



Department of Energy
Albuquerque Operations
Los Alamos Area Office
Los Alamos, New Mexico 87544

DEC 28 1987

Received
12/30/87
RECEIVED
DEC 29 1987
EID DIRECTOR'S OFFICE

Permit

CERTIFIED MAIL - RETURN RECEIPT REQUESTED

Mr. Michael Burkhart, Director
N.M. Environmental Improvement Division
P.O. Box 968
Santa Fe, NM 87504

Dear Mr. Burkhart:

Presently the Department of Energy's Part A hazardous waste permit application for Los Alamos National Laboratory (LANL) reports the detonation of small quantities of reactive chemicals and gas cylinders with unknown contents. This treatment practice is required because the reactive chemicals and gas cylinders are considered nontransportable under the Department of Transportation (DOT) regulations thereby eliminating shipment to an offsite treatment facility for ultimate disposal. We have received written approval to conduct the activity from the Environmental Improvement Division in a letter dated October 26, 1984. The letter allows LANL to use its discretion when implementing this practice.

During previous Resource Conservation and Recovery Act inspections by both Environmental Protection Agency and Environmental Improvement Division personnel this treatment practice was described in detailed. It was recommended by the inspectors that further written notification would be required along with detailed procedures (see enclosure) that will be employed for the above stated detonation of chemicals and gas cylinders.

By this letter and enclosure we have fulfilled your request to provide sufficient descriptive information and notification of the detonation of chemical and gas cylinders considered nottransportable under DOT regulations. If you have questions, please call James Phoenix of my staff at 667-5288.

Sincerely,

Harold E. Valencia
Harold E. Valencia
Area Manager

8021A

Enclosure

cc:

- A. Tiedman, LANL, ADS, MS A120
- T. Gunderson (HSE8-87-1335-1, 12/17), LANL, HSE-8, MS
- A. Davis, US EPA, Dallas, Texas



January 11, 1987

Standard Operating Procedures
for HSE-7 Handling and Transport of Reactive
Wastes and Gas Cylinders That Are To
Be Detonated

APPROVED BY: Ralph A. Koenig DATE 4/13/87
Ralph Koenig, HSE-7, Grp. Ldr.

APPROVED BY: John L. Warren DATE 4/10/87
John Warren, HSE-7, Assoc. Grp.
Ldr.

APPROVED BY: Karen A. Balo DATE: 4-9-87
K.A. Balo, HSE-7, Section
Supervisor

WRITTEN BY: Stanley Zygmunt DATE: 4-9-87
Stanley Zygmunt, HSE-7, Staff
Member

Standard Operating Procedures
for HSE-7 Handling and Transport of Reactive
Wastes and Gas Cylinders That Are To
Be Detonated

I. Introduction

This SOP establishes the operational and general safety procedures for handling and transporting reactive wastes and gas cylinders that are prohibited from commercial transport by Department of Transportation (DOT) regulations and that must be disposed of by detonation at TA 36. These wastes are generated throughout the Laboratory and are either transported to TA-54 Area L where the wastes are stored until a sufficient quantity has accumulated to justify detonation, or transported directly from the point of generation to the detonation site. Reactive wastes generally consist of unused reagents in their original container and individually are small volumes (less than one gallon). These wastes are not commercially transportable because age has made the material unstable, the container has deteriorated and repackaging is not possible, or the current DOT regulations prohibit commercial transport of the material. Gas cylinders are generally small lecture cylinders although an occasional large cylinder is received. Cylinders processed for detonation are cylinders that are not returnable to the manufacturer.

This SOP deals only with handling and transport of these wastes to TA-36. All other handling and transport is performed under the SOP for Chemical Waste Operations. Detonation is conducted in accordance with a SOP administered by M-8 personal (SOP M-8-5). Because the nature of the wastes changes for each detonation, a special work permit is prepared that identifies the specific wastes and recognizes the character and hazards of the waste handled for each planned detonation.

Individuals responsible for overall operations under this SOP are the HSE-7 Solid Waste Disposal Section Leader, the Associate Group Leader for Solid Waste Operations, and the HSE-7 Group Leader, who must approve any deviation from these procedures. Special work permits must be approved by HSE-3, HSE-5, HSE-7, HSE-8, M-8, and M-DO. If any of the material is radioactive, HSE-1 will also be consulted.

II. DESCRIPTION

1. A Chemical Disposal Request form is completed by the waste generator. HSE-7 personnel review the form to ensure

it is complete and accurate and inspect the waste containers to determine their condition.

2. Gas cylinders are inspected and leak tested. A leak check solution is applied to all screwed fittings and to any area of the cylinder that appears corroded. A piece of tape is put over the cylinder nozzle and bubble solution is put over a pin hole in the tape to check valve tightness. Any bubble formation is considered an indication of a leak. The special work permit identifies precautions to be taken to protect human health should a leaking cylinder have to be transported. If the safety cap cannot be removed because of corrosion, the valve will not be tested.

3. A minimum of two weeks prior to a planned detonation, a special work permit is prepared by HSE-7 and supplied to HSE-5, HSE-8, M-8, and M-DO. The special work permit includes descriptions and quantities of the wastes to be detonated and procedures for handling the wastes. The procedures recognize the nature of the wastes handled and the condition of the containers. HSE-5 reviews the waste list to determine if there are any unusual risks associated with the handling, transport, and detonation of the wastes and prescribes safety equipment to be used and precautions to be taken. HSE-8 reviews the list to ensure the operation meets environmental regulatory reporting requirements. Recommendations from these groups are incorporated into the special work permit.

4. On approval of special work permit, personnel who handle the wastes are instructed in the handling procedures. The proper use of protective clothing and emergency equipment is reviewed.

5. HSE-7 personnel package the waste in accordance with the special work permit. In most cases, the waste containers are either set in a box or can containing vermiculite. Lecture gas cylinders are set in a drum with vermiculite or other packing to hold the cylinder steady. Individual packages and containers are labeled as to the contents. Each package receives a hazard label as dictated by DOT regulations.

6. Individual packages are then loaded on a truck for transport to TA-36. The truck size is large enough to accept the load and to allow space to segregate the wastes as required by DOT regulations. Small packages and cylinders (roughly less than 20 pounds) are hand loaded on the truck. Large packages and cylinders (roughly 20 pounds or greater) are handled with appropriate equipment such as hand trucks or fork lifts, the choice of equipment dependant on the package weight and dimensions. Large packages are lifted into the truck using the truck's hydraulic lift gate.

7. After loading, the truck is placarded in accordance with DOT regulations. If the wastes constitute more than one hazard, the truck is placarded for the worst hazard.
8. The Chemical Disposal Request form, completed by the waste generator, serves as the shipping manifest required by RCRA Hazardous Waste Regulations (40 CFR 262.20). The driver keeps a copy of the Chemical Waste Disposal Request form in the truck cab during the transfer.
9. The transfer truck driver and other personnel who ride in the truck wear protective clothing as dictated by HSE-5 during the transfer. Any respiration equipment required by HSE-5 is maintained in the truck cab during the transfer.
10. The transfer truck is followed by an escort vehicle equipped with breathing equipment, protective clothing, spill kits and fire extinguishers that are compatible with the wastes handled. The escort vehicle must follow no more than 50 feet behind the transfer truck to observe the transfer truck for any irregularities.
11. Both the transfer truck and the escort vehicle are equipped with two-way radios and can contact each other, the HSE-7 base station, and the Laboratory Central Alarm Station (CAS) dispatcher.
12. The loaded transfer truck's speed is limited to 35 miles per hour.
13. On reaching the trucks destination, the truck is unloaded, small packages unloaded by hand and large packages lowered from the truck with the hydraulic lift and moved to the detonation area with a fork lift or hand truck.
14. At the detonation site, the wastes are unpacked and the containers inspected. Any packaging that is contaminated by a leaking container is included in the detonation. Dependant on the waste's hazard and as directed by the special work permit, packed wastes may be delivered to the detonation pad. All other packing materials are removed from the site. Personnel unloading and unpacking wastes wear safety clothing and breathing equipment as prescribed by HSE-5.
15. Detonation of the wastes is performed under an M-8 SOP.

III. HEALTH, SAFETY, AND ENVIRONMENTAL CONCERNS

There are two major concerns with transport of these wastes:

- o unplanned reaction of wastes, and
- o unplanned release to the environment.

Unplanned reactions can generate sufficient energy to harm personnel handling the wastes. Releases to the environment can have harmful health effects on the waste handler and general population that is significantly exposed as a result of a release.

IV. PROCEDURES FOR SAFE OPERATIONS.

The handling and packing procedures developed in preparing the special work permit address the conditions that would result in container failure or unplanned reaction. The packaging provides protection for the container during transport and a secondary barrier between the waste and the environment to prevent contact of the wastes with elements that could cause the waste to react. The release of some material may not be avoidable, such as that occurring during the transport of a leaking gas cylinder. The special work permit must address these circumstances and specify procedures that protect the waste handlers as well as the general public.

Safety equipment and spill cleanup kits are maintained on both the transport truck and the escort vehicle. The HSE-7 personnel who handle the wastes, in addition to being trained in hazardous waste handling procedures and emergency response, are briefed on any specific hazard associated with the materials handled before packaging starts. These personnel are trained to provide first response to emergencies.

Both vehicles are equipped with radios. In the event of an emergency, the CAS dispatcher is contacted. Response to the emergency is as described in the Hazardous Waste Facilities Contingency Plan (see the Laboratory's RCRA part B Permit Application). The plan includes provisions for additional response personnel and equipment. Details for area evacuation are given in the contingency plan.

To lower the risk of traffic accident and lower the risk of exposing reactive wastes to moisture, wastes are only transported under good weather conditions. Wastes are not moved during rain or snow storms or when roads are snow packed or icy.

V. RELATIONSHIPS BETWEEN OPERATIONS AND SUPPORT ACTIVITIES

1. HSE-7 is responsible for scheduling the waste transport, inspection of waste containers, preparation of the special work permit, waste packing, and waste transport.

2. HSE-5 reviews the list of wastes and recommends special handling precautions, safety clothes, respirator protection and safety equipment for each waste shipment.

3. HSE-8 provides meteorological information and dispersion modeling to ensure safe dispersion of detonation gases.

4. M-8 provides facilities for the detonation and the detonation is conducted by M-8 personnel in accordance with that group's SOP.

VI. TRAINING

All personnel involved in the packaging and transport of wastes have received hazardous waste related training as defined in Section 8 of the Laboratory's RCRA Part B Permit Application. In addition personnel are briefed as to any special hazards associated with the wastes to be handled.

VII. EMERGENCY PROCEDURES

General response to emergencies is as follows:

A. Fire or Explosion

1. Pull the local fire alarm, if available, and call 9-911 to furnish information, or contact the CAS dispatcher by radio.
2. Notify HSE-7 Group Office and supervisor of the area affected.
3. Notify HSE-DO Emergency Number 7-7878.
4. Evacuate the scene in an upwind direction. If in a technical area, report to the local muster area. If the emergency occurs during transport, move a safe distance upwind, control traffic flow, and wait for emergency response personnel.

B. Serious Injury

1. Render assistance to any injured personnel.
2. Call 9-911 or contact the CAS dispatcher by radio for an ambulance.
3. Notify the HSE-7 Group Office and supervisor of the area affected.

C. Spill or Release of Hazardous Material.

1. If the released material is toxic or the nature of the material can not quickly determined, evacuate the immediate vicinity and post the area to prevent unauthorized re-entry.
2. Call 9-911 or contact the CAS dispatcher.
3. Notify the HSE-7 Group Office.
4. If a liquid spill is known to be non toxic, control the spill with the on hand spill kit.

Notification of the CAS dispatcher or the HSE-7 Group Office of an emergency involving a hazardous waste results in the Laboratory's Hazardous Waste Emergency Coordinator (HWEC) being notified of the emergency. The HWEC immediately proceeds to the site and evaluates the situation. Based on guidelines defined in the Hazardous Waste Facility Contingency Plan, the HWEC decides whether or not to implement the Hazardous Waste Facilities Emergency Contingency Plan. Details of the HWEC duties and responsibilities are given in the Contingency Plan

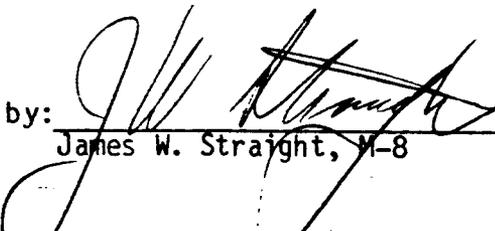
VIII. RESPONSIBILITIES

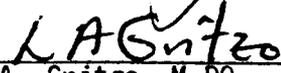
The HSE-7 Group Leader has the overall responsibility for these waste handling activities. The Associate Group Leader for Solid Waste Operations manages the waste handling activities and a Section Leader reports to the Associate Group Leader. For each planned waste shipment, a staff member is assigned to schedule, plan and oversee the packaging and transport of the waste.

		Work	Home
Group Leader	Ralph Koenig	7-4301	662-2458
Deputy Grp. Ldr.	Ludgard Emelity	7-5839	662-7993
Assoc. Grp. Ldr.	John Warren	7-5398	662-9639
Section Leader	Karen Balo	7-6095	672-1369
Site Staff	Paul Emerson	7-6095	672-1028
Site Staff	Brian Myers	7-6095	672-9509

SOP M-8-5: Firing Operations
Version D: 0319Z/0001W
Topic: Explosives
Page 1 of 19 page(s)
Date of original issue 2-3-60
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STANDARD OPERATING PROCEDURE
FOR
FIRING OPERATIONS

Approved by:  Date: 5 Oct 87
James W. Straight, M-8

 Date: 10/20/87
L. A. Gritzo, M-DO
JG 10/20

 Date: 11/25/87
W. C. Courtright, HSE-3
EKG/123

I. PURPOSE

This SOP presents the procedure for conducting test-firing operations involving explosives at TA-36 (Kappa Site). It covers these operations at the five firing sites, Bunkers TA-36-3 (Eenie Site), TA-36-6 (Meenie Site), TA-36-8 (Minie Site), TA-36-12 (Lower Slobbovia), TA-36-55 (I.J.Point), and the associated firing mounds. TA-14 (Q-Site) operations are covered in separate SOPs

II. DEFINITIONS

- A. Firing-Site Leader: For the purposes of this SOP, the term "firing-site leader" will refer to those individuals specifically designated by the M-8 Group Leader as eligible to fire shots involving explosives at TA-36.
- B. Knowledgeable Visitor: A non-M-8 employee whose work duties require frequent visits within the M-8 firing areas and who is familiar with the M-8 firing safety procedures may be designated as a "knowledgeable visitor" by the M-8 Group Leader. This person does not need to notify the M-8 Group Office that he is in the firing areas and may take other visitors behind the barrier without notification of the Group Office.

III. FIRING SITE SAFETY FEATURES

The following features cover the operations at all firing sites.

- A. Access is controlled to the M-8 firing sites by means of a radio-controlled gate located 100 m west of the Main Office Building (TA-36-1). M-8 personnel and knowledgeable visitors gain access to the firing areas by using portable actuators to lift the gate barrier.

All other individuals must clear through the Group Office before they will be allowed access to the firing area. Group Office personnel will instruct the visitor on the site hazards and enter his/her name in a log. The visitor will contact the Group Office as he approaches the gate, and the Group Office will raise the gate to allow the visitor's vehicle to enter. As the visitor is leaving, he/she will again contact the Group Office at the gate, and the time of departure will be recorded in the log. Non-M-8 personnel accompanied by an M-8 employee or a knowledgeable visitor need not clear through the Group Office.

- B. Each firing circuit is locked, and only authorized M-8 employees have keys to these locks. The unit cannot be operated without the key.

- C. Flashing red lights are located at the entrance to each firing site. They start operating automatically when the firing circuit is unlocked, and a signal light at the firing bunker indicates that the warning lights are operating. At present, I.J. Point is not equipped with flashing lights. Routine clearance procedure requires that the access road be blocked by a manned vehicle during firing operations; therefore, the alternate procedure does not compromise safe operations.
- D. A Klaxon sounds automatically when the firing circuit is unlocked. The Klaxon is loud enough to be heard anywhere within the firing area. Hearing protection should be worn by any person outside the bunker and near the Klaxon because the noise level is above the recommended short-term exposure limit.
- E. Warning signs at each firing-site entrance, except I.J. Point, read:
- DANGER
STOP
When lights are operating.
This sign is a safe distance from the explosion.
Return to sign if horn or siren is sounding.
- F. A warning sign near the firing mound reads:
- DANGER
EXPLOSIVES
Return to lights if any horn or siren is sounding.
- G. A warning sign is used for blocking the access roads during a clearance procedure and reads:
- DANGER
Fragment Area
Keep Out
- H. There is free-channel radio communication among all firing bunkers, the charge preparation rooms, vehicles used for clearance operations, and the Group Office.
- I. During the time that the firing circuit is unlocked, the telephone line to the site shall be reserved solely for calls concerning the shot being fired.

SOP M-8-5: Firing Operations

Version D: 0319Z/0001W

Topic: Explosives

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Date of original issue 2-3-60

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- J. The firing-bunker door is interlocked with the firing circuit and, except as provided in SOP-M-8-14-B (Special Firing Procedure), must remain secured throughout the firing sequence. I.J. Point is not equipped with the interlock system. This deficiency will be corrected when a new firing control system is installed.
- K. Either the detonator cable or high-voltage supply must be connected manually from within the bunker.
1. The normal (2500-V) firing units are located inside the firing bunker. The detonator cables are disconnected from the CDU after each shot and are not reconnected for another shot until all personnel are inside shelter, as specified in Sec. VII.B.
 2. For those shots in which the firing unit must be located adjacent to the shot assembly, the high-voltage power supply shall be located within the firing bunker and the high-voltage supply cable shall be disconnected from the firing unit within the building and not reconnected until everyone is under shelter, as specified in Sec. VI.B, paragraph 2.

Note: For a full discussion of the operation of the firing units, see Appendix A.

- L. An interlock system precludes connecting detonator cables to the 2500-V CDU, or the high-voltage supply to the short-firing-cable CDU while electronic maintenance and tests are being performed.
- M. The timing of warnings and firing-circuit charging is controlled by a sequence timer. Four minutes (during which the Klaxon is sounding) are provided for warmup of the firing circuitry. A 30-second siren warning is sounded, followed by a 30-second period without the siren sounding. A 45-second siren warning follows, after which high voltage is available for the firing unit.
- N. A spring-loaded "Arm Switch" controls the charging of the CDU. It operates high-voltage relays between the high-voltage power supply and the capacitor bank in the CDU. Pushing the "Arm Switch" disconnects a shunt across the capacitor bank, connects the bank to the high-voltage supply, and enables the CDU trigger circuitry. Redundancy is provided by a similar circuit inside the CDU. This circuit is controlled by an arming relay inside the CDU that is activated by the sequence control in the control board. Actuation of this arming relay occurs with the enabling of the "Arm Switch" and is the final event in the timed sequence.

IV. PRELIMINARY PREPARATIONS

- A. If, in the opinion of the firing-site leader, there is a possibility that a fire will be started as a result of a planned shot, the firing-site leader will contact the Group Office 24 hours in advance of the scheduled shot time. The Group Office will notify the M-Division Office, which will contact the Fire Department. On the actual shot day, a one-hour warning of the firing time will be called directly to the Fire Department by the firing-site leader. If an earlier firing time is desired, the firing-site leader must contact the M-Division Office, and the Division Office will contact the Fire Department to reschedule, if possible. Reschedule the Fire Department if the prearranged time is delayed by more than 45 minutes. (Note: communications within one hour of the scheduled shot time are made directly between the site leader and the Fire Department; otherwise, the M-Division Office should make the contact). When reporting standby requirements, the firing-site leader should give the shot a hazard category—low, medium, or high. The Fire Department will decide the number of tankers to be assigned to the shot. Special consideration should be given to shots involving uranium or copper. During the firing procedure, Fire Department personnel shall remain outside the area cleared for the firing operation until they are cleared for entry. Under exceptionally high fire hazard conditions, the group leader may allow the Fire Department vehicles to be placed at a closer location.
- B. The Group Office should be notified, preferably 24 hours in advance, if an exceptionally large charge (100 kg or more) is to be fired. The Group Office will notify the M-Division office.
- C. If the fragment range is expected to include areas under the control of other groups (M-4 or M-6), the involved group shall be contacted through the M-8 Group Office for approval at least 24 hours in advance. An appendix to this SOP discusses the evaluation of fragment hazards.

V. CIRCUIT TESTING AND MAINTENANCE

Before actual firing, but frequently after a charge has been assembled on the firing mound, it is desirable to test various aspects of the firing control circuits, including charging and triggering the CDU. A by-pass system is installed at each firing site. This by-pass, actuated by turning a firing circuit lock switch to the "Test Mode," permits the CDU to be charged and triggered without the audible and visual warnings or the door interlock systems. This by-pass system is interlocked with a cable trap door, through which the detonator cables must pass to be connected to the CDU.

Thus, connecting a detonator cable to the CDU disables the by-pass function, thereby preventing the firing of a shot when the warning system is not operating.

- A. Warning signals must not be sounded on the horn or siren when any of the firing equipment is being maintained, adjusted, or operated with any intention other than that of indicating that a hazard exists, except that the warning signals may be tested to determine whether they are in operating condition.
- B. Various components of the firing-control circuit are modified and improved at infrequent intervals. However, the design logic of the firing circuit shall always include a redundant system (two or more logic operations in series), which inhibits the connection of detonator firing cables or the high-voltage supply cable to the CDU during the testing and maintenance phase.

VI. CLEARANCE PROCEDURE

Under the conditions stated in Sec. III.A, people who are not knowledgeable about M-8 firing procedures may be within the hazard area. Therefore, it is imperative that the hazard zone be carefully cleared before any hazardous operation is initiated. Only M-8 personnel or people accompanied by an M-8 employee will be allowed to remain within the hazard zone in a safe place. Persons remaining within the hazard zone must be in the firing bunker and not in either a day magazine or a charge preparation room. Depending on the real extent of the hazard zone, as determined by the firing-site leader, one of the following two levels of clearance will be used.

In each case described below, roadblocks will be established by parking a radio-equipped vehicle in the center of the access road. The emergency warning lights on the vehicle will be operated throughout the clearance operation. If anyone passes a blockade and enters a hazard zone, the helper manning the roadblock shall immediately notify the firing-site leader to "STOP" the firing sequence. The employee manning the roadblock shall remain at his station and shall not attempt to chase the miscreant. The firing-site leader shall immediately discontinue the firing sequence and confirm receipt of the message by stating:

"The firing sequence has been stopped at Bunker ___."

The firing-site leader should then take steps to clear the area again before restarting the firing sequence.

- A. If the charge is bare [surrounded only by a low-density material such as wood, foam, sand, cardboard, etc. or has only very thin, low-density metal (2-mm aluminum)] and the site leader conducting the firing operation determines that the hazard zone is within the boundaries of the particular site, only that firing site need be

cleared. This is accomplished by a helper who searches the site in a radio-equipped vehicle and proceeds to a safe position on the site entrance road. The vehicle should be parked, or a sign placed, to physically block vehicular access to the firing mound. The helper doing the clearing will then notify the site leader by radio that the firing area is clear for firing. The helper shall use the following format for this radio transmission:

"Calling Name of Site Leader at Bunker No. from Name of helper; the firing area has been cleared to Location."

The site leader will then confirm the transmission as follows:

"This is Name of Site Leader at Bunker No., confirming roadblock at Location."

The manned roadblock will remain in place until the site leader notifies the helper that a safe condition exists.

- B. When the hazard zone extends beyond the boundaries of the site at which the shot is to be fired, the following clearance procedure will be used. A general map of the firing sites is presented in Appendix B of this SOP. Each firing site has a map of its immediate area with a scale of 1 in. = 400 ft.

The firing-site leader will call the Group Office and obtain the number and location of visitors in the firing areas of Kappa Site. The site leader may then begin the clearance procedure, ensuring that all visitors have been cleared from the hazard zone or moved to a safe location under the aegis of an M-8 employee. Employees and visitors remaining during a shot must stay in the firing chambers, not in a day magazine or a charge preparation room.

Because of the geographic locations of the firing sites, four clearance procedures will be outlined.

1. Bunker 12 (Lower Slobbovia)

The site helper will clear the firing site in a radio-equipped vehicle and proceed to a safe position on the site entrance road. If the hazard zone extends beyond the Main Magazine area (TA-36-9 and -10), the fragment-area warning sign must be placed in the center of the site entrance road while the Main Magazine area is being cleared. After the hazard zone has been cleared, the helper will park the vehicle to block the road and notify the site leader by radio (using the format specified previously) that the Lower Slobbovia area is clear for firing. The helper will remain at his vehicle until he is notified by the site leader that a safe condition exists.

If it is necessary to fire a shot for which the hazard zone extends 500 m (1600 ft) north-northeast toward Pajarito Road, a special SOP will be required.

2. Bunker 3 (Eenie); Bunker 6 (Meenie); Bunker 8 (Minie)

Two radio-equipped vehicles will be required. The driver of one vehicle will proceed from Minie Site and clear the Minie-Site area. While Minie Site is being cleared, the driver of the second vehicle will clear Meenie Site area. After Meenie Site and Minie Site have been cleared, the vehicles will meet at the Potrillo Drive intersection. The drivers will then proceed separately to the Main Magazine and I.J.-Point turnoffs. Eenie Site will be cleared by the person going to I.J.-Point turnoff. This may be done by placing the fragment warning sign in the center of Potrillo Drive and searching the site, or by contacting Eenie-Site personnel and asking them to clear the site. The person conducting the clearance must not leave the Eenie-Site entrance until the site personnel have informed him that Eenie Site is clear. When the clearance operation has been completed, each operator will park the vehicle or place a sign to block the road, and then he will notify the firing-site leader that the area is clear for firing. The same format is followed for radio transmission as given previously. Each helper will remain at his vehicle until he is notified by the site leader that a safe condition exists.

3. Bunker 6 (Meenie) and Bunker 8 (Minie)

When Meenie-Site or Minie Site-personnel are firing a shot that might throw fragments to the adjacent site but that would not throw them to any portion of Potrillo Drive, the clearance operation should follow the outline described above, but it need extend no farther than the Meenie/Minie road intersection with Potrillo Drive. A driver in a single vehicle may clear with a sign on the road or radio communication.

4. Bunker 55 (I.J. Point)

- a. Firing operations will be limited to those shots whose non-directional fragment ranges are less than 550 m (1800 ft), to reduce interference with Group M-4's operations. A separate SOP will address the operations in which longer fragment ranges are expected and in which M-4 firing sites must thus be cleared.

- b. The gate between TA-36 and TA-15 along Ridge Road will be locked with a chain and padlock just before a firing procedure is started. The key for the padlock will be retained by the I.J. Firing-Site leader during the firing operation. The chain will be removed after the firing operation has been completed or discontinued.
- c. An M-8 employee in a vehicle equipped with a radio will clear the area adjacent to the firing mound and then proceed to a safe distance along Ridge Road toward the main M-8 (TA-36) area. The road will be physically blocked to prevent access to the I.J. firing area.
- d. Fragment shots that require clearance along the I.J.-Point/M-4 road beyond the Ridge Road gate will require a special procedure.

All or any combination of sites (one to five sites) may fire under the same clearance operation if the site leaders determine that no unusual hazards will be created by more than one firing operation under a single clearance.

- C. Outside of normal working hours, when the firing sites are normally unoccupied, a modified clearance procedure will be used. The Group Office will be informed that a firing will take place outside of normal hours. The Group Office will notify the M-Division Office about shots fired outside of the period 8:00 a.m. to 5:00 p.m. on work days, and at any time on weekends and holidays. For a late shot, the Group Office will leave the access gate in the closed position. A sign will be left at the gate actuator located in the Group Office stating which site is conducting a late firing. The site personnel are responsible for leaving the access gate in the open (upright) position after the firing operation has been completed. For shots to be fired before normal working hours, the site personnel shall close the hazard-area access gate before starting the firing sequence. Group Office personnel will notify Security Station 100 that a firing outside of hours is scheduled, and they will give the location and approximate time that the shot will be fired. For weekend and holiday firing activity, when the Group Office is normally not operating, the firing-site leader is responsible to verify that the Security Communication Office (Station 100) has been properly notified.

1. Hazard zone within individual site boundaries

If the hazard zone is within a site's boundary, then the procedure outlined in Section VI.A shall be followed for shots outside of normal working hours.

2. Hazard zone extends beyond the individual firing-site boundary

Only one helper is required to clear the hazard zone for shots fired outside of hours when the hazard zone extends beyond the firing-site boundary. When the site leader is ready to start the clearance procedure, his helper will proceed to Lower Slobbovia in a radio-equipped vehicle and clear the entire area to I.J.-Point turnoff or beyond, where a roadblock will be set up and maintained until the site leader notifies the individual that the firing area is in a safe condition. Warning signs will be used to prevent access into the hazard zones that have been cleared whenever the individual doing the clearance must leave Potrillo Drive to clear unoccupied areas.

- D. If clear radio contact cannot be maintained between the helper stationed at the roadblock and the firing site-leader, a relay may be set up through a telephone or another radio, provided that such action has the prior approval of the group leader and that the individual acting as the relay operator is familiar with the M-8 field operations.
- E. To reduce the possibility of confusion or misinterpretations of radio messages, the following are suggested.
 1. Reserve the use of words such as "hold" and "stop" for emergency communications to have the site leader terminate the firing sequence until further notification.
 2. Use the name of the individual being contacted by radio, in addition to the site designation, during any radio communications involving hazardous operations.
 3. Refer to M-8 sites by these designations in radio transmissions:
 - BUNKER 3 (Eenie Site)
 - BUNKER 6 (Meenie Site)
 - BUNKER 8 (Minie Site)
 - BUNKER 12 (Lower Slobbovia)
 - BUNKER 55 (I.J. Point)
 4. During Confirmation of the radio check and site clearances, proceed in sequence from Lower Slobbovia through to I.J. Point turnoff and Building 1.
 5. Avoid and curtail nonessential radio transmissions while any firing operation is in progress.

VII. FIRING PROCEDURE

- A. When the firing-site leader receives notification that the hazard zone has been cleared, he will secure the firing-bunker door, unlock the firing circuit (thus starting it), and make certain that the warning lights and Klaxon are operating. If the flashing light, Klaxon, or siren fails to operate, he shall shut down the firing operation without firing.
- B. He may connect the detonator cable to the CDU and proceed with any other preparatory activities required while the normal firing sequence progresses.
- C. If the warning lights, Klaxon, or siren is not operating, after terminating the firing sequence, the site leader may contact the group leader for special permission to restart the firing sequence without the lights, Klaxon, or siren. Before giving such permission, the group leader must establish that the shot can be safely fired without the warning signals, including additional roadblocks and visitor check, if needed, and that the delay required to repair the inoperative equipment would unduly delay the group operations.
- D. Just before actuating the "Arm Switch," the firing-site leader will contact each roadblock by radio to ensure clear radio contact. The format of this transmission shall be as follows:

"This is a radio check from BUNKER No."

The helper shall respond:

"Received Loud and Clear at Location."

After the firing-site leader has assured himself that all radio checks have been received, he may then proceed to fire the shot at his discretion.

VIII. MISFIRES AND ABORT CONDITIONS

If the firing-site leader pushes the "FIRE" button and the shot fails to fire, he will try, without sounding the "All Clear," to determine whether the failure creates a potential hazard, e.g., a "hangfire." Without terminating the firing sequence, he will look for possible trivial causes (an open interlock circuit or an unconnected detonator cable). If the cause is not located or is not trivial, he will disconnect the firing cables and wait five minutes. After this waiting period, a remote visual inspection will be performed for any sign of reaction (smoke, fire, etc.), either through the

camera periscope, or by the person blocking the road. If no evidence is noted, the site leader will then terminate the firing sequence as indicated below. If there are any unusual circumstances, conditions, or any indication of reaction, the Group Leader or Group Safety Officer will be contacted for special instructions on terminating the firing sequence. The warning signals should not be continued for longer than ten minutes unless a hazardous condition exists that cannot be safely removed. After finding the apparent cause of the misfire (except for trivial causes) and before attempting to fire the shot a second time, the firing-site leader will contact the group leader or another firing-site leader and review the operation and the corrective measures taken.

IX. COMPLETION OF FIRING OPERATION

- A. The firing operation is completed by disconnecting the detonator cables from the firing unit, permitting the siren to sound for an additional 60 seconds to allow time for the shrapnel to fall, and then locking the firing circuit. An "All Clear" of two short blasts of the siren is then sounded. If the hazard zone is confined to the firing site, the firing circuit may be locked immediately after the detonator cables have been disconnected and the "ALL CLEAR" has been sounded.
- B. In an emergency shutdown of the firing operation before the charge is fired, the 60-second sounding of the siren may be omitted.
- C. Notice of completion or cancellation of the firing operation must originate with the firing-site leader and be transmitted to all involved personnel. The format for this transmission shall be as follows:

"The shot at BUNKER No. is ALL CLEAR and it is now safe to enter."

No one is to leave shelter until he/she receives this notice.

APPENDIX A

Description and Use of Detonator Firing Units

Only exploding bridgewire detonators (EBW) and electrically driven foil detonators are allowed for Normal Operation at M-8. These types of detonators require a high-voltage, high-energy electrical source to react with sufficient violence to initiate detonation in an acceptor explosive. The energy source routinely used is a capacitor discharge unit (CDU). Only CDUs approved by M-7 are allowed for Normal Operations at M-8. This appendix describes the two categories of CDUs in current use at M-8. A commercial CDU supplied by Reynolds Industries may be used on rare occasions, and its use is covered in SOP-M-8-52.

Category I

This category is restricted to firing units in which both the CDU and the high-voltage supply are located inside the firing bunker. Generally, they are designed to fire several detonators on long firing cables (greater than 5 m). The standard 50-point unit is an example. All firing units in current use in this category use an external high-voltage supply. Detonator cable connections at the CDU are not made until after the hazard zone has been cleared and the firing sequence has been started. (See main text, Sec. VII.B).

Category II

Certain detonator types and shot assemblies must be fired with the CDU less than 2 m from the charge. In firing units allowed under this category, the CDU is located on the firing mound and the high-voltage supply is inside the firing bunker. The control circuit and firing thyatron are also located in the bunker. When Category-II CDUs are in use, the detonator must be connected to the CDU before the hazard area is cleared of personnel. Because this is inherently a more hazardous operation, the following procedure shall be followed.

- A. No detonator cable may be connected to a Category-II CDU unless the firing-site leader directly authorizes it.
- B. Before giving this authorization, the firing-site leader will ensure that
 1. the firing and test circuits are off and locked;
 2. the high-voltage supply cable is disconnected at its interlock box located on the control panel inside the firing bunker;
 3. the measured resistance across the high-voltage connector on the mound-access housing is 50 ± 10 kilohms; and

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4. the high-voltage cable from the CDU to the mound-access housing is connected. (This ensures that the safety shunt circuit is connected and operational.)
- C. After these conditions have been met, the firing-site leader may authorize the connection of the detonator cable to the CDU, shorting the detonator connector on the CDU before making the connection, as a final check that the circuit is safe.
- D. After the hazard area has been cleared and the firing sequence started, the high-voltage supply may be connected to the CDU from within the firing bunker as described in the main text (see Sec. VII.B).

No provisions are made in this procedure for firing units in which the CDU has an internal high-voltage supply. Until such provisions are made, this type firing unit is not permitted.

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APPENDIX B

M-8 Firing-Site Boundaries

A gentlemen's agreement among the various M-Division firing groups defines the geographical boundaries of the land controlled by each group. The agreement is that fragments produced by one group will not encroach into the area controlled by another group without prior notification. Section IV.C of this SOP requires that the affected group be given 24 hours warning of the scheduled shot if the hazard area extends outside the land controlled by M-8. The attached map (Fig. B-1) shows the boundaries separating TA-36 (M-8) from TA-15 (M-4). This boundary is slightly more than 300 m from Eenie Site and 400 m from Meenie Site. The 300-m radius and the envelope of the 600- and 900-m radii centered about each site are also shown on the map. In addition, each site has a topographic map, with these radii indicated at a scale of 1 in. = 400 ft.

Pajarito Road lies within 600 m of Lower Slobbovia. Shots that could throw fragments to Pajarito Road are not to be scheduled at Lower Slobbovia without the preparation of a special SOP.

Within M-8, the individual sites leaders have access control of the land immediately surrounding their own firing site and, as stated in this SOP, they will clear those areas of personnel during explosive test firings. When there is a possibility that fragments from a shot might fall in an area under the control of another M-8 site, an extended clearance procedure is required; it is detailed in the main text of this SOP. Each site leader is responsible for the final evaluation of the hazard radii for shots fired under his control.

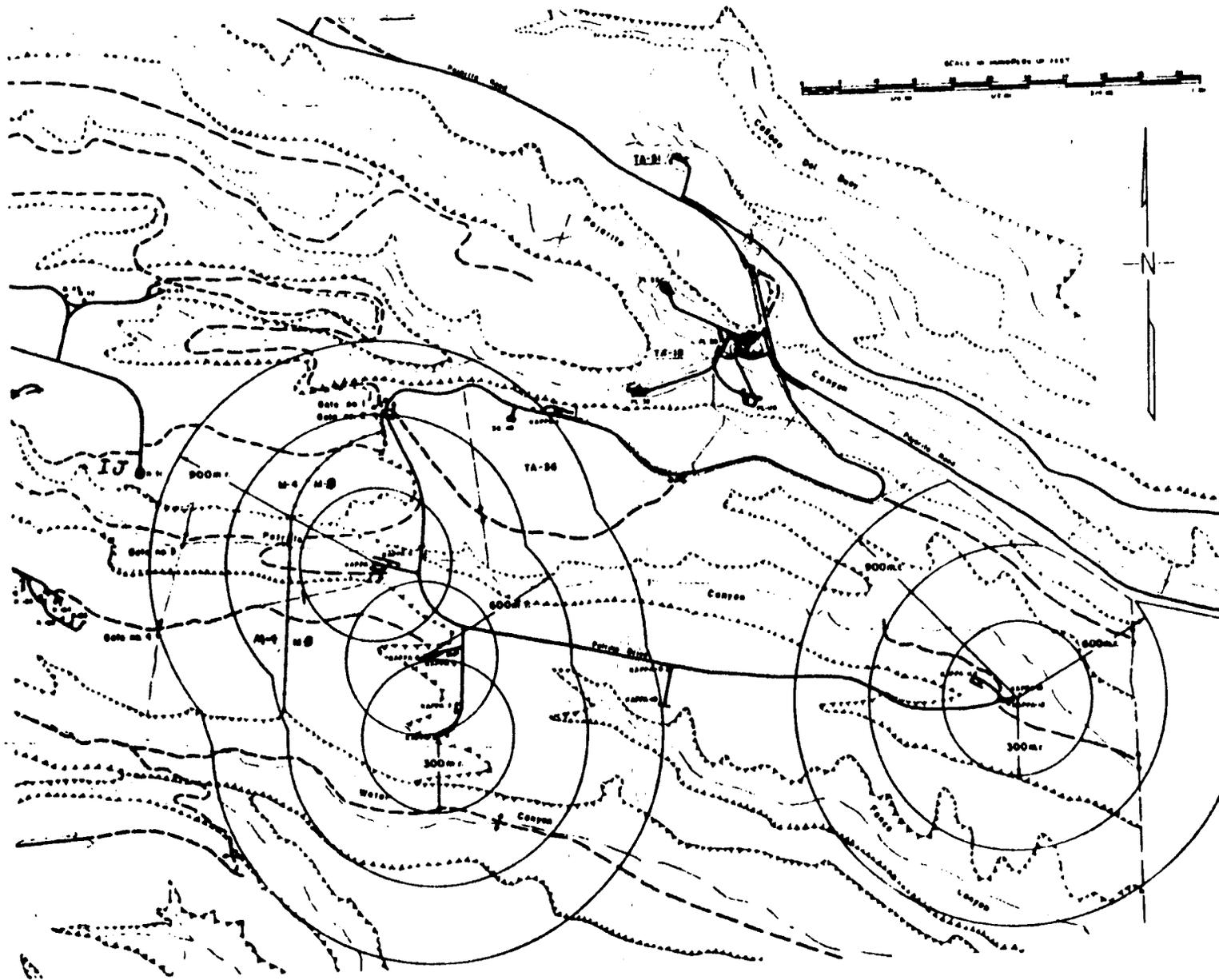


Fig. B-1

APPENDIX C

Evaluation of Fragment Hazards

The responsibility for evaluating the hazard radius for an explosive shot rests with the site leader. His evaluation must be based on his practical experience, but this appendix is to be used as a guide by firing-site personnel in this decision.

The precise solution of the range of a ballistic projectile with a defined shape is an extremely complex problem. In addition to the obvious factors, such as velocity, mass, and gravity, the additional factor of aerodynamic drag must be taken into account. For the marksman, the wind velocity (windage) must be corrected; i.e., the aerodynamic drag perpendicular to the line of flight between the muzzle and the target must be calculated. The artillery range officer may also correct for the humidity and the change in air density with altitude when he is trying to hit the desired target. The mathematics describing the ballistic trajectories is extremely complex and requires a computer for the solution.

At first thought, it might seem that gravity's effect on slowing down a fragment would provide a reasonable upper estimate of the hazard range and the flight time, as given by

$$t = V_v/g \quad , \quad (1)$$

where t is the time for the fragment velocity to decrease to zero, V_v is the initial velocity in the vertical direction, and g is the gravitational constant. A typical free-surface velocity for an M-8 shot might be 1.5 mm/ μ s and $g = 9.8$ m/s, giving a vertical flight time of 153 s and a total flight distance of 115 km! Obviously incorrect! Therefore, it is essential that the aerodynamic drag be considered. Fragments from an explosive shot have no predictable shape, however, and it is impossible to predict the drag with perfect accuracy.

A sufficiently accurate approximation for our purposes has been given by W. C. Davis (M-3-QR-78-4). He has shown that the critical parameter for estimating the range is the characteristic length L given by

$$L = \rho_m h \quad , \quad (2)$$

where ρ_m is the density of the metal in grams per cubic centimeter and h is the thickness in millimeters of the fragment measured in the direction of flight. For example, 12 mm of copper, 36 mm of Dural, or 5 mm of tuballoy have a characteristic length of 100 m. The initial velocity affects the flight distance of a fragment driven from a high explosive, but to a much smaller extent than the value of the characteristic length. The height and flight times for fragments driven vertically are given in Table C-I for three values of L and two values of initial velocity.

TABLE C-I

VERTICAL FLIGHT OF PROJECTILES FOR VARYING INITIAL CONDITIONS

L (m)	10	100	100	1000
h (mm) of fragment	1.2-mm copper	12-mm copper	12-mm copper	55-mm tuballoy
V_v (mm/ μ s)	3.1	3.1	1.0	3.1
y_{max} (m)	58	461	347	3450
t_{up} (s)	1.58	5.0	4.9	15.5
t_{down} (s)	6.5	16.9	13.2	41.7
t_{total} (s)	8.1	21.9	18.1	57.2

The calculation of the horizontal range is more complex than for the vertical trajectory. Davis has made a simplifying assumption and has found reasonable agreement with data for bullets. Figure C-1 summarizes the results obtained for initial velocities of 3.1, 1.0, and 0.5 mm/ μ s. To stay within a 600-m radius from a firing site, the characteristic length at 3.1 mm/ μ s must be less than 110 m, and for a velocity of 0.5 mm/ μ s, L must be less than about 200 m.

In evaluating the hazard radius for a shot, the site leader should use the results presented here as a guide. Barricades such as sand-filled boxes and bags, and water-filled containers will substantially reduce the predicted range. Some metals tend to break into small fragments (Dural) and others tend

to break into large fragments (nickel). The previous analysis uses only the thickness as a measure of the flight distance, whereas, in actuality, fragments tumble and large fragments will fly farther than small ones. We believe the range estimates presented here are a conservative basis for estimating hazard ranges.

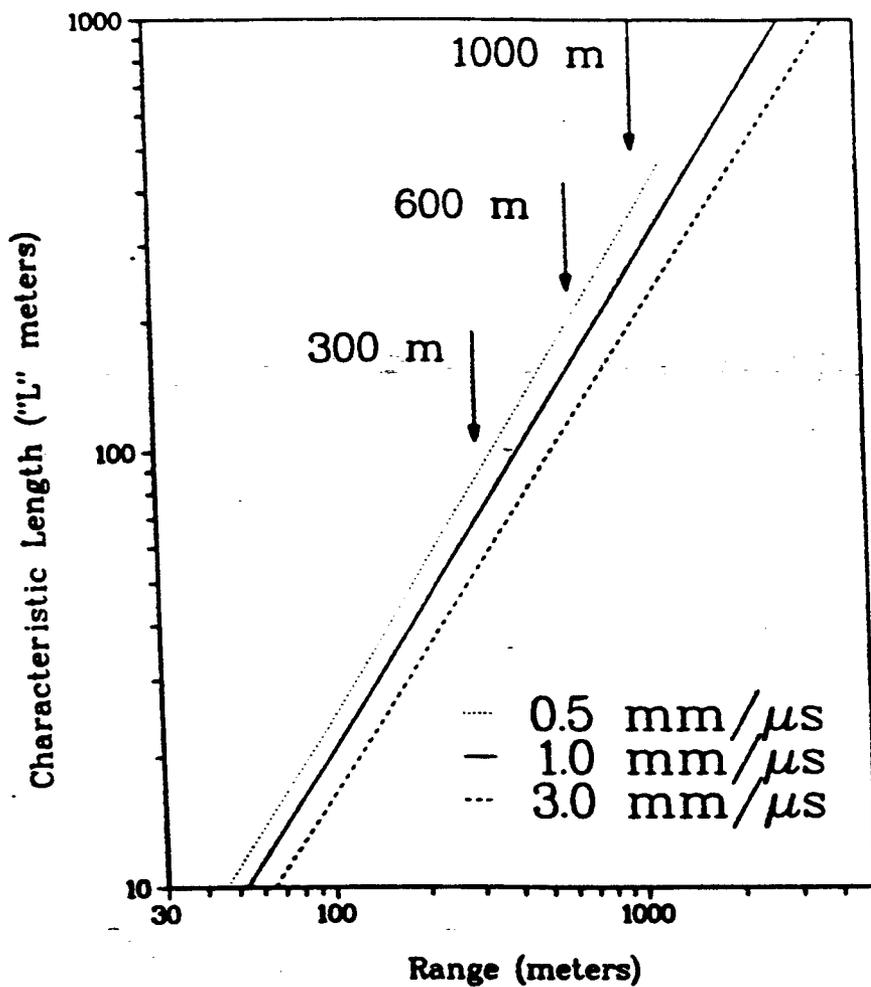


Fig. C-1 Estimated Range for Explosively-Driven Fragments with Different Initial Velocities