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THE HANDLING OF HIGH EXPLOSIVES at FIRING SITES

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Per ~~Phil Belcher~~ 4/11/54
(Person authorizing change in classification) (Date)

By Pat McAndrew 12/9/54 (Date)

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[illegible] for area

[illegible]

[illegible] firing site should [illegible] and [illegible] the [illegible] the firing site [illegible] to nearby buildings [illegible] [illegible] by personnel. The hazardous zones should be delineated on [illegible] various size charges employed by the section. The [illegible] zone is understood to be the region surrounding a detonation in which the hazard to life from fragments or blast is greater than the normal hazards to life on the [illegible] from automobiles, lightning, and so forth. It is also understood that, the hazardous zone is a zone in which positive steps will be taken for each shot to insure that all personnel are either excluded or under adequate cover.

(b) For detonations in the open air, the following distances may be considered as approximate definitions of the hazardous zone under the conditions indicated:

Weight of Charge	Metal Parts Present	Metal Parts Absent*
1 lb.	500 yds.	50 yds.
10 lbs.	750 yds.	60 yds.
50 lbs.	1000 yds.	75 yds.
100 lbs.	1500 yds.	200 yds.
500 lbs.	2500 yds.	500 yds.

*These distances are mainly determined by the hazards from the charge support.

(c) It is considered that all personnel will confine themselves to roads, buildings, and work areas. Hence, although wooded areas will normally be found in hazardous zones, such areas will be considered as clear at all times. (It should therefore be noted that any personnel expecting to enter wooded areas in hazardous zones should get specific permission from the

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firing supervisors of the adjacent firing sites.)

2. Provision of Adequate Personnel Shelter for Blast and Fragments.

(a) Shelter should be provided and clearly marked for all personnel who must remain within the hazardous zone as defined in A 1 (b). If fragments are involved in a detonation, then the walls of the shelter toward the detonation must be protected by earth and/or concrete to equivalent earth depth of at least two feet.

(b) All buildings which are unsafe for personnel during a detonation should be so marked with conspicuous signs.

3. Provision of Adequate Day Storage Magazines.

(a) Each firing site should provide day storage magazines which are sufficiently large so as to hold the amount of explosive required for the conduct of not more than one week's operations.

(b) Such day magazines should be protected against extreme temperature changes by earth covering or other insulation. They should be provided with adequate lightning protection. Their size should be such so that at least one cubic foot of space is available for each 10 pounds of explosive stored. Adequate racks or supports should be incorporated for the type of explosive casting stored, and care should be taken that explosive is never stored in such a manner that it can roll or fall. There should be provided an adequate approach to the magazine which can be kept in a non-slippery condition. A lock should be provided in the access to the magazine.

(c) Primacord may be stored with HE in such day magazines. Blasting caps, PETN caps, or other primary explosives must never be stored in such a magazine. However, PETN boostersterminating primacord in made up charges may be permitted in such magazines.

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4. Provision of Adequate Trimming and Boostering Buildings.

(a) If the activities of the site require the trimming and/or drilling of explosives, an adequate space should be provided for this purpose. Where possible, all mechanical alteration of explosive castings should be done under water. All electrical fixtures in such a building should be explosion proof. The floors should be provided with conducting composition material. All large permanent metal fixtures should be grounded, and the building provided with adequate lightning protection. All benches should be covered with linoleum or equivalent material with no cracks exposed.

(b) No electrical operations, other than permanently installed explosion proof equipment, should be permitted in such a building. All heating should be either steam or electric-steam.

(c) The amount of explosive stored in trimming or boostering buildings shall be limited to the amount upon which work is actually being done. It should not be used as either a day or indefinite storage magazine.

(d) The amount of primacord and pellets kept in such buildings should be limited to the amount actually required for the day's operation.

(e) Such buildings should be swept and all bench and shelf spaces dusted daily. Particular care should be given to seeing that explosive dust and particles do not accumulate in bench cracks, bench drawers, and similar locations.

(f) Suitable jigs and supports should be provided for holding castings upon which mechanical work is being done.

5. Provision of Adequate Locked Cap Storage Space.

(a) A locked space, completely removed from all proximity to HE, pellets, or primacord shall be provided for the storage of caps. This should be located and constructed so that in the event of a spontaneous cap ignition, no accident to personnel would ordinarily occur.

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(b) Caps should always be stored in their original containers as far as possible, and specifically kept in their cardboard shields until actually ready to remove and use.

6. Control of Traffic Entering Area.

(a) Means should be provided so that traffic arriving at the farthest boundaries of the largest hazardous zone cannot enter the hazardous area without securing definite permission, or making a definite observation of some safety signal. It is recommended that a field telephone be provided at such points which connects with some point at the firing site from which specific and definite information can usually be obtained concerning firing operations in progress. Firing sites should man the telephone sufficiently long before a shot so as to permit a vehicle to reach the shelter from the road barricade.

(b) In addition to a telephone and a conspicuous sign, it is also desirable to place a chain guard or gate across the road which must be removed and replaced by entering or leaving traffic. This chain may be removed when the area is to be clear for a long period and the telephone not manned.

(c) Firing sites that have occasional need to close off main traffic roads on the mesa should prepare a detailed and specific plan of the means by which this is accomplished and verified, and the circumstances under which it is to be invoked.

(d) All firing sites should be provided with some form of audible signal which may be sounded prior to a detonation and to indicate that the area is "all clear." Even if no blast or fragment hazard accompanies the detonation (e.g. for rounds fired in essentially closed chambers) this audible signal should be sufficiently loud so as to warn passing vehicular traffic, if any.

7. Listing of Personnel Authorized to Supervise Firing.

(a) Each section leader whose section is engaged in the firing of high

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explosives. Should prepare a list of personnel too specifically [illegible] to [illegible] firing. Such persons are the only ones authorized [illegible] command "Fire", and no round should be fired unless they have so [illegible]. In the event of accident, such authorized firing supervisors are to be considered as primarily responsible and subject to the burden of proving that the accident was due to causes beyond their control and that all usual safety precautions were taken.

2. Provision for First Aid and Reporting Accidents.

(a) Each firing site should have available the usual small First Aid Kit. A conspicuous sign should be posted near a telephone listing the procedures to be followed in case of a major accident. These procedures should follow those listed in the memorandum by Dr. Hempelmann.

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B. Handling of High Explosives.

1. Transportation from Casting Room to Site.

(a) When explosives are transported by vehicles, the number of persons riding in the vehicle should be limited to a driver and assistant.

(b) Neither the driver nor his assistant should have matches, lighters or other fire, flame or spark-producing devices in his possession nor will such devices be in the glove compartment or other compartments of the vehicle.

(c) When it is necessary to transport explosives at night, the vehicle carrying the explosives will be preceded and followed by other vehicles.

(d) Vehicles transporting explosives should carry a sign front and rear. This sign must read "EXPLOSIVES" and must have red letters on a white background. The letters must be at least 4" high.

(e) Vehicles used to transport explosives must not have random loose metal in the portions of the vehicle used to transport the explosives.

(f) Vehicles used in the transportation of explosives should be so

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loaded that no part of the load can fall off.

(g) Vehicles with metal strips in the body floor should not be used in the transportation of explosives unless a wooden floor or lattice is provided, or the explosives are boxed.

(h) Vehicles carrying explosives should not stop near any point where a fire may be burning.

(i) Vehicles used in the transportation of explosives should be kept in good condition particularly as to brakes, tail gates, doors, exhausts, mufflers, fuel leaks, tires and lights. An inspected fire extinguisher must be carried in the vehicle. It shall be the duty of the person in charge of the group transporting the explosives to make frequent inspections of the vehicles.

(j) Explosives, whether in containers, in bulk or loaded, must not be handled roughly, thrown about, tumbled over the floors or over other containers, dragged or pushed along the floor or in any way handled so that shock or friction may cause a fire or explosion.

(k) Vehicles loaded with explosive materials should not be left unattended.

(l) After a vehicle has been used to haul explosive material, it should be checked thoroughly to be certain that no particles of the explosive material remain.

(m) Vehicles carrying explosives must not proceed at more than 20 miles per hour.

(n) Caps must not be carried in the same vehicle as explosives.

(o) In general castings will be transported in suitable containers provided with adequate padding and support.

(p) Caps and booster pellets may be transported together but not with any other HE including primacord. However primacord may be transported with and under the same conditions as ordinary HE charges.

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. Transportation from [illegible] to Boostering [illegible] from [illegible] building to firing point.

(a) The above regulations will apply except [illegible] 'sc[illegible]' crew may ride to the firing site on the truck transporting the [illegible] may be carried separately from the [illegible].

(b) Boostered charges will be transported in containers, as provided in [illegible](c).

(c) If it is impossible to use a container, the interior of the vehicle should be padded and the charge held so that it cannot strike [illegible] parts

(d) Certain types of charges may be conveniently and safely carried and held in the lap of some person other than the driver of the truck.

5. Handling of Caps.

(a) Caps will be withdrawn from the main storage magazine in units of not less than one sealed box.

(b) Caps will be transported in accordance with [illegible] and [illegible] above.

(c) Caps will not be transported loose, or withdrawn from their protection tubes, and the protection tubes will be kept in place until the cap is ready to be attached to the firing line. They will be kept shorted at all times until ready to use.

4. Handling of Booster Pellets.

(a) Booster pellets will not be transported loose.

(b) Booster pellets will be withdrawn from the main storage magazine in units of not less than one sealed box.

5. Handling of Primacord.

(a) Primacord should be handled, stored, transported, and treated as a high explosive. It should be cut only with a sharp razor against wood or hard rubber.

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(b) Series of primers should be disposed of in the same manner as HE turnings or scrap; i.e. by burning in small quantities as described in paragraph B 9.

6. Smoking Regulations.

(a) Smoking shall not be permitted within 100 feet of any high explosive material in open areas nor in any building into which explosives may be brought.

(b) Within the area in which HE is employed smoking should be confined to specific buildings. These buildings shall be ones in which HE is specifically forbidden to be brought at any time. Smoking should be forbidden at all times outside these buildings, and personnel entering the area should be required to deposit matches, lighters, and smoking materials within one of the smoking permitted buildings. Electric lighters should be provided in those buildings in which smoking is to be permitted. Conspicuous "No Smoking" and warning signs should be posted.

(c) Group Leaders are responsible for ascertaining that regulations pertaining to smoking and to the carrying of forbidden articles are not violated.

7. Use of Power Tools, Hand Tools, Trimming Tools.

(a) In all operations involving explosives, insofar as practicable, safety tools shall be used exclusively. Safety tools are tools constructed of wood and other non-sparking substances, or of bronze, lead, beryllium alloys, or other metals having low sparking characteristics, and which under normal conditions of use, will not produce sparks. Steel drills, saws, and other cutting tools may be used in finishing operations on castings made of TNT, Composition B, Torpex, and Pentolite provided that the operations are carried out under water or with an adequate stream of water flowing over the cutting tool and the surface being machined. Adequate stops and other safeguards must be provided to prevent cutting tools from coming in contact with the metal component of an explosive charge. Machining operations on water-soluble explosives

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such as Baronal, Baratol, [illegible], and [illegible] must be done by remote [illegible] behind barricades capable of protecting from injury the operator and all other personnel within range of the blast and missiles resulting from a detonation of the charge being machined. The use of rasps, files, grinding wheels, [illegible] paper, or similar abrasives in finishing operations is prohibited except where the operations can be carried out under water and where the process has had the written approval of Lt. Hooper. Power tools should be operated at the slowest practicable speed, and every possible precaution should be taken to avoid excessive friction and local overheating. Power tools should be driven by air motors or from line shafts powered by motors or engines located outside the building in which the operation is to be carried out. Approved types of explosion-proof electric motors with approved starters and other electrical fittings may be used inside the building. Tools and equipment used in finishing operations should be so constructed that they can be readily cleaned after each use and explosives dust and cuttings must not be allowed to accumulate. Cutting, drilling, and other finishing operations are prohibited in magazines or in buildings containing large quantities of explosives or personnel.

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8. Provision for Adequate Supports, Jigs, Terminals.

(a) The supports, fixtures, jigs, etc. used to hold explosive charges in place during finishing operations, and assembly and rigging should be carefully designed and constructed with an ample safety factor to withstand all the stresses involved. Makeshift set-ups should not be tolerated.

9. Cleaning up, Disposal of Waste Explosives and Other Material.

(a) Waste explosives such as trimmings, short lengths of prim cord, tetryl pellets, and broken castings can be best disposed of by burning in small quantities along with waste paper, excelsior, or scraps of wood. Particular care must be exercised in burning aluminum-bearing explosives such as Torpex as the intense heat liberated is likely to induce a detonation if the explosive is

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heaped up in piles. A burning pit surrounded on three sides by an earth bunker and located at a safe distance (at least 500 ft.) from magazines and other buildings is the most suitable arrangement. Material to be burned will be alr[illegible] removed from containers as attempts to burn certain explosives under even slight confinement may result in explosions. Waste charges which are sufficiently intact to be detonated completely by means of a booster and a blasting cap can be destroyed effectively and quickly by this means at firing sites where this can be carried out safely.

C. Requirements for Firing Equipment

1. General Requirements.

(a) The firing leads and associated equipment should be so designed that they not only provide certainty of firing at the time required, but also that premature firing is impossible even in the event of defect or defects in the equipment or carelessness on the part of any personnel on the site. These requirements can be met by adherence to the following regulations. Any departure from these regulations necessitated by the particular type of measurements to be taken must be authorized by the Safety Committee.

2. Identification and Isolation of Firing Leads.

(a) Firing leads should be isolated and readily distinguishable from all other leads on the site.

(b) Firing leads may be run in conduit but other leads must not run in the same conduit and the conduit must have an independent ground.

(c) Firing leads must never be used for any other purpose than firing.

3. Termination of Firing Leads.

(a) Permanent firing leads should be provided which are terminated at the end remote from the charge in a metal box which can be locked. Only one key to the box should be used and this should be carried by the person setting the cap.

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(b) No permanent leads other than the firing leads should be connected to the box. When the box is closed it should be impossible for any leads other than the firing leads to enter the box or for any electrical connection to be made to either of the firing leads.

(c) It should be impossible to close and lock the box until the ends of the firing leads inside the box are shorted and grounded to the box which must have an earth connection independent of power circuit earth connections. Switches used for shorting and grounding should be constructed so that rough usage will not result in any possibility of the box being closed without the firing leads being grounded and earthed.

(d) Immediately after firing or attempting to fire, all connections to the firing leads should immediately be broken and the leads shorted and grounded and the box locked. Connecting leads should also be removed from the generator, battery or power source. In the event of a misfire, the key of the box must be carried by the person instructed to investigate the misfire.

(e) Temporary firing leads should only be used when permanent leads are not available and on the specific instructions of a Group Leader. If temporary leads have to be used, the ends remote from the charge should be withdrawn from the building and held by a person in full view of the person setting the cap who is responsible for insuring that the correct leads are so held. Immediately after firing, or attempting to fire, the leads must be disconnected and shorted as under (d) and in the event of a misfire the ends must be withdrawn from the building and held, as in setting the cap, before the charge is approached.

4. Sources of Current for Firing.

(a) The safest source of current for firing is a hand generator the handle of which is carried by the person connecting the cap.

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(b) When a battery is used for firing, no other connection should be made to this battery except that necessary for firing and this should not be made until all personnel are under cover.

(c) All switches in the firing circuit should be of the simplest form, and electronic firing switches should be avoided as far as possible. If electronic switches are unavoidable, they should be designed so that there is no possibility of firing on connecting the firing leads or on initially energizing the electronic equipment or on changing slightly the capacity or insulation resistence across the firing switch.

D. Firing Procedure

1. Rigging of Charges.

(a) Supports for charges should be checked before use, to insure that strength is adequate, and to insure that the charges will rest stably in the supports.

(b) Supports should not be nailed or pounded on after charges have been put in place. Use screws.

(c) In general, supports should be designed so that primacords can be inserted after charges are put in place.

(d) Primacords may be inserted at any time but they should be arranged so that they will not be stepped on or otherwise damaged by further work near the charge. The detonator must not be attached until immediately before firing.

2. Testing of the Firing Line.

(a) The firing line should be shorted at the control end (and preferably also at the detonator end) until the cap is ready to be connected, or while the line is being tested. (See C 1 above).

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b) The firing line should be periodically checked by:

(1) Visual inspection for insulation breaks, etc.

(2) Ohmeter tests for resistance between wires, between wires to ground, and for continuity.

(3) Firing a test cap.

(c) The firing line must always be tested just before attaching the cap, in order to insure that no voltage is on the line. The proper procedure is to touch the wires together, and watch for sparks; then feel the ends with fingers, and finally with tongue. Only the tongue test is sensitive enough to detect the minimum voltage which will fire a detonator.

3. Attaching the Cap.

(a) Do not remove the cap from its cardboard tube until it is ready to be connected.

(b) Place the cap inside a heavy steel pipe or behind a barricade so that accidental detonation will not injure personnel, or the charge, or primacords.

(c) Next test the firing line for voltage, and if possible make sure the control ends of the firing line are still shorted. If the firing line has a locked switch, the key should be in the possession of the man setting the cap.

(d) Connect the detonator cap leads to the firing line, and finally attach the detonator to the primacord. (Lucite adapters, available from S/Sgt. Fitzpatrick are probably somewhat safer than tape.)

(e) No unnecessary personnel should be within the hazardous zone while the cap is being attached, or at any time thereafter.

4. Disposition of Personnel.

(a) The firing supervisor is responsible for making sure that all personnel are accounted for and in safe places before shooting.

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(b) It is desirable to have a periscope or other viewing device to make sure that the danger area is clear the moment before firing.

(c) All personnel must remain in shelter until the "All Clear" signal is sounded.

5. Testing the Firing Line Preliminary to Firing the Charge.

(a) Any testing of the firing line after the detonator is connected must be done with the expectation that the charge might go off. Hence all precautions regarding personnel disposal and shelter must be taken.

(b) Tests should be made with low voltage D.C. instruments, and with a high resistance in series with the battery.

6. Warning signals for the area.

(a) Warning signals will vary, depending on the hazard and size of the danger area.

(b) Their function is twofold:

(1) To allow time for a person, who has been overlooked by the firing supervisor in the danger area, to attain safety before the charge is fired.

(2) To avoid startling personnel not in the danger area.

(c) A suggested sequence is as follows: A short warning of at least 15 seconds. Silence for one-half minute; then a long enough blast to allow plenty of time to take cover. Then fire the shot before the tone has died.

(d) If the shot was successful, it should be followed after an appropriate time (usually 1 minute) by two short blasts to indicate "All Clear". In case of a misfire, no signal will be sounded and all personnel will remain in shelter until an "All Clear."

(e) If the shot failed to fire, all personnel will remain under cover with the exception of the firing supervisor who may approach the charge after a period of ten minutes to investigate the nature of the difficulty. If the difficulty can be cleared immediately, the long blast of the firing signal

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will be re-sounded and the charge fired in the usual manner. If the difficulty cannot be immediately remedied, then the cap shall be shorted and removed, and the "All Clear" signal sounded. No specific signal will be used to indicate a misfire.

(f) The warning signals used at each firing site must be conspicuously posted near the site.

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