June 1977

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A Typical LASL Underground Nuclear Test

Walter P. Wolff

mos
oratory
California
CO 87545
rtunity Employer

UNITED STATES
ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
CONTRACT W-7405-ENG. 36

INTRODUCTION

In support of US nuclear weapon needs, the Los Alamos Scientific Laboratory (LASL) is engaged in the design, development, and testing of nuclear explosives. Since 1963, when the Limited Test Ban Treaty was signed by the United Kingdom, the Soviet Union, and the United States, nearly all US nuclear tests have been conducted deep underground at the Nevada Test Site (NTS).

Such nuclear explosive (device) tests generally are conducted for one of two purposes:

- Weapon tests evaluate device performance. These tests usually are conducted in a vertical drilled hole.
- Effects tests evaluate the effects of device output on various critical components of missiles and warheads. These tests usually are conducted in a long horizontal pipe located deep underground in a mined tunnel.

This review describes a typical sequence of events for the weapon test of a device in a vertical drilled hole at NTS, emphasizing preparations, safety precautions, device emplacement, and detonation. Figure 1 schematically depicts the general layout for a typical weapon test.

INITIAL PREPARATIONS

The decision to conduct a nuclear test, made by a panel of senior LASL staff members, begins the complex process of theoretical design and engineering development. Because only limited numbers of such tests may be conducted, careful consideration must be given to need and priority. Approval for all such tests is staffed through the Energy Research and Development Administration (ERDA). Final detonation authority must come from the Office of the President.

After the decision to conduct a nuclear test has been made, initial preparations include the following activities.

- Diagnostic instrumentation is selected that will provide data the designers need to determine the device performance.
- The proper hole depth and diameter are determined as dictated by yield and diagnostics. Typical depths range from 600 to 3000 feet, and typical diameters range from 48 to 90 inches. Figure 2 shows a large drill bit used for drilling such holes.
- The timing, control, arming, and firing (TCA&F) system is selected.
- Design and fabrication of the diagnostic rack is started. This rack houses the device and the associated firing components, diagnostics, and instrumentation.
- The layout of the ground-zero complex is determined. This plan must consider the required electrical cables, power sources, buildings, towers, cranes, emplacement hardware, and stemming (hole-filling) material. Figure 3 shows the device firing and recording facilities near ground zero, the many cables leading from the hole, and a large crane for lowering the rack into the hole.

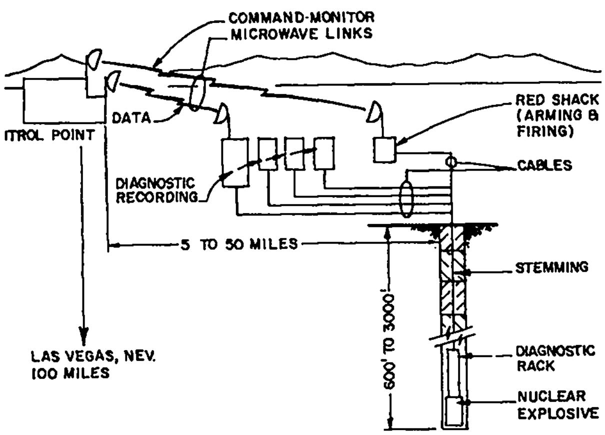

Figure 1.

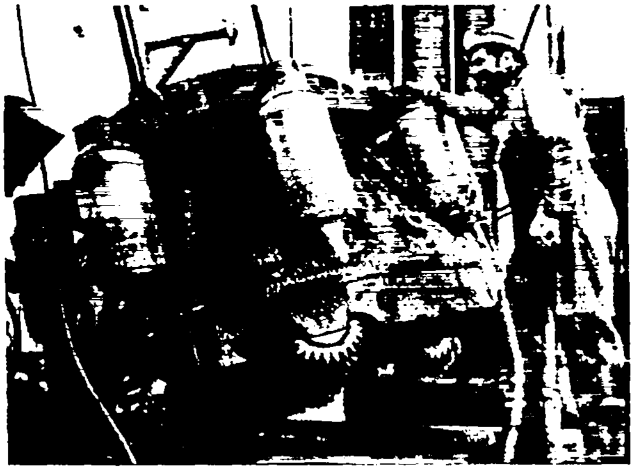

Figure 2.

SAFETY

In addition to all the normal industrial safety considerations, two special aspects of the test are examined.

(1) The containment of all radioactive debris and gases is of primary importance for any NTS underground test. An intensive study of the geology of the drill hole and the surrounding medium is undertaken. A stemming plan is determined that includes gas blocks for electrical cables, together with the type, quantity, and placement of sand, gravel, concrete, and epoxy. All of the geological and operational information is then presented to a Containment Evaluation Panel, composed of members from several agencies, that must approve the plan.

(2) ERDA also has an established program whereby all operations involving a nuclear explosive must be approved. This approval is granted only after detailed studies of the operations are conducted by formal Nuclear Explosive Safety Study groups. Topics considered in these studies are security, assembly, storage, transportation, emplacement, stemming, control, arming, and firing.

Furthermore, all personnel who perform critical duties on the device or its firing system must have the proper training and experience and must be qualified under a Personnel Assurance program that evaluates their mental and emotional stability.

ADVANCED PREPARATIONS

The test device may be assembled at Los Alamos or at NTS, depending upon operational requirements. In either case, experienced LASL design and assembly personnel perform all of the tasks, including device placement in the diagnostic rack at ground zero. Transportation of the device or components is provided by ERDA.

The TCA&F system is designed and operated to be reliable, rugged, and redundant, but it must also provide for the maximum in safety and control. Before any electrical connections to the device are made, the system is thoroughly tested and many dry runs are conducted to ensure complete compatibility.

Device diagnostics, which determine the various nuclear outputs of the test device, must be designed to detect and record these data before the sensors and coaxial cables are destroyed by the detonation, usually within a fraction of a millisecond. The information is sent uphole through cables to very fast optical recording devices or to digitizers for storage in a computer memory. The recording stations are only a few thousand feet from ground zero and so must be able to withstand the ground shock from the detonation. Much of the data is also transmitted by microwave to the control point (CP) several miles away for recording (see Fig. 1).

New data transmission and handling techniques involving fiber-optic bundles (to replace expensive coaxial cables) and improved digital methods are presently under development.

Engineering data such as temperature, pressure, acceleration, shock, radiation, ground motion, and seismic signals are also obtained. These data assist in equipment design, containment predictions, and effects evaluation.

OPERATIONAL SEQUENCE

Assuming proper scheduling and work progress, the device will be assembled and ready for transport to ground zero when the various systems located in the diagnostic rack are completed and fully checked out. Once the device leaves the assembly area, the time until it is placed in the

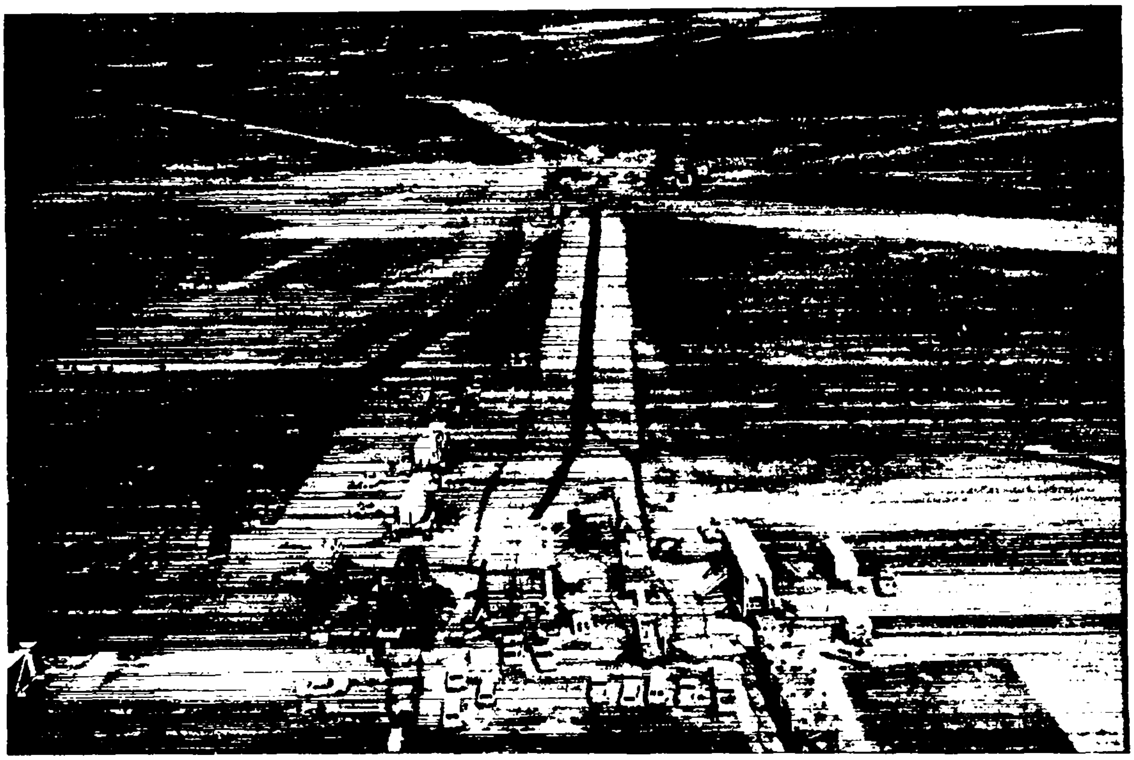

Figure 3.

rack, lowered to the bottom of the hole, and stemmed is kept to the essential minimum.

A typical sequence of events in a weapon test is as follows.

(1) The diagnostic rack is suspended from a large crane (up to 300-ton capacity) directly over the drill hole and is readied for the device.

(2) The device is transported to ground zero in a special container and placed near the rack.

(3) The device is taken from the container, placed in the rack, and aligned with the diagnostic systems.

(4) The arming and firing system is connected to the device following detailed checklists.

(5) All systems are given a final visual check and the device and its associated components are lowered into a protective canister which is then bolted to the rack.

(6) The rack and canister are lowered to the bottom of the hole using wire rope harness and a large crane. Special care is taken to protect the nuclear explosive and the hundred or so power and signal cables.

(7) The hole is then stemmed with materials that will ensure the containment of the nuclear explosion. During this time (up to two weeks), the timing and firing system and recording systems are checked and rechecked.

(8) On the scheduled day of detonation, experts from many different agencies form a "shot panel" that will advise the ERDA Test Controller on matters of safety and related subjects. Considerations such as weather, possible fallout of radioactive debris should there be a leak, security, damage assessment, and personnel safety are of primary importance. Figure 4 is the Operational Control Center, where the shot panel convenes.

(9) The LASL Test Director is given approval by the Test Controller to "arm the device," and the arming party makes the final connections of the arming and firing system to the downhole firing components. The arming party then returns from ground zero area to the CP several miles away. All other personnel have already been cleared from the forward area.

(10) After a final determination of acceptable weather conditions, the Test Controller gives the Test Director "permission to fire." The control signals are sent from the LASL control room (see Figure 5) by microwave link to the "Red Shack," which houses the arming and firing equipment near ground zero.

Contrary to popular belief, there is no "pushing the button." Most signals are sent by automatic sequence that typically cycles through its program in 15 minutes. Power is turned on, coded signals are sent to "unlock" the system, and high voltage is applied to the firing unit. A final "fire signal" is sent and the device is detonated.

There is not much to see as the detonation occurs. Puffs of dust due to ground shock waves may rise from the immediate ground zero area and from nearby craters. Structures in the recording trailer park will jump and sway. In a few seconds a ground roll or two may be felt in the CP and, in the case of large-yield shots, in the high rises. and casinos of Las **Vegas** 100 miles away.

The most spectacular occurrence may be the later collapse of the area immediately surrounding ground zero. Tremendous temperatures and pressures are generated by the energy released by the nuclear detonation, and a pool of molten earth and rock is formed deep underground in a "room" or cavity. As the temperature slowly drops, the pressure is relieved and the roof of the cavity will start to drop in, and eventually a partial chimney is formed (not extending to the surface). When the supporting strength of the earth above the chimney is exceeded by the weight of the overburden, a sudden collapse will occur and a large crater forms on the surface. It is quite a sight!

The entire test is monitored independently by teams from the US Environmental Protection Agency for off-site radiation or inadvertent release of radioactive debris. LASL's containment record has been excellent.

The test is over, but the work is only starting for the many people who will recover radioactive samples 'for analysis, retrieve the valuable data from their recording devices, and sort out the mass of information for the designers.

Figure 4.

The months, even years, of planning, designing, building, and fielding of a nuclear test by the hundreds of people involved will increase our knowledge and will eventually strengthen the nuclear deterrent capabilities of our country.

Figure 5.

Mini-Review readers are encouraged to correspond directly with Walter P. Wolff Mail Stop 679