = 489.7 lb/ft3
lead density = 11.3 g/cc = 704 lb/ft3

```
***** PROGRAM FRANG VERSION 2.1b *****
*** SEPT 1997 ***

CAPABILITIES OF THIS PROGRAM INCLUDE:
  1. UP TO FIVE FRANGIBLE PANELS CAN BE TRACKED
  2. INITIAL DISPLACEMENT AND VELOCITY OF PANELS CAN BE INPUT BY USER
NFESC FRANG2


Bldg. 327 Z-Cave Analysis

Global Parameters
    Charge Weight ...........................    0.10 lbs
    Volume ...... ...........................  680.00 ft^3
    Initial vent area .......................    0.25 ft^2
    Number of frangible panels ..............       0
    Time step ...............................    1.00 msec
    All output will be suppressed ...........   false

GAS PRESSURE CALCULATION
    Peak Gas Pressure .......................    2.00 psi
    Gas Load Duration (No Panels) ........... 1824.61 msec

REVISED SHOCK IMPULSE ON PANELS
  PRESSURE LESS THAN .001*PEAK PRESSURE AT T =  1046.00

        *************************  WARNING  ************************
             W/V = .0001 < .001

        *** CALCULATED IG/W**(1/3) MAY BE LESS THAN ACTUAL VALUE ***

                                     RESULTS SUMMARY
  GAS          PEAK GAS      TOTAL GAS     CHARGE     TRIANGULAR GAS
DURATION       PRESSURE       IMPULSE      DENSITY    DURATION, Teq
Tg  (ms)       Pg (psi)     Ig (psi-ms)      W/V        Ig*2/Pg (ms)
1046.00           2.00        1368.00       0.000        1369.90

***** END FRANG RUN.
```

References:

(Back et al, 1997A), N.L. Back, D.W. O'Brien, R.A. Richardson, P.C. Wheeler, "Analysis of X-Ray Induced Charge Separation and Electric Field Effects in Weapons", UCRL-ID-126264, February 24, 1997.

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(Wager, 1997), P. Wager and J. Connett "FRANG User's Manual", Naval facility engineering Service Center, May, 1989. (The code used in this calculation is a 1997 version)

:rdepartmental letterhead

:il Station L - 345

t: 2-7149

HAZARDS CONTROL DEPARTMENT
Technical Support & Policy Development

Date: December 11, 2000

⊃:	Ken Dolan, L-333
ROM:	J. E. Dotts, L-281
UBJECT:	Use of Room B273A for Operations With 125 Grams of TATB

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have reviewed the operations with TATB proposed for room 273A in the ;ubbasement of Building 237. These operations are the same type of operations :urrently conducted in rooms B169F and B169H. The equipment used in Room 237A will not induced energy into the explosives, which could cause a reaction in the explosives. (Reference 1). Therefore the operators will not be exposed to a hazard greater than that approved for other operations in the facility.

The operation in room B273A will be considered a Class II operation in accordanc with the DOE Manual, Chapter VI, Paragraph 4.1b.

If explosives other than TATB are to be used in Room 273A an additional analysi will be required.

JED

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Reference 1 - Norman L. Back, Dennis W. O'Brien, Roger A Richardson, P: Wheeler, "Analysis of X-Ray Induced Charge Separation and Electric Fields Eff Weapons" UCRL-ID 126264, February, 1997

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Report on Explosives Repository Testing

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ABSTRACT

After initial testing of the repositories, management determined that additional testing should be done to a.) test the non-propagating array at 12.5 grams to provide for a 25 percent over test as recommended in DOE M 440.1-1, Chapter II, Sections 13, and 21 and b.) determine the level of damage to a repository at explosives charge levels of 1- 7 grams of C-4. Verification of non-propagation at the 12.5-gram level will substantiate the decision to allow storage of ≤ 10 grams of explosives in each array cubicle up to the drawer limit of 50 grams.

The testing verified that there is no propagation between array cubicles with 12.5 gram of explosives.

Testing of the drawers was conducted using explosives weights starting at 1 gram and ending with 7 grams. The object of the test was to try to determine at what weight of explosives a repository drawer will open. The repository drawers involved in this test series totally contained the detonation effects of explosives weights 1 through 7 grams. During the final test at the 7-gram level, the repository drawer allowed a small amount of smoke to exit. The drawer, however, remained shut. All drawers remained operational after testing and could be opened easily.

Experimental testing of the four-drawer repository was conducted as follows:

Test Set up:

A. For 12.5-gram non-propagation test

1. For the 12.5-gram overpressure test the repository drawer contained a steel bottom plate and a standard non-propagating array as described in "Report on Explosives Repository Testing dated March 15, 2000." (See Photo 1, 12.5-gram setup.)
2. The test drawer was configured with four 10-gram PETN receptor charges placed adjacent to a 12.5-gram donor charge.

B. For Level of damage test

1. The repository drawers selected for testing response to individual explosives charges, 1 gram through 7 grams, were configured with a steel plate on the bottom and a standard non-propagating array.
2. Each charge ranging from 1 gram through 7 grams was placed in the center pocket of the non-propagating array. (See Photo 4 for donor charge setup, all quantities.)

Test Criteria:

1. For the 12.5 gram shot, the test will be considered a pass if there will be no propagation between the donor charge and the receptor charges.
2. There are no pass/fail criteria for the individual drawer response testing. The objective is to determine, if possible, at what explosives loading the locking pin on the drawer fails and the drawer opens.

Data Collection:

Still photos were taken of each test configuration prior to test and at the end of each test to show the results. Video footage was also taken of each test.

Material Requirements:

- One Fire King four drawer Repository with functional drawers.
- One 3 mm steel plate for the bottom of each drawer to be tested.
- A functional non-propagating array with foam insert in the selected array cubicle.

Results:

1. Detonation of a 12.5 grams donor charge of C-4 did not cause propagation of the 10-gram PETN receptor charges. (See Photos 2, 3.)
2. Detonation of 1 gram through 7 grams did not cause the repository drawer to open. (See Photos 5, 6, representative of all tests.)

Conclusions:

1. Storage of ≤10 grams of explosives in each cubicle of the non-propagating array may be continued. HEAF storage in 10-gram quantities provides Level II protection for personnel in the rooms were the repositories are used. Where possible, the repository should be positioned such that the drawers do not open directly toward the work area.
2. The repository drawers do not open at 7 grams explosives weight therefore the decision to reduce the MCE in repositories in B-132N to 5 grams per array cubicle adds an additional level of protection to that facility.

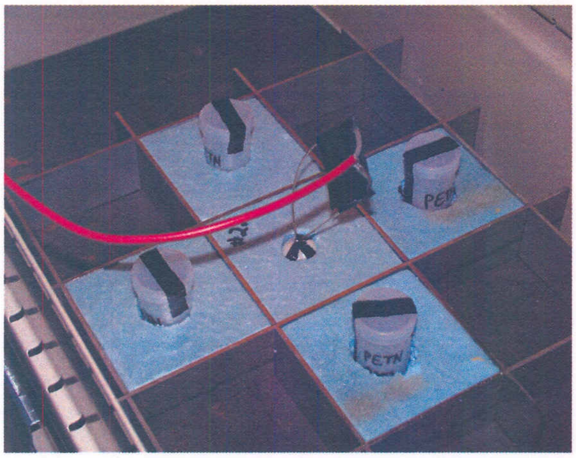

Photo 1 12.5-Gram Test Setup

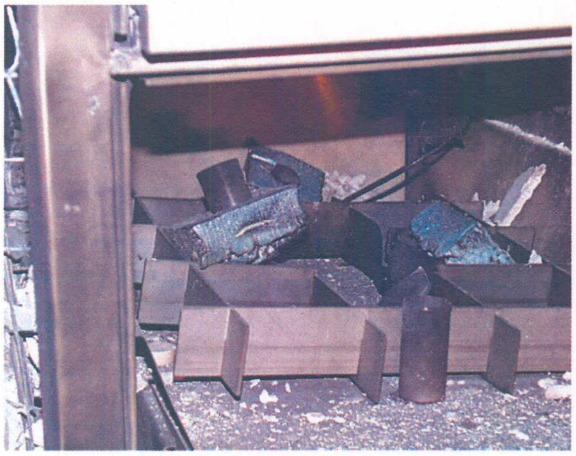

Photo 2 12.5 gm Array After Test

Photo 3 Repository After 12.5 gm Test Charge

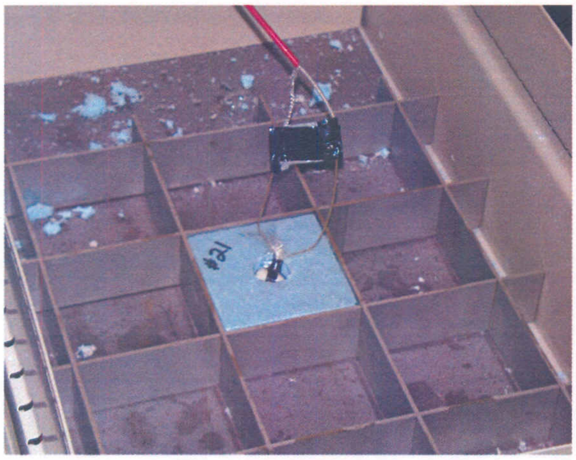

Photo 4 Sample Setup 1 gm to 7 gm Test Charge

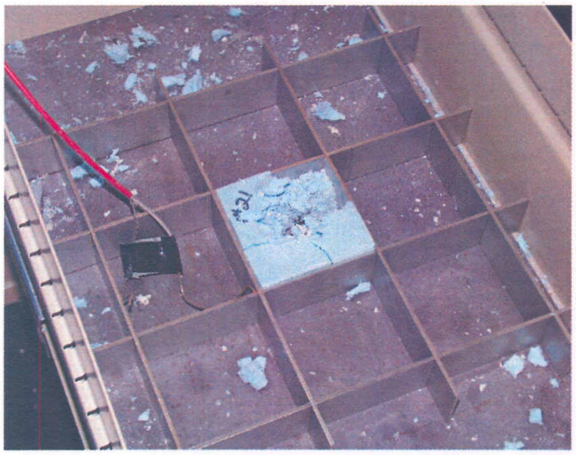

Photo 5 Representative Drawer and Array after 1gm to 7gm test (Drawer opened by Experimenter)

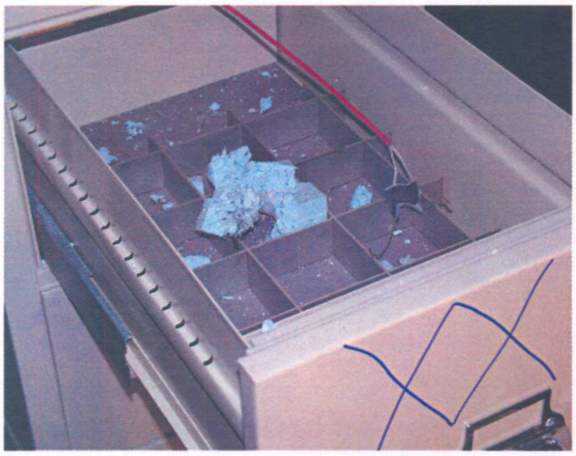

Photo 6 Representative Drawer and Array After 1 gm to 7 gm Test (Drawer opened by Experimenter)