

Seismic Reflection Survey: Health and Safety Plan

Kansas Geological Survey
Exploration Services Section

Oak Ridge National Laboratory,
Martin Marietta Energy Systems, Inc.
Oak Ridge, Tennessee
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KANSAS GEOLOGICAL SURVEY EXPLORATION SERVICES
ACCIDENT PREVENTION PLAN

I. PROJECT DESCRIPTION

Project Name: Feasibility of Shallow Seismic Reflection Techniques to Delineate Geologic Structures Influencing Transport and Fate of Contaminants in the K-25 Area of the Oak Ridge National Laboratory, Oak Ridge, Tennessee

Location: Oak Ridge, Tennessee

Site Safety Officer: Richard D. Miller

Plan Prepared By: Richard D. Miller

Estimated Duration of Field Work: 10 days

II. STATEMENT OF WORK

This high resolution seismic reflection study is designed to determine the feasibility of shallow seismic reflection techniques to image and delineate structural features influencing off-site migration of contaminants from the K-25 area of the Oak Ridge Reservation (ORR). K-25 (formally known as the Oak Ridge Gaseous Diffusion Plant) was used until 1985 for the enrichment of Uranium Hexafluoride. A result of the more than 40 years of activity at K-25 a variety of materials (hazardous, nonhazardous, radioactive, and combinations) have been stored, treated, and disposed of at various locations (Poling et al., 1992). Accurate hydrologic modeling, necessary to fully determine transport and fate, and therefore environmental risk, requires a well-defined geologic model. In a similar geologic setting at X-10 shallow seismic reflection proved to be a technique with the potential to delineate structures hidden by unconsolidated surface material and to extrapolate surface outcrop to depth (Doll et al., 1994).

The goal of this study is to image, delineate, and evaluate stratigraphic contacts, structural contacts, and karst features at the K-25 plant. Previous geophysical studies were successful in mapping the surface location of some faults but could not be used to infer dip angles or directions and were adversely influenced by cultural interference (Doll et al., 1993; Doll et al., 1994; Lemiszki et al., 1993). Key geologic targets of this reflection survey include the K-25 Fault, Whiteoak Mountain Fault, and a syncline/anticline pair within the plant area. Successful seismic interpretations of these features would provide such basic information as thickness of identified units, exact trace of the faults, approximate displacement, dip and consistency of the fault plains, as well as any associated unmapped features. The survey will be designed to image from slightly less

than 100 ft to as much as 3000 ft. Shallow, high resolution seismic reflection techniques have proven effective delineating stratigraphic and structural features at X-10 (Doll et al., 1994).

This study is proposed to include an extensive series of walkaway noise tests and approximately 18 CDP reflection lines (Figure 1). If initial testing verifies the effectiveness of the techniques at K-25, approximately 17 miles of high resolution seismic is proposed to ascertain the three dimensional expression of previously mapped surface geologic structures (Lemiszki, 1994). The survey is designed to determine: 1) sub-surface expression of mapped surface geologic features, 2) presence of previously undocumented structures, 3) optimal monitoring well locations and depths, 4) resolution potential (both horizontal and vertical) of the technique at K-25, 5) the optimum source and acquisition geometries, and 6) limitations of technique at K-25. Proven high resolution techniques (Steeple and Miller, 1990) will be used to acquire and process data on this survey. Production data will be acquired in a standard CDP format (Mayne, 1962) using roll-along acquisition techniques similar to conventional petroleum exploration data acquisition. The geophone spacing, analog filtering, seismic source, geophone type, spread geometry, sampling interval, total samples, shots/point, and acquisition philosophy will be based on extensive pre-production tests.

Geologic Setting

The ORR is in the western region of the Appalachian Valley and Ridge physiographic province. Differential erosion of folded and faulted Cambrian to Pennsylvanian sedimentary rock units are responsible for the characteristic valley and ridge topographic features of this area (Fenneman, 1938). K-25 is located on the Kingston thrust sheet and is adjacent to the Whiteoak Mountain fault (Hardeman, 1966). The East Fork Ridge syncline and Whiteoak Mountain fault are reported to be responsible for most bedrock structures at the K-25 site (Lemiszki, 1994). Even though significant differences are noted in the geology between X-10, Y-12, and K-25 (Lemiszki, 1994), previous seismic surveys at X-10 and Y-12 allow estimations of field geometries/parameters and resolution requirements and potential.

Acquisition Logistics

The project will consist of two major phases: testing and production, carried out on as many as three unique site visits. The testing phase will commence as soon as a mutually agreed time can be arranged between the Kansas Geological Survey (KGS) and Oak Ridge National Laboratory, Martin Marietta Energy Systems (ORNL/MM). The testing phase will take about 5 days and consist of several walkaway tests near planned survey lines and will be designed to evaluate parameters and equipment. The walkaway noise tests will be gathered according to common shot station and separated into distinct groups according to recording parameters (source, receiver, recording parameters, etc.). The quality and potential of the test data will dictate the acquisition approach taken during the production portion of the project. If both KGS and ORNL agree that walkaway test data warrants continuation of the project, the production phase will commence.

Acquisition of the production data will require two visits of 10 to 14 days each (depending on conditions) and will follow established shallow high resolution data acquisition procedures (Hunter et al., 1984; Knapp and Steeples, 1986; Steeples and Miller, 1990). The basic structure of both the acquisition and processing flow will be roughly designed around the findings of the preliminary testing. Ideally, an uphole or check shot survey should be acquired in a nearby borehole to enhance confidence and preliminary event identification. Step-by-step analysis during the acquisition and processing phases of the survey will be continuous, with appropriate modifications made if deemed necessary to ensure the quality of the final product.

Experimental (Testing) Phase

The experimentation will primarily revolve around walkaway noise tests. The walkaway noise tests will represent the first operation to take place after initial equipment shake-down. Each walkaway noise test should be completed in one day, allowing selection of the optimum acquisition parameters and equipment for the production portion of the project.

If access is granted to a nearby well, a velocity survey measuring the acoustic travel time from the ground surface to various depths in the subsurface will be acquired. A velocity survey will greatly improve interpretations of depth and bed thickness on CDP stacked section. The uphole information will be used to determine true average velocity and represent preliminary ground truth for the time-to-depth conversions critical for accurate event identification during initial testing.

The walkaway noise tests will be conducted along proposed seismic lines and as near to any control wells as possible. The walkaways will consist of source-to-receiver offsets ranging from 8 ft to approximately 1600 ft (up to 2000 ft maximum if deemed necessary). The receiver interval will be 8 ft. An accelerated weight drop (Bison EWG or equivalent), Bolt LSS-6 land air gun, and IVI MiniVib high frequency vibrator will be evaluated to determine the optimum source for the near-surface conditions, target depth, resolution requirements, and environmental constraints. Each source will be evaluated with as near equivalent conditions and parameters as possible. Experience with source testing (Miller et al., 1986; Miller et al., 1992; Miller et al., 1994; Doll et al., 1994) will greatly enhance both the quality and the efficiency of source evaluations at this site.

The receivers available for testing will include strings of both 30 Hz Mark Products L-28A geophones (6 per string) and 40 Hz Mark Product L-28E geophones (3 per string) wired in series. The 40 Hz geophones will be tested first, and from previous experience will probably produce the best response. The need for a strong signal from geophones with a high spurious noise threshold is paramount and from previous experience the lower quality geophones will not produce the desired output within the desired frequency band. If at any point during the noise testing an optimum parameter or component is identified, the affected portions of the remaining tests at that site could be by-passed.

Data collected during the experimental phase of this survey will be reduced to the appropriate final display format on site. All walkaway noise tests will be displayed according to source-to-receiver offset with separate displays for each source, receiver type, and low-cut filter tested. The final walkaway sections will be trace balanced and displayed in a variable-area wiggle trace format. Spectral analysis will be used in conjunction with forward modeling to determine the basic characteristics of reflection data collected with each of the sources tested. The uphole velocity files will be trace balanced and displayed individually in variable area wiggle trace format. Determination of source configuration and field parameters for the CDP production lines at each site will be based on analysis of all walkaway tests.

Production Phase

The production acquisition phase of this project will begin as soon as possible after the test data is thoroughly analyzed and both ORNL and KGS are satisfied with the parameter design. The data should be acquired on two site visits of 10 to 14 days each. Source and receiver selections will be qualitative choices based on frequency, potential penetration depths, quantity of ground roll relative to body waves, and physical site and near-surface constraints.

The equipment and parameters used to acquire the production lines will be based on the results of the individual walkaway tests performed at each of the proposed sites during the testing phase of the survey. The data will be acquired on two 48-channel, 24-bit, Geometrics StrataView floating point seismographs physically mated to operate as a single 96-channel system. One seismograph is the property of KGS the other is presently the property of ORNL. Access to ORNL's seismograph will be necessary to acquire 96-channel data.

Parameters such as sampling interval, record length, and analog filtering will be determined after careful examination of the dominant frequency and usable bandwidth of reflection energy recorded during the walkaway noise tests. The sampling interval will be chosen to ensure at least 10 samples/wavelength of the dominant reflection energy. The total number of samples will be chosen based on maximum time (depth) of interest as determined by both the sampling interval and the uphole survey (if possible). Once the seismograph's variable settings are selected, the settings will not change for the duration of the particular line being acquired. This is to ensure consistency in phase and to avoid confusion relating to plotting scales, alias values, and system response. Based on experience at other ORNL sites, the most probable source to be used for production will be the IVI high-frequency vibrator. Triple L-28E 40 Hz geophones with variable damping capability will probably be the preferred choice for the receivers on the production line. Acquisition filters will be used to balance the spectra if a stacking source is selected as the optimum source (Steeple, 1990). The equipment parameters chosen to record the CDP lines will incorporate the results of both walkaway noise tests and uphole surveys.

The data will be acquired using a standard CDP roll-along technique which will result in a nominal 48-fold CDP stack. The geophone station interval will be confirmed

by computations and qualitative judgments made from data acquired during the testing phase. The most probable geophone spacing is 16 ft. The data will probably be acquired using an end-on source/receiver geometry to enhance continuity and increase velocity control. The source-to-nearest receiver offset will probably be on the order of 50 ft with a maximum source-to-receiver offset of approximately 1500 ft. Modifications to the source/receiver geometries and offsets may be necessary after analysis of the data acquired during the testing phase.

Final design of the field geometries will incorporate analysis of potential (using physical properties derived from the test data) versus required resolution (Miller et al., 1995). The 1/4 wavelength criteria of Widess (1973) will be used to determine the best vertical resolution with equipment and near-surface conditions present during the acquisition of the test data. The potential versus actual horizontal resolution of the test line and planned production lines will be based on the radius of the theoretical Fresnel zone. Oversampling of the first Fresnel zone will not exceed 15 times (Miller et al., 1990) while a minimum of four times will be maintained throughout the survey (Knapp and Steeples, 1986).

The equipment and recorded data will be continuously monitored during acquisition to ensure the highest quality CDP stacked section. The response amplitude of receivers will be monitored using a modified tap test performed after the planting of each geophone or group of geophones. The continuity and leakage of each active station will be meter monitored prior to each shot. The system will be subjected to a series of pre-acquisition tests designed to ensure the integrity of analog filters, consistency in system noise, and precision in digitally stored data. Visual analysis of general signal-to-noise ratio, environmental noise, DC bias, and variations in the optimum recording window will be performed on at least every fifth field plot.

Data Processing

The principal CDP lines collected at each of the three sites will be processed with commercial processing software into a CDP stacked format. The basic architecture and sequence of steps to be followed during the generation of the final stacked sections will be similar to conventional petroleum exploration processing flows (Yilmaz, 1987). The primary exceptions relate to the step-by-step QC necessary for the generation of a stacked section that allows the highest confidence in the interpretation of shallow features and realization of full resolution potential (Miller et al., 1989, Miller et al., 1990, Miller and Steeples, 1991). The main distinctions relate to the emphasis placed on velocity analysis (Miller, 1992), lack of extensive wavelet processing, care and precision placed on muting, step-by-step analysis of effects of each operation on reflected energy, limiting statics operations to maximum shifts no greater than 1/4 wavelength of the dominant reflection energy with large correlation windows, and coincident iterative velocity and statics analysis.

Each analysis step in the processing flow will be available to ORNL for critique. Any additional information requested by ORNL during the processing flow will be generated within a reasonable amount of time (amount of time determined jointly). All

digital information requested by ORNL will be delivered on the requested magnetic media (based on previous cooperative research with ORNL 4mm Colorado DAT tapes). All hardcopy printouts of analysis steps as well as any specially requested data will be delivered to on 11" fanfold from a 180 dpi, HP PaintJet printer, or 600 dpi HP LaserJet. Horizontal and vertical scale on hardcopy printouts will be set to maximize the analysis potential and will be discussed and agreeable with ORNL staff.

Special emphasis will be placed on all the analysis portions of the processing flow. It has been proved necessary and most effective to do velocity, spectral, and on certain occasions deconvolution analysis on every CDP (Steeple and Miller, 1990). Many times variability in near-surface materials and/or conditions require changes in processing parameter over distances of less than 20 m. To ensure the highest quality geologically representative stacked section, velocity analysis of every CDP is necessary. In association with point-by-point analysis, care must be taken to ensure that all coherent events on stacked sections interpreted as reflections are reflections. Biasing processing parameters to enhance events interpreted as reflections that are actually coherent noise must be avoided at all cost. Differentiating reflections from direct wave, refractions, air wave, and ground roll in the early portion of a stacked section is an extremely difficult task and must not be taken lightly (Steeple and Miller, 1990).

As much effort as possible will be made during processing of this data to interact with ORNL geoscientists to ensure the most accurate stacked seismic reflection sections. The interpretation stage of this project will be critical and should involve integration of geophysical models with geologic models. The interpretation of the resulting CDP stacked section and generation of associated geophysical models should be a cooperative effort between geophysicists and geologists.

The data acquired and processed on this survey will be managed to ensure the highest quality and most accurate acoustic representation of the geologic setting possible. The current state-of-the-art techniques will be used in a fashion that is appropriate and verified with step-by-step QA/QC. The most important (possibly even essential) information that will be provided (besides the CDP stacked section itself) are data in a shot gather format as they look after application of each intermediate step. This information allows the geophysicist and geologist to make determinations as to the authenticity of processed seismic sections. Seismic processing software and techniques are very powerful tools that, if not used properly, can and most likely will result in bogus interpretations.

Geologic Questions to be Answered

- What is the dip angle and dip direction of the K-25 fault, single or zone?
- Is the K-25 fault really a continuous structural feature from its tip in East Fork Valley to the point where it intersects the Whiteoak Mountain Fault?
- Does the K-25 fault continue southwest into the plant area losing apparent displacement into the hinge of the syncline?
- What is the thickness of the fault bounded slide of the Rome formation?

- Relative to the Rome formation, what is the geometry of the underlying faults and all bounding faults?
- Does the underlying fault everywhere juxtapose the Rome formation against the Chickamauga carbonates?
- Where is the exact surface trace of the Whiteoak Mountain Fault?
- Does the White Oak Mountain fault dip steeply where it underlies the lower Rome shales?
- What is the thickness of the lower Rome shales and do they overlie Chickamauga carbonates?
- What is the depth to the detachment fault of the syncline/anticline pair?
- Are there any other faults associated with the syncline/anticline pair?

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III. RESPONSIBILITIES

The responsibility for employee safety rests with each employee's respective employer. This plan, therefore, applies only to KGS for the survey activities. Each employee of KGS will strive to identify and mitigate any safety hazards encountered. All parties will cooperate in working as safely as possible and will comply with all applicable safety requirements as set forth by ORNL as well as those included in this document.

In addition to the safety procedures indicated herein, we will adhere to the following:

1. In the event of electrical storms in the vicinity, all surface operations will cease if lightning strikes are closer than three miles (determined by 15 second count between lightning and thunder).
2. If conditions become excessive (i.e., temperature > 100°), continuous day operations will be modified to minimize chances for heat-related medical problems.
3. Appropriate field boots will be worn and due caution will be exercised with respect to snakes.
4. At least one gallon of fresh water will be on hand at the beginning of each day for each crew member.
5. The seismic crew will operate with an established written protocol for initiating seismic sources. The safety plan will be approved by the ORNL/MM Representative prior to initiation of field operations.
6. Appropriate drivers licenses will be held by operators of vehicles while on ORNL controlled properties (DOT regulations).

IV. SAFETY PERSONNEL

Project Personnel and Emergency Contacts

1. Rick Miller (KGS)—Site Safety Officer
2. Joe Anderson (KGS)—Operations
3. Bill Doll (Oak Ridge National Laboratory, Martin Marietta Energy Systems [ORNL/MM])—Delegated Representative and Site Consultant
4. David Laflen (KGS)—Line Chief
5. Jianghai Xia (KGS)—Technical Specialist

Key K-25 Project Personnel

Telephone numbers and the names of other K-25 Site personnel to contact for non-emergency assistance are provided below. Only the last four digits of the telephone numbers listed below must be dialed in order to contact the individuals below by plant telephone. Because of the remote location of some seismic monitoring activities and to assist with emergency response planning, the PSS shall be notified daily of the location where the planned field activities for the day will be conducted. **See also Section IX—Contingency Plan on p. 25.**

<u>Responsibility</u>	<u>Name</u>	<u>Telephone</u>
DOE Program Manager	Gary Bodenstein	576-9429
K-25 ER Program Director	John Lyons	574-9262
K-25 ER Groundwater Program Manager	Lance Hull	241-2135
K-25 ER Groundwater Project Manager	Robert Poling	576-5493
K-25 ER Health and Safety Manager	Larry May	576-4018
K-25 ER Field Coordinator	Ken Keever	576-4051
K-25 Industrial Hygiene	Darryl Bonner	576-6848
K-25 Industrial Safety	Greg Lester	241-2518
K-25 Radiological Control Organization	Robert Gee	576-7571
K-25 Plant Shift Supervisor	N/A	574-3282
ORNL Technical Project Support	Bill Doll	576-9930

Specific Safety Requirements

Personnel Safety Equipment: All personnel will be equipped with hard hats, safety shoes, hearing protection, and eye protection while working in the field during the seismic data acquisition phase of this project.

Vehicular Safety Equipment: All KGS vehicles and the ammunition vehicle will be equipped with a first aid kit and a fire extinguisher. A portable cellular phone will also be required in the KGS vehicle and will be the primary means of communication in the event of an emergency.

Fire/Explosion Prevention: No smoking or open fires are allowed in or around the vehicle carrying the blasting ammunition. The blasting vehicle will be equipped with a fire extinguisher. The blasting vehicle will not be left running and unattended. The shotgun ammunition will be kept in steel ammunition cases which will be stored in a locked steel container inside the ammunition vehicle.

Time of Work: Attempts will be made to expedite all work during clear daylight hours under unrestricted visibility, in good weather conditions.

Accident Prevention Plan Participation: All personnel participating on this project will be required to review this plan.

All will be required to comply with rules outlined with this plan. Failure or inability of ORNL/MM or KGS personnel to comply with the site safety guidelines presented herein will be grounds for suspending all project work until compliance can be assured.

Copies of this Accident Prevention Plan will be on the dashboard of each project vehicle. Emergency call numbers and evacuation routes are posted on the Recording Cube wall.

The following are the General Health and Safety Rules required by KGS for all staff and subcontractors in all operations.

1. Accidents or injuries must be reported immediately to the site safety officer, no matter how minor they seem.
2. Know how to do your job. Check your work area to determine what problems or hazards may exist. Review the safety requirements of each assigned job with your supervisor. Your activity may endanger other persons or nearby equipment or property. Take necessary steps to safeguard them. Be aware of what others are doing insofar as their actions may affect your safety.
3. Always maintain a safe distance away from any of the explosive seismic materials and devices unless you are specifically authorized or trained to handle these materials. Keep persons not authorized in the use of these materials away from the explosive work area at all times. Those authorized to prepare

explosives shall use every reasonable precaution including, but not limited to, visual and audible warning signals, flags, or barricades to ensure safety.

4. Report unsafe equipment, hazardous conditions, and unsafe acts.
5. Use the safety equipment specified for the job.
6. Practice good housekeeping in the work area.
7. For your protection, obey all warning signs such as "Keep Out," "No Smoking," "Eye Protection Required," and "Authorized Personnel Only." Become familiar with site specific emergency response plans.
8. Do not take shortcuts. Use ladders, ramps, stairways, and designated paths.
9. Do not engage in horseplay or roughhousing at any time. To do so may lead to injury and/or be cause for discharge.
10. No KGS staff person is permitted to use intoxicants or to be under the influence of any intoxicant or drug while on the job. This includes any time when operating a company vehicle. Failure to obey this policy may result in immediate termination of employment with KGS.
11. When in doubt about safety equipment or procedures required to do your job, ask your Supervisor, Department Head, Site Safety Officer, or the Survey Health and Safety Officer.
12. Failure to follow practices relating to your safety or that of fellow staff or failure to properly safeguard equipment, tools, or materials may lead to discharge.

V. EMERGENCY INFORMATION

Ambulance: _____

Hospital Emergency Room: _____

Poison Control Center: _____

Police: _____

Fire Department: _____

Airport: _____

Explosives Unit: _____

State Environmental Agency: _____

Client: _____

Emergency Contacts

Safety Coordinator: Phone _____ - _____

Project Manager: Phone _____ - _____

Emergency Routes

(Include road or other direction; attach map with routes highlighted. To be filled out by Site Safety Officer.)

Hospital:

VI. TASK SPECIFIC HAZARDS

The purpose of the geophysical investigation is to image and delineate structural features influencing off-site migration of contaminants from the K-25 area of the Oak Ridge Reservation, Oak Ridge, Tennessee.

One of the geophysical tests proposed to be employed requires the use of an auger gun (shotgun type device) to introduce energy into the ground. This device consists of a small skid-steer loader with an attached auger/screw. The operation consists of (1) screwing the auger, which houses the shotgun device, approximately 3 ft into the ground, (2) loading and firing the gun, and (3) unscrewing the auger from the ground. The auger gun uses a blank 8-gauge shotgun shell fired under the ground surface in a downward direction. The device is built to minimize any danger to the person handling the device, and avoid any residue materials left in the ground. The shotgun shells will be secured in a specially designed steel, lockable, explosives box in a vehicle at all times. The operation/safety rules and regulations for the auger gun are presented as an appendix to this plan.

Field operations will consist of geophysical investigations to determine the effectiveness of shallow seismic survey methods at this site to delineate the complex structures evident in the pit wall. The introduction of acoustic energy into the ground in a controlled fashion involves equipment or material with the potential to do harm if not properly handled and operated. Good common sense, training, and experience are the rule for seismic field operations. These can usually be easily accomplished if manufacturers' operating and use instructions are followed.

The field investigations will involve project personnel performing geophysical surveys of the study area utilizing other non-intrusive seismic sources. These sources include a vehicle mounted vibrator, accelerated weight drop, and air gun. The principal hazards associated with this type testing would consist of handling or moving the equipment.

SAFETY RISK ANALYSIS

The sections below describe the tasks associated with the field activities to be conducted by Kansas Geological Survey during the seismic reflection and gravity studies in and around the Department of Energy (DOE) K-25 Site in Oak Ridge, Tennessee. Potential safety and health hazards associated with each task are identified, and hazard control measures are provided. The requirements included in the Environmental, Safety and Health Evaluation for the project, which immediately follows p. 26, shall also be followed. During this project, no entries will be made into radiological areas and no contact with chemical contaminants are anticipated.

A. Work Item: Use of Class "C" Shotgun Ammunition

Specific Hazards—The specific hazards involve injuries to persons or property damage arising from normal or accidental detonation or improper handling of the shotgun ammunition.

Control Measures—All project personnel working with or around the shotgun ammunition, seismic guns, and associated equipment will exercise all appropriate and reasonable precautions to prevent or limit accidents arising from use of explosives. All explosive devices will be Class "C," consisting of fully containerized smokeless black powder in the form of shotgun ammunition. Site work will conform with appropriate and reasonable Class "C" explosives handling, storage, communication, and detonation procedures. All seismic shots will occur in shallow boreholes 2 to 4 feet below ground level.

Rick Miller of the Kansas Geological Society will be responsible for the safe use of the shotgun ammunition to be used. He will review the blasting communications and safety procedures at the initial site safety meeting and again prior to the initiation of the first seismic shots. All project personnel must become familiar with and abide by these protocols.

Specific shotgun ammunition safety measures are as follows:

- **Storage:** All shotgun ammunition will be stored in a locked metal container. The storage container will have proper DOT labels for Class "C" shotgun ammunition.
- **Transportation:** The ammunition vehicle will carry proper DOT labels and will be operated by Rick Miller on or near site. The vehicle will contain a fire extinguisher, First Aid kit, and will be parked far enough off any road to minimize the potential for a collision with other vehicles.
- **Handling:** Only Rick Miller, KGS, will be allowed to access, handle, and load the shotguns. Shotgun loading and firing will be conducted in accordance with the attached "Operations/Safety Rules and Regulations for the Auger Gun."
- **Firing Communication:** Rick Miller shall establish a series of warning signals to be used prior to and following each shot. One short horn blast, whistle blow, or other audio signal will indicate the beginning of a blast (or prior site specified requirements). He will review the precise warning procedures with all project participants at the initial site safety meeting, and will monitor compliance with these procedures.
- **Safe Distances:** All project personnel not authorized to handle the shotgun ammunition and guns must stay a distance of 25 feet away from the guns and shot locations. Non-project personnel will not be allowed in the work area.

Blasting shall not commence if any of these protocols is not met.

Transportation. Transportation of the auger gun and ammunition is on a standard one-ton flat-bed four-wheel drive truck and gooseneck trailer. The ammunition is carried in .50-caliber military-style ammo boxes. The ammo boxes are locked in 10-gauge steel boxes that are permanently bolted to the truck bed. The ammunition is classified as "Class C Explosive" by the U.S. Department of Transportation. No more than 2,000 rounds of ammunition will be transported to this project, packed in quantities of 160 per ammo can.

B. Work Item: Bolt LSS-6 Land Air Gun

The Bolt Land Air Gun (BLAG) consists of a three-cylinder diesel engine, a four-stage air compressor, and an enclosed, water-filled chamber that serves as housing the "gun." The apparatus is transported by an F-350 four-wheel-drive truck. The three-cylinder diesel engine powers the air compressor and a hydraulic system designed for raising and lowering the gun chamber. As the gun chamber is hydraulically lowered, the weight of the truck serves as a counter-balance to anchor the BLAG onto the ground surface.

The gun is detonated electrically from the cab of the truck. No moving parts are exposed during detonation. Both the diesel engine and air compressor are housed in a protective enclosure. The sound generated by the detonation is approximately equivalent to the effect of the detonation of 1/8 lb of highly explosive material buried 3 to 4 ft beneath the ground surface. Instructions for safe operation of the BLAG and for control of hazards are provided below.

Control Measures

- 1) The instructions found in the owner's manual on safe operating practices for the four-wheel-drive truck shall be followed.
- 2) The instructions found in the operator's manual on safe operating practices for the BLAG shall be followed.
- 3) The operator or the BLAG should be aware of the proximity of others to the apparatus.
- 4) No work personnel should come within 50 ft of the gun while the operator is remotely activating the hydraulic lift. While the operator is in the truck cab, only part of the apparatus is visible to the operator.
- 4) Hearing protection (down 30 dB) is required personnel within 50 ft of the truck while it is in operation.

C. Work Item: MiniVib

The MiniVib is a vibrating device designed to shake the ground in a controlled manner for a duration of four to eight seconds. The device consists of a hydraulically-powered plate approximately 3 ft in diameter and is mounted on the underside of the vehicle. The plate is lowered to the ground beneath the vehicle and uses the vehicle's weight to keep the plate in contact with the ground. A hydraulic servo transfers energy

of varying frequency to the plate over a preset duration of time, creating the vibration. Hydraulic pressures in excess of 1500 psi are routine for the operation of the MiniVib. The MiniVib has no moving parts that would present a potential for entrapment, and the maximum movement of the plate relative to the vehicle is a distance less than 2 in. Instructions for safe operation of the MiniVib and for control of hazards are provided below.

Control Measures

- 1) The instructions found in the operator's manual on safe operating practices for the MiniVib shall be followed.
- 2) Work personnel shall not be within 20 ft of the vehicle when it is turning.
- 3) When the MiniVib is in operation, all shields shall remain in place.
- 4) No maintenance or service shall be performed while vit is in operation.
- 6) Inspection of the MiniVib is required prior to lowering the pad.
- 6) Hearing protection is required for personnel within 50 ft of the MiniVib while it is in operation.

D. Work Item: Accelerated Weight Drop

The accelerated weight drop (AWD) generates acoustic energy by accelerating a 50 to 100 lb weight through a 2 ft stroke to impact with a steel plate. The plate has a diameter of 18 in and is held in contact with the ground surface by the weight of a skid-steer style loader. The AWD takes place within an enclosed steel guide.

The apparatus consists of a hydraulic motor that turns a set of sprockets to deliver power to a lift arm that in turn pulls the weight against the resistant force of an industrial rubber band. The mechanism is similar to that of a sling-shot. All moving parts are shielded, and the contact area is sufficiently enclosed to prevent any debris from the impact becoming airborne. Instructions for safe operation of the AWG and for control of hazards are provided below

Control Measures

- 1) The operating instructions found in the owner's manual of the Case 1225 Uni-Loader shall be followed, as applicable to the AWD loader.
- 3) All shields shall remain in place while the AWD is in operation. Routine maintenance shall only be conducted when the loader engine has been turned off.
- 4) The operator shall exit the vehicle only after the weight drop is in full contact with the ground surface.
- 5) Personnel are not permitted within 30 ft of the AWD device while it is in operation.
- 6) Hearing protection (30 dB down) is required for personnel within 50 ft of the AWD while it is in operation.

E. Work Item: All Terrain Vehicles

All-terrain vehicles (ATVs) such as the Yamaha Terra Pro, Kawasaki Mule, and the Polaris 4x6 may be used in field mobilization and other work activities during this

project. The ATVs shall not be used at speeds in excess of 15 mph, and care shall be taken when loading the vehicles. The potential for tip-over exists with the use of ATVs; therefore, caution will be used when traversing grades and the manufacturer's guidelines shall be followed regarding acceptable grades for safe operation of each ATV. The four-wheel design of the ATVs reduces the potential for tip-over of the vehicles.

1) The Yamaha has a powered cable winding device mounted on the front of the vehicle and will be used for rolling seismic cable. Operation of the cable winding device is powered by a power take-off (PTO) feature. A safety override mechanism for the PTI "kills" the engine if the vehicle operator is not in the driver's seat and/or if the Yamaha is not traveling in the lowest speed range.

2) The Mule will be used to carry the seismograph and 12-volt AC/DC batteries. The mule shall not travel at speeds greater than 5 mph and is only used for transportation during approximately 1% of field activities.

3) The Polaris will be the most frequently used ATV during field activities. It is used to transport geophones and cables in a 3x3 steel box mounted behind the seat. This ATV has 6 wheels with four-wheel-drive capability. Because of this design, the Polaris is very stable and can support a capacity of > 700 lbs. The Polaris will not be operated at speeds greater than 15 mph.

Instructions for safe operation of the ATVs and for control of hazards are provided below.

- 1) The instructions found in each ATV's operator's manual on the safe operating practices for each ATV shall be followed.
- 2) Each ATV is equipped with blinking yellow hazard lights that shall be used during field activities to increase the visibility of the vehicles.
- 3) Work personnel shall wear orange safety vests while operating the ATVs.

F. Work Item: Vehicle Traffic

Because of the nature of the collection of data for seismic reflection profiling, project work activities will be conducted in close proximity to roads. Vehicular traffic is an obvious hazard to work personnel and to property. Instructions for safe operating practices when working around vehicular traffic and for control of hazards are provided below.

Control Measures

- 1) All work personnel shall be aware of their proximity to roadways and shall limit the duration of activities that must be conducted near roadways, to the extent that is possible.
- 2) Traffic cones shall be used to mark a buffer area between traffic and the area where work is conducted.

- 3) "Men Working" signs and/or flagmen shall be used to alert traffic of the presence of work personnel.
- 4) Work personnel shall wear orange safety vests to increase their visibility to vehicle operators.

VII. TRAINING

Personnel conducting work associated with this project shall have completed the following training prior to participating in field activities:

General Employee Training,
K-25 Site Access Training,
Defensive Driving on Non-paved Roads, and
Heat Stress Training.

At least one KGS personnel working at the site in connection with the project shall have received hazardous waste worker training in accordance with 29 CFR 1910.120(e), be certified in First Aid, and CRP trained. This includes 40-hour initial training, 8-hour refresher training, and yearly First Aid refresher.

VIII. PERSONAL PROTECTIVE EQUIPMENT

Personal protective equipment (PPE) protects employees from the hazards and potential hazards they are likely to encounter as identified during previous site characterization activities. PPE consists of a combination of protective clothing and respiratory protection equipment. Selection of PPE is based on an evaluation of the performance characteristics of the PPE relative to the requirements of the site and the task specific conditions and duration. The level of protection is upgraded when site monitoring or conditions indicate that increased protection is necessary to reduce employee potential for exposure.

Based on the available information assessing the current condition of the sites, minimal skin protection is required for general access. Work personnel shall wear modified EPA Level D personal protective equipment. For the purpose of this project, modified Level D shall consist of:

Short- or long-sleeved shirts and full-length pants
Steel-toed safety boots,
Orange vests,
Hearing protection (as required),
Eye protection (as required), and
A hard hat (as required).

No respiratory protection equipment is required. At the present time based on all available information, the atmosphere contains no known hazards. There is no expected potential for inhalation or contact with hazardous levels of any chemical.

In the event that other hazards are identified, additional PPE items may be required by K-25 Site safety and health disciplines (i.e., Industrial Hygiene, Industrial Safety or Health Physics).

IX. CONTINGENCY PLAN

In the event of an emergency, work personnel shall immediately contact the K-25 Site Plant Shift Superintendent (PSS) by dialing 4-3282 or 911 from any plant telephone. Two-way radios will be used as a means of site communication for crew members. A radio that is compatible with the K-25 Site radio system shall also be available onsite during work activities, and the PSS office may also be contacted using the plant system radio. The PSS will provide instructions and summon additional assistance to the emergency scene, if required. Medical emergencies will be transported by ambulance to the nearest hospital, which is the Oak Ridge Methodist Medical Center. In the event of fire, fire suppression will be provided by the K-25 Site Fire Department.

Any emergency situation or any deviation from planned work activities as described in this plan should be reported to the K-25 Groundwater Project Manager, the K-25 Groundwater Program Manager, and the K-25 ER Health and Safety Manager. Telephone numbers and the names of other K-25 Site personnel to contact for non-emergency assistance are provided on page 9. Because of the remote location of some seismic monitoring activities and to assist with emergency response planning, the PSS shall be notified daily of the location where the planned field activities for the day will be conducted.

X. SPECIAL HAZARD PROCEDURES

Heat stress is recognized as a potential hazard for this project because of the season during which these field activities will be conducted and because of the outdoor nature of the work. Work personnel shall receive training on heat stress prior to beginning field activities and meet all other specified requirements for recognition, treatment, and control of heat stress. Potable water and drinking cups shall be available to work personnel for the duration of field activities, and the length of work days shall be limited to a maximum of 12 hours. Provisions for sanitation shall also be available.

XI. SAFETY ANALYSIS

The attached analysis lists postulated hazards, consequences of those hazards, and the means of prevention or mitigation of each hazard associated with this survey activity.

XII. ENVIRONMENTAL IMPACT ANALYSIS

The environmental impact of this activity has been evaluated at more than 6 U.S. Government facilities (Y-12 ORNL, Oak Ridge, TN; WAG-10, ORNL, Oak Ridge, TN; Paducah Gaseous Diffusion Plant, Paducah, KY; Nevada Test Site, Las Vegas, NV; Fort Ord, CA; INEL, Idaho Falls, ID).

XIII. HANDLING AND DISPOSAL OF UNEXPLODED ROUNDS

The handling of live ammunition will be in complete compliance with sections VI.A. and seismic gun operation procedures (both sections of this report). In the event a round does not detonate using standard operating procedures, the seismic source will be left in place undisturbed for a minimum of 5 minutes. After this initial 5 minutes, the shell will be extracted to insure minimal contact with operators. The unexploded round will be placed in the metal container used for the storage of spent rounds. If the round is an 8-gauge it will remain in the sleeve for a minimum of 20 minutes after placement in the metal can prior to being placed in a metal can and locked in the steel containers attached to the truck. If it is a 50-cal. round it will remain in the can for 20 minutes before it will be removed and re-stored in a metal can in the metal transport boxes attached to the truck. The unexploded rounds will then be transported back to the KGS Lawrence, Kansas, facility where they will be properly disposed of.

XIV. REFERENCES

Applicable portions of the following documents form the basis for this safety plan.

From the United States Department of Energy:

DOE Order 5480.16, *Firearms Safety*.

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

ID Appendix 0550, *Standard Operational Safety Requirements*, Part III, Subpart I, "Explosives"

From the United States Department of Defense:

DOD 6055.9-STD, *Ammunition and High Explosive Safety Standards*

AR-385-63, *Safety Policies and Procedures for Firing Ammunition for Training, Target Practice, and Combat*

PROJECT ES&H EVALUATION INSTRUCTIONS

The Facility Safety Procedure FS-6-1, "Safety Review of Experiments", requires that all projects conducted at ORNL have adequate provisions for the safety and health of workers and the public and for the protection of the environment. The Principal Investigator (PI) is responsible for initiating and updating this evaluation that fulfills the requirements of FS 6.1. This form is required for all ESD projects to document that environment, safety, and health (ES&H) training and other issues have been considered. This evaluation is the first part of your ES&H plan and should be completed before significant project work begins. If no significant ES&H concerns associated with this project are identified and this is agreed upon by the PI and ES&H Group Leader, then this ES&H Evaluation will serve as the project's ESD ES&H Plan.

If there are significant ES&H concerns associated with this project, then further review and documentation may be required. Based on the information provided in the evaluation and agreed upon by the PI and ES&H Group Leader, the ES&H group will provide specific guidance outlined in a better (e.g., mini waste plan, site-specific chemical hygiene plan, training plan, personnel protection equipment requirement) on what information is required to complete the ES&H plan. The evidence of implementation of the ES&H plan must be readily available to the project staff, ES&H group, and auditors. Although not required that the plan be compiled into a single document, it is the ES&H group recommendation that it be in a single document.

Instructions:

Following are step-by-step instructions for completing the evaluation. Complete all parts that are relevant to the project.

1. Date this form is submitted to the ES&H group.
2. PI's name and phone number. Other staff that should be contacted by the ES&H Group regarding project ES&H issues.
3. Name of the research project.
4. All locations where work will be performed (e.g., bldg., room., field site).
5. Starting date for the research and estimate how long the work will last (the number of weeks, months, years, etc.).
6. Give a brief description of the project's work, or attach a written description. Give sufficient detail for an ES&H evaluation of the research. The ES&H aspects of the project's work are important in this description, rather than a discussion of the theoretical or scientific aspects of the project.

7. List all chemicals to be used in the research. Give details about the quantities to be used, the concentrations, and the chemical form of the materials. Distinguish between stock and diluted/working concentrations that will be used.
8. List the known safety equipment needed for this work (e.g., safety glasses, gloves, dust masks, fume hoods, face shields, safety shoes).
9. List all radioactive isotopes to be used in the research. List the isotopes used, specific activities of radioisotopes, and the operation concerning how the isotope will be used.
10. Give a brief description of the soil being used in your project's work, or attach a written description. Give sufficient detail for an ES&H evaluation of the research. The location and how the soil is being used in the project's work are important in this description.
11. If your project involves the use of polychlorinated biphenyl (PCB), give a brief description of how the PCBs are being used and what concentration of the will be project will be using. Give sufficient detail for an ES&H evaluation of the research.
12. If your project requires NEPA documentation, gives a brief description of what NEPA documentation your projects requires (CX, EA, FONSI, etc.).
13. Check all topics that will be a part of this project's tasks. The PI is responsible for the ES&H evaluation, development, and implementation of controls to ensure that ES&H requirements are met. The ES&H group will review the information provided in the ES&H evaluation and determine what ES&H requirements must be met to conduct the project. If needed, the ES&H group will also provide specific guidance regarding what is required to have a complete ES&H plan.
14. The Principal Investigator and the ES&H Group Leader will agree and mark one of the two choices given based on this evaluation. The Principal Investigator will sign and date the Form in the approval space. The ES&H Group Leader will also sign indicating agreement.
15. Copies of the completed Project ES&H Evaluation Form will be distributed to those persons/offices listed.

ES&H Group, Bldg. 1505, MS-6035
Project Record Copy
ESD Section Head

ENVIRONMENTAL, SAFETY AND HEALTH EVALUATION

Project Identification: _____ (to be entered by ES&H Group)

1. Date ES&H Evaluation Submitted: April 18, 1995
2. Principal Investigator: W.E. Doll Phone: 6-9930

Other Staff Members: R.D. Kaufmann (OREIS Post-masters)

NOTE: Most of the field work will be conducted by the subcontractor, Kansas Geological Survey. Kaufmann or Doll will be present to supervise the subcontractor and assist where needed.

3. Title of Research: Seismic Reflection Profiling at K-25
4. Location of work: K-25 Site and nearby roads
5. Estimated Start Date: May 15, 1995 Estimated duration: 6 months
6. Is this a paper or computer only project? Yes ___ No X

If "No", provide a written description, or attach a copy of a prepared written description of the project:

See the project document "Work Plan for Seismic Reflection and Gravity Studies in and around the K-25 Site, Oak Ridge, Tennessee."

A video showing the seismic sources for the project in operation is available for viewing.

7. List chemicals (c.g., acids, bases, toxic, teratogenic, carcinogenic, allergin, etc.) to be used.

<u>Chemical/RECID #</u>	<u>Chemical Form</u>	<u>Concentration</u>	<u>Quantity</u>	<u>MSDS</u>
			<u>(Y/N)</u>	
<u>Vehicles use gasoline and hydraulic fluid.</u>	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____

12. Does your project require NEPA Documentation? Yes ; No

If "Yes", please provide information concerning the NEPA Review.

It will fit under a K-25 CX. A letter confirming the applicability of the exclusion is currently being obtained by K-25 Environmental Restoration.

13. The following ES&H issues have been identified for ESD work: (Please check all that apply; shaded area to be filled in by ES&H Group)

ES&H PI TOPICS PROCEDURE TRAINING

Chemical Hazards

<input type="checkbox"/>	—	Carcinogens	IHP-13	Y
<input type="checkbox"/>	—	Corrosive Materials	IS-2.3, 3.1	Y
<input type="checkbox"/>	—	Cryogenics (Glove Selection)	IS-2.3	
<input checked="" type="checkbox"/>	X	Flammable Liquids or Materials	IS-3.3, 8.16	
<input type="checkbox"/>	—	Hazardous Chemicals	IS-3.1, 8.5, 8.6	Y
<input type="checkbox"/>	—	Herbicides, Pesticides, Fungicides	IHP-24, EPM-10.1	
<input type="checkbox"/>	—	Incompatible Chemicals	IS-3.1 Appendix A	Y
<input type="checkbox"/>	—	Mercury	EPM-1.4	
<input type="checkbox"/>	—	Oxidizing Agent	IHP-24	
<input type="checkbox"/>	—	Reproductive Hazard	IPH-08	
<input type="checkbox"/>	—	Storage of Hazardous Chemical in Lab	IHP-29, EPM-8.2	
<input checked="" type="checkbox"/>	X	Batteries	IS-8.9	
<input type="checkbox"/>	—	Toxic Materials	IHP-1, 3, 24, 29	Y
<input type="checkbox"/>	—	Other _____		

Physical Hazards

<input type="checkbox"/>	—	Boating	ES-ADM-93-010	
<input checked="" type="checkbox"/>	X	Compressed Gas Cylinders (AIR GUN SOURCE)	IS-3.2, IS-3.4	
<input type="checkbox"/>	—	Confined Spaces	IHP-14, IHP-24	
<input type="checkbox"/>	—	Elevated Work	IS-7.3, IS-7.4	Y
<input type="checkbox"/>	—	Ergonomic	IHP-07	
<input type="checkbox"/>	—	Explosives	IS-8.4	
<input type="checkbox"/>	—	Vehicle Safety	IS-8.12	
<input type="checkbox"/>	—	Firearm	IS-8.14, ES-ADM-92-008	
<input checked="" type="checkbox"/>	X	Heat/Cold Stress	IHP-18	
<input type="checkbox"/>	—	Hotwork Operation (SWP needed)	IS-8.8	
<input type="checkbox"/>	—	Lifting and Rigging (>50 lbs)	IS-7.1, IS-7.2	Y
<input type="checkbox"/>	—	Noise	IHP-04, IHP-24	Y
<input checked="" type="checkbox"/>	X	Pressurized Equipment	IS-6.2, 6.3, 6.4	
<input type="checkbox"/>	—	Rotating Machinery or Tools	IS-6.5, 6.6	
<input type="checkbox"/>	—	Other _____		

14. A review of this project for ES&H issues indicates that: (Signed after agreement between PI and ES&H Group)

ES&H PI

- [X] There are no significant ES&H concerns associated with this project that require further preparation of a ESD ES&H Plan.
- [] There are significant ES&H concerns associated with this project and further review is required.

APPROVAL

Principal Investigator: _____ Date: _____

ES&H Group Leader: _____ Date: _____

Rad. Protection Review: _____ Date: _____ (if applicable)

15. Copies of the completed Project ES&H Evaluation Form will be distributed to those persons/offices listed.

ES&H GROUP, Bldg. 1505, MS-6035
Project Record Copy
ESD Section Head
K-25 Environmental Restoration (for their review)

SAFETY ANALYSIS

<u>Potential Hazard</u>	<u>Consequences</u>	<u>Mitigation/Prevention Mechanism</u>
Lost/Stolen Ammunition	Personal injury or property damage from unauthorized use.	Implementation of system to issue daily ammunition allotment and control inventory, in addition to physical control of ammunition at all times.
<u>During Loading/Unloading:</u>		
Dropped cartridge	Personal injury from accidental discharge.	Assure training of personnel in proper handling of live ammunition.
Introduction of foreign material into breech or barrel	Damage to barrel, breech, or bolt and resulting personal injury.	Assure training of personnel in proper handling of ammunition and in-process inspection of ammunition and seismic gun.
<u>During Firing:</u>		
Muzzle Air Blast	Personal injury from flying rocks, soil, debris.	Close fit of barrel in boreholes suppresses muzzle air blast and its effects.
Ricochet	Personal injury from ricocheting projectile or fragments.	Design and use of seismic gun prevents the escape of projectile or fragments from the borehole with sufficient energy to cause personal injury.
Flashburns	Burns from muzzle flashes	Discharge into earth or containment device suppresses muzzle flash.

SAFETY ANALYSIS

<u>Potential Hazard</u>	<u>Consequences</u>	<u>Mitigation/Prevention Mechanism</u>
Misfire	Personal injury from subsequent accidental discharge of misfired round.	Assure training of personnel in proper handling and disposal of misfired ammunition.
Accidental discharge of seismic gun	Injury to unintended target.	Assure that operating procedures prevent transport of loaded seismic gun.
Plugged barrel - dirt	Damage to barrel and resultant personal injury.	Assure that operating procedures include thorough bore sighting between shots and/or probing with dowel after installation in borehole.
Plugged barrel - water	Damage to barrel and resultant personal injury.	Assure that operating procedures require inspection of borehole for water, and sealing of end of barrel with tape or balloon if water is encountered in borehole.
Barrel disengagement from plate	Personal injury to crew member(s) by flying rifle.	Implement an inspection/maintenance procedure for the barrel-to-plate attachment.
Breech disengagement from barrel	Personal injury to crew member(s) by flying breech and bolt groups.	Implement an inspection/maintenance procedure for the breach-to-barrel attachment.
<u>During Transport</u>		
Accidental discharge	Injury to unintended target.	Assure that operating procedures permit loading only after seismic gun is installed in borehole.

SAFETY ANALYSIS

<u>Potential Hazard</u>	<u>Consequences</u>	<u>Mitigation/Prevention Mechanism</u>
Accidental drop or collision	Damage to barrel or firing mechanism	Assure that operating/transportation procedures require thorough inspection of seismic gun after drop or collision incidents. Seismic gun is disassembled and stored in special compartment during vehicular transport.

TRAINING OUTLINE FOR USE OF SEISMIC GUNS
"GOOD GUN SENSE"

I. Handling (always assume loaded and ready to fire)

A. *Transporting (vehicle, on foot, etc.)*

1. In field:

Always point down or away from populated areas

Always avoid lodging foreign material in barrel

Never strain to carry, get a second person

Never assume anything

2. To and from site and storage:

Must be storage in a metal locked container

Must be stored with bolt and gun in separate locations

Must be completely broke down and cleaned prior to storage

Access to guns and ammo must be limited to trained personnel only

Live rounds cannot be stored closer than 5 ft from guns

B. *Cleaning*

1. Daily:

Must be inspected for unusual wear, signs of metal fatigue, or structural weakness at the beginning and end of each days service

Bolt and breech must be oiled and check for mechanical operation

At the end of each 1/2 day service the barrel will be carefully inspected and checked for signs of fatigue.

The bolts that secure the gun to the protective steel plate are checked at least 3 times a day.

2. Seasonal:

R/R springs in extraction system and those associated with the firing rod

R/R bolts and nuts that attach to protective steel plate.

R/R mounting bracket as necessary

C. *Firing*

1. Assumptions

NONE

2. Never Do's

Move from downhole placement with shell in chamber

Gun loaded with no one standing on plate

With one person on plate

With knees locked

Extract a shell in less than 2 minutes that does not detonate

Without both operators aware of detonation

Drop a loaded round

Return a mis-fire to live round canisters

March 24, 1987

MANDATORY SAFETY RULES FOR USE OF THE
.50-CALIBER SEISMIC GUN

The .50-cal seismic gun is powerful and must be securely positioned when fired. Danger exists not only with the bullet projectile, but also with the recoil of a loose gun. Be sure that all mounting bolts are tight. Never strike the gun or bolt with a metal object. If the gun is jamming or sticking, clean it thoroughly with WD-40. Wiping down cleaned parts will help avoid the cohesion of dirt and sand to the parts.

Operational Safety Rules

1. Each day the Party Chief must make sure all personnel are fully trained in safety rules.
2. Arm the gun ONLY when the gun is in position to be fired.
3. ALWAYS unlock the bolt when moving the gun (disarm it).
4. NEVER move the gun with a live round loaded.
5. ALWAYS remove the bolt completely from the gun for transportation and storage.
6. ALWAYS double check safety procedures.
7. Use common gun sense.

Downhole Mode

Be sure all mounting bolts are tight. Do not force the gun down an augered hole. Re-auger the hole, if necessary. Be sure that the base plate rests on the ground. Have two people stand on the plate when firing (flex knees to absorb the shock).

If the hole has water in it, seal the muzzle of the gun with tape or a balloon to keep water from seeping into the barrel. Avoid this situation, if possible. Water in the barrel may seriously damage the gun when fired. Injury is possible.

Surface Mode

Be sure all mounting bolts are tight. Carefully protect the breech, trigger, and bolt when moving the apparatus. THE TRIGGER IS EASILY BROKEN.

OPERATION/SAFETY RULES AND REGULATIONS
FOR THE

AUGER GUN

The auger gun is a multi-component shallow seismic source which is designed for safe operation. The auger gun can detonate up to a 400 grain black powder load (approximately equivalent to one-twelfth of a pound of high explosive). Improper handling or operation of the auger gun or any of its components can potentially result in serious injury. Proper use of the auger gun includes not only safe operation and handling of the gun mechanism (firing rod) itself but also the skid-steer loader that transports and powers the device. The auger gun is not intended to fire projectiles but it has been designed to do so safely with no damage to the gun or operators. Proper maintenance is critical to the longevity and smooth operation of the auger gun. As with operating any firearm or explosive device, maintenance, transportation, and storage handlers must always assume the firing rod is loaded and the safety is off.

Operation and Safety Regulations

- 1) Each day the Site Safety Officer (SSO) must brief all members of the seismic crew on the proper operation and maintenance of the auger gun.
- 2) Prior to set-up on any location the site must be cleared of all potential underground hazards and utilities. The 'tip-over' potential of a site (directly related to topography) must also be considered prior to access with the loader.
- 3) The firing rod is never transported or stored loaded or in firing mode (locked into the auger) prior to downhole placement of the auger.
- 4) The firing rod is stored unloaded (no sleeve snapped onto the bottom) in the left side storage holster during downhole placement and in-field movement.

5) Only after the auger has been screwed into the ground and the center bit extracted and placed in the right side storage holster will the firing rod be removed from the left side storage holster. The shells should be pre-loaded into metal sleeves and ready for loading prior to removing the firing rod from the storage holster. Once the firing rod has been removed from the holster, the firing rod should be pointed toward the ground and the loaded sleeve snapped into place making certain that nothing (hand, finger, etc) is covering the powder end of the sleeve. The firing rod should then be immediately lowered downhole and locked into place.

6) Firing of the device should only take place after the hole has been water flooded and the firing rod handles securely locked in the J notches. If after a sharp blow with a hammer the shell does not detonate wait for at least 5 min. prior to removing the firing rod from its locked position. Once the firing rod is removed from the auger, the unfired round should be released from the firing rod and dropped into the empty shell casing can on the right side of the device making certain not to touch the sleeve itself. The unfired round should not be removed from the metal sleeve for at least 20 minutes after placement in the empty shell casing can.

7) The skid-steer loader should be operated with good common sense taking no chances that would compromise the safety of either the operator or any other crew member. No one should be allowed to operate the loader without proper training.

8) The firing rod should always be handled as if it is loaded. The firing rod has an automatic safety that will only allow the firing pin to travel through the rod if the gun is locked into place in the auger.

Improved Shallow Seismic-Reflection Source: Building a Better Buffalo

John Healey, Joe Anderson, Richard Miller, Dean Keiswetter, Don Steeples,
and Brett Bennett, Kansas Geological Survey

SUMMARY

An improved design of the buffalo gun, incorporating hole drilling and shooting into one operation with almost total blast containment, provided nearly 50 percent more recordable seismic signal than the traditional buffalo gun. The 'auger gun' is designed to optimize field efficiency, source couple, and safety. The auger gun consists of three main parts: power source, auger/screw, and modified buffalo gun. Amplitude spectra indicate the auger gun delivers approximately 20 percent more total energy and 50 percent more reflection energy with no noticeable increase in recorded ground roll at a test site in Lawrence, Kansas. Subtle changes in source environment, such as a 15 cm gap between the detonation point and the base of the hole or inclusion of water as opposed to air at the detonation point, have a significant effect on the quality of the recorded data. The auger gun should increase field efficiency by over 50 percent on most shallow surveys, while improving the signal-to-noise ratio and total energy in comparison to the buffalo gun.

INTRODUCTION

Increasing environmental and engineering applications of reflection seismology have spurred research and development of shallow high-resolution reflection techniques and equipment. Resolution on the order of a meter is necessary to detect ultrashallow targets—generally the goal of most environmental and engineering studies (Steeple and Miller, 1990). Resolution can be increased by boosting the recorded frequency and the signal-to-noise ratio of reflection wavelets. Recent advances in engineering seismographs have made possible cost-effective acquisition of 15-bit or greater floating point data. Generating a high-frequency seismic source pulse has been accomplished in a multitude of different ways in the past (Miller et al., 1986).

The most commonly used seismic sources on shallow engineering surveys have fallen under two main categories: explosives or weight drops. The explosive category includes both high explosives and 'guns'. Weight-drop sources include everything from mechanically assisted vertical mass impacts (usually >20 kg mass) to human-assisted vertical mass impacts (sledge hammers, mallets, and thors). Recent advances in high-frequency engineering sources have come predominantly under the 'gun' classification. Development of a downhole shotgun capable of generating a consistently high frequency source wavelet with only minimal increase in expense and effort over hammers, spurred the shallow seismic-reflection industry. Downhole shotgun sources possess significantly more energy in

the 200 to 600 Hz range in comparison to hammer sources (Pullan and MacAulay, 1987).

DESIGN AND TECHNIQUE

The auger gun is designed to optimize field efficiency, source couple, and safety. A measure of success with the downhole shotgun source (as with any downhole explosive source) can be related to efficiency in generation of broad-band, high-frequency energy. Improved energy transfer is obtained when downhole placement of the shotgun shell includes a water stem and restricted recoil (Miller et al. 1989). Containment of the air-coupled wave has been at least partially accomplished for downhole projectile sources with a steel containment plate (Steeple et al., 1987). To obtain proper downhole placement of existing gun sources, a minimal diameter pilot hole (generally 6 cm, or so) approximately 80 cm deep must be bored. The auger gun described here incorporates all the previous operations and configurations into a single pass source.

The auger gun consists of three main parts: power source (skid-steer loader), auger/screw, and modified buffalo gun (Figure 1). The power source for testing described here is a 25 hp, 4-wheel drive, 1.2 m wide, hydraulic loader. The auger/screw is a modified hydraulic auger that receives its hydraulic drive power from the loader. The buffalo gun used for these tests was elongated to slightly over 2 m in length, is designed for bottom loading (as opposed to the standard screw-on head), solenoid firing, time break from a downhole sensor. The firing pin has an automatic (spring-loaded) safety. These components when assembled represent approximately 1500 kg and are transportable in the bed of a standard pick-up truck.

Operation of the auger gun is a three-step process: (1) screwing the auger flight into the ground, (2) loading and firing the gun, and (3) unscrewing the auger flight from the ground. Once the 4-wheel-drive loader is in place, the containment plate is lowered to the ground surface with the weight of the loader placed on the plate. The hollow-stem auger flight is then screwed into the ground using a gaging device designed to ensure the flight is screwed into the ground at a fixed rate and no material is removed from the hole. Screwing the auger flight into the ground accomplishes both exceptional blast containment and minimal residual borehole. After the auger flight is securely screwed into the ground 80+ cm, the modified buffalo gun is loaded (by sliding the gun over a shotgun shell), lowered down the center of the hydraulic drive head, through the hollow stem auger flighting, and seated into a sleeve at the base of the auger flight. Water can be poured through the hollow stem auger prior to downhole

placement of the buffalo gun to improve source couple. Once positioned, the gun can be fired by either a hammer impact on the top of the firing pin or with an electric solenoid.

Safety must be of the utmost concern in any operation involving seismic sources. Designed into the auger gun are several critical safety improvements over the traditional buffalo gun. First, is the improved loading design that does not require the operator's hand to come any closer than a meter from the shell either during loading or while the live shell is in the firing chamber. Another improvement is related to containment of the entire gun mechanism in its downhole position throughout the firing operation. Finally, the firing-pin lock or safety is spring-loaded and does not require operator intervention prior to firing. The entire design and operation of the auger gun revolves around maximizing the recorded reflection energy without compromising the safety of the operator or bystanders.

The auger gun incorporates several key characteristics designed and previously shown to enhance high-frequency seismic signal at the expense of air-coupled wave and ground roll while maximizing mobility, operator safety, field efficiency, and ground coupling. Containment of the explosion is optimized by screwing the auger into the ground and positioning most of the loader weight on the gun. Field efficiency is maximized by incorporating the borehole preparation with the gun placement and detonation. The massive nature of the design and improved shell-loading procedure minimizes risk to the operator. Mobility is only restricted by the 1.2 m wide, 4-wheel-drive loader. Environmental impact is minimal with remnants of the operation restricted to a nominal 4 cm corkscrew hole approximately 80 cm deep.

RESULTS

Data acquired for this test were recorded on an Input/Output DHR-2400 seismograph with no analog low-cut filtering. The sampling interval was 1/2 ms and record length was 500 ms. The receivers were three L-28E Mark Products 40-Hz geophones wired in series and arranged in a 1 m in-line array. The source-to-closest-receiver was 20 m with a geophone station interval of 4 m. The shells used for this test were 8 gauge, 400 grain black powder blanks. The recording environment was consistent throughout the comparison.

Auger gun and buffalo gun field files acquired under identical conditions allows for comparison of several key source characteristics (Figure 2). The amplitude of the data is noticeably higher with the auger gun with very little difference in the dominant frequency on either field file. Reflection information is not directly interpretable on these shot gathers. A 150 Hz digital low-cut filter reveals a strong reflection present on both files at approximately 80 ms (Figure 3). The low-cut filter does a good job of removing the ringy refraction arrival clearly dominating the upper 120 ms of the unfiltered files. Some subtle indications of 50 Hz

ground roll are still present on filtered files. The general characteristics of the 80 ms reflection seem to be consistent for both sources.

Amplitude spectra suggest the auger gun produces more useable seismic energy per grain of explosive than the traditional buffalo gun (Figure 4). Almost 25 percent more energy is present on the auger gun spectra in the 30- to 70-Hz range than the equivalent buffalo gun spectrum. Little or no observable increase in the amount of recorded ground roll can be observed on spectra of unfiltered data. Peaks in the spectra around 90 Hz represent reflection energy at this site. The auger gun delivers almost double the recordable high-frequency reflection energy of the buffalo gun.

Subtle changes in source environment make considerable difference in the amplitude spectrum of auger gun data. Leaving a 15-cm air-filled space between the base of a shell loaded in the auger gun and the bottom of the screw hole reduced total recorded reflection energy almost an order of magnitude. A water column placed in the hollow stem auger flight just prior to loading the shell tight against the base of the screw hole increased recorded reflection energy by over 50 percent. Significant variability in frequency and amplitude of the recorded energy resulted from slight changes in the downhole environment. These subtle changes and their resulting effect on the seismic data are indicative of how the near surface acoustically responds to gun powder explosions.

CONCLUSION

The auger gun should represent a 50 percent improvement in acquisition rates and recorded reflection energy at most sites when compared to the traditional buffalo gun. The auger gun is a modification of the original buffalo gun design (Pullan and MacAulay, 1987), and at some sites will represent an improvement. As with all seismic equipment and techniques, site characteristics dictate relative effectiveness. One characteristic of the auger gun that is not site-dependent and does represent an improvement over the buffalo gun is overall safety. The massive nature of the auger gun should allow detonation of series charges totally as much as 1000 grains of black powder. Preliminary testing indicates that at some sites it may be possible to acquire over 500 shotpoints a day when station spacings are 5 m or less.

ACKNOWLEDGMENTS

We wish to thank Esther Price for her work on manuscript preparation and Pat Acker for her quality graphics.

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Pullan, S. E., and MacAulay, 1987, An in-hole shotgun source for engineering seismic surveys: Geophysics, 52, 985-996.

Steeles, D. W., Miller, R. D., and Knapp, R. W., 1987, Downhole .50-caliber rifle—an advance in high-resolution seismic sources [Exp. Abs.]; in Technical Program Abstracts and Biographies: Soc. Explor. Geophys. 57th Ann. Mtg., 76-78.

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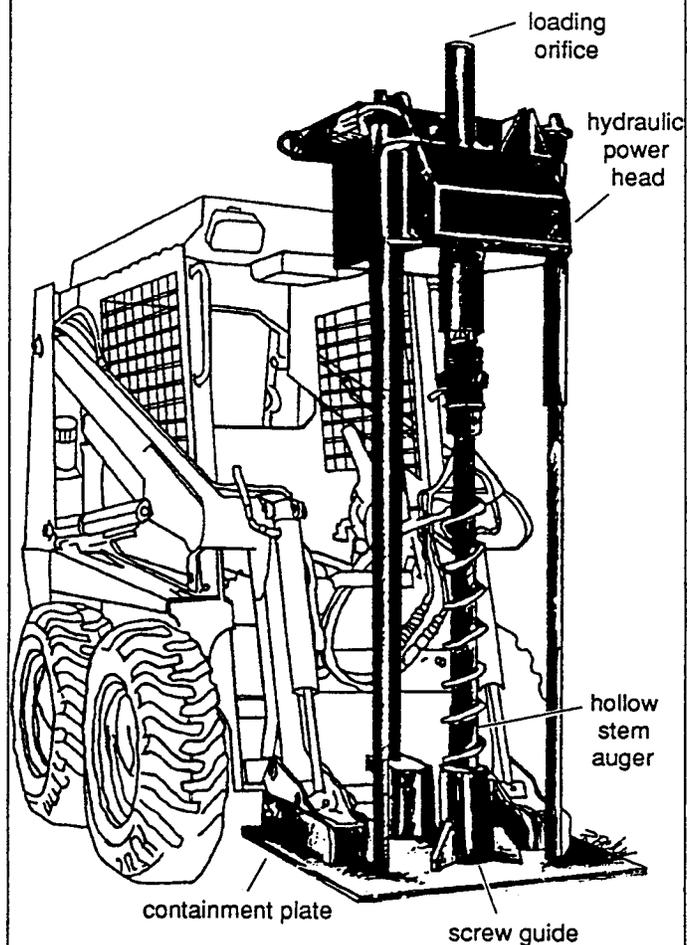


Fig. 1 Diagram represents the auger gun in above-ground position. Modified buffalo-gun portion of the auger gun is not shown, but is conceptually the same as previously documented (Pullan and MacAulay, 1987).

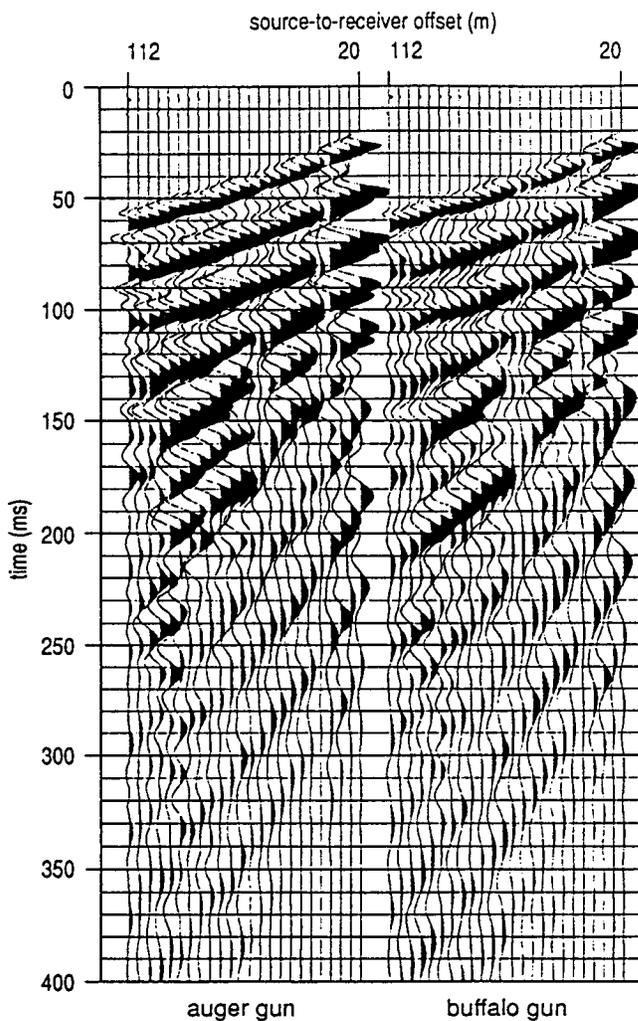


Fig. 2 Auger gun field file (left) compared to the buffalo gun (right).

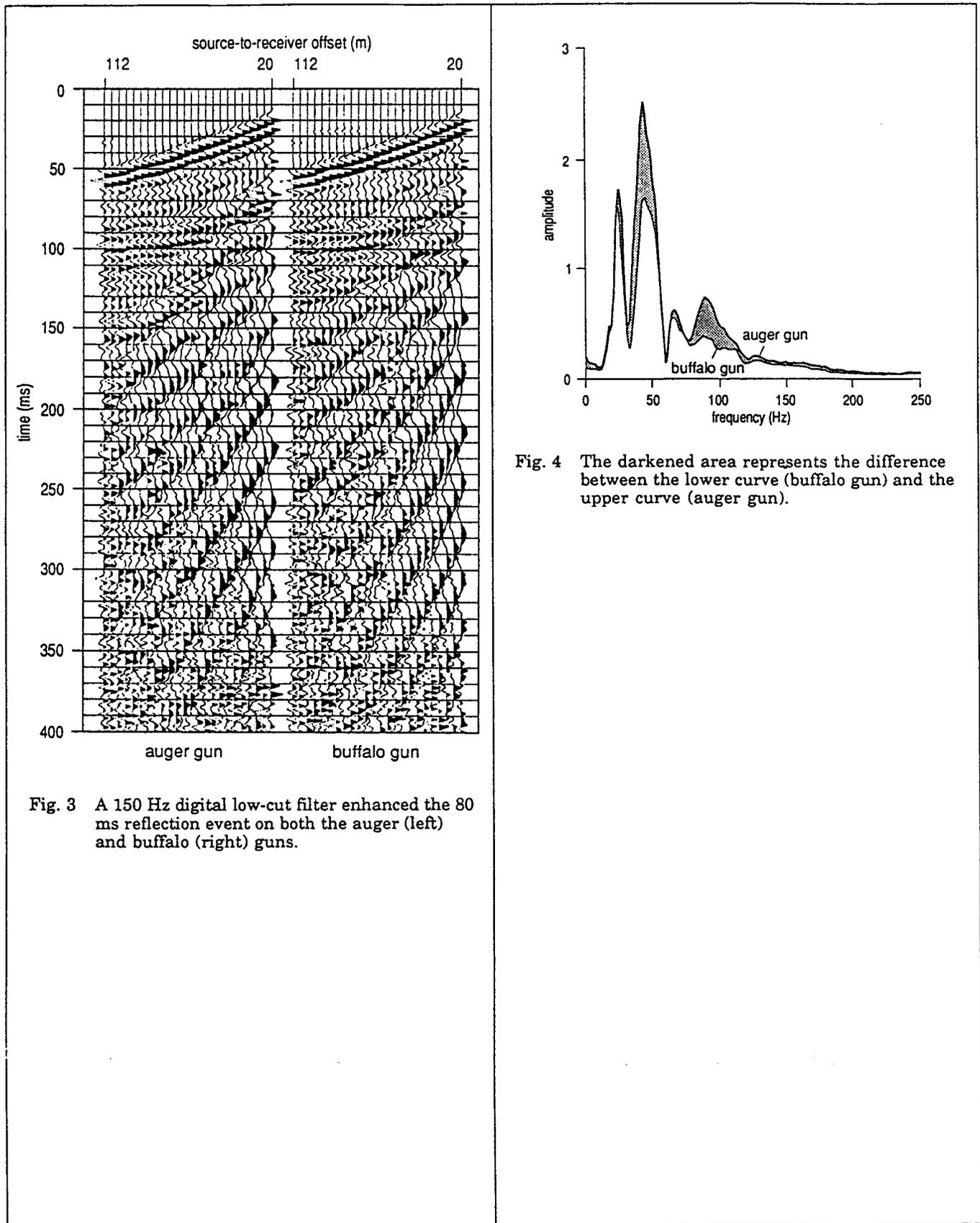


Fig. 3 A 150 Hz digital low-cut filter enhanced the 80 ms reflection event on both the auger (left) and buffalo (right) guns.

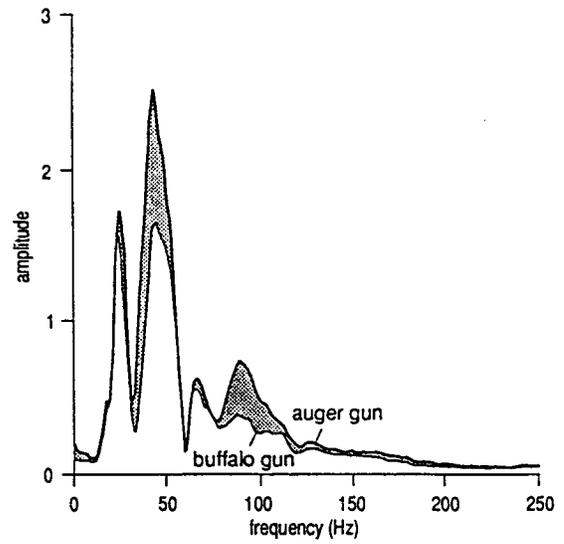


Fig. 4 The darkened area represents the difference between the lower curve (buffalo gun) and the upper curve (auger gun).

Downhole .50-caliber Rifle—An Advance in
High-Resolution Seismic Sources

Don W. Steeples, Richard D. Miller, Ralph W. Knapp,
Kansas Geological Survey.

SUMMARY

In a direct comparison, the downhole .50-caliber seismic source produced more seismic energy, a broader body-wave frequency spectrum, an amplitude drop in the air-coupled wave, and a higher dominant frequency of the recorded body-wave energy than the silenced surface .50-caliber source. The recorded seismic energy of the downhole rifle showed an increased amplitude of 6 to 12 dB over that recorded by the silenced surface rifle. The dominant frequency of the recorded reflection energy was consistently 20 to 40 Hz higher than the surface rifle. The air-coupled wave amplitude was decreased over 12 dB by subsurface firing of the rifle. The frequency spectrum of the body-wave pulse was broadened by almost a half octave on the high end. The safety of operation of the source is not compromised. Reflectors with a dominant frequency in excess of 180 Hz can be easily identified on field files at depths of less than 30 m using the downhole .50-caliber rifle. Identification of 100-Hz reflectors from 1,100 m is possible on field files of multiple vertically stacked downhole .50-caliber shots. The source will operate in an efficient manner collecting CDP data, common-offset data, or spot-correlation data.

INTRODUCTION

Increasing environmental and engineering applications of reflection seismology have spurred research and development of shallow high-resolution reflection techniques and equipment. Resolution on the order of a meter is necessary to detect ultra-shallow targets which are generally the goal of most environmental and engineering studies. This increased resolution can be obtained by boosting the frequency of the source pulse which, in turn, increases the dominant frequency of the recorded seismic-reflection energy. Generating the high-frequency seismic source pulse necessary for shallow applications has been accomplished in a multitude of different ways in the past (Miller et al., 1986).

Recent seismic source advances at the Kansas Geological Survey (KGS) have mainly revolved around surface projectile-type sources (Steeple and Knapp, 1982; Miller and Steeples, 1986; Seeber and Steeples, 1986). A .50-caliber rifle, which was designed and built to safely fire a 750-grain bullet vertically into the ground, has more recently been adapted to operate partially underground with only the firing apparatus above ground. This allows safe operations, a higher-frequency source pulse, and an increased signal-to-noise ratio.

DESIGN AND TECHNIQUE

The general design centers around optimizing the conversion of energy produced by a .50-caliber rifle bullet into seismic (acoustic) waves. The

majority of the energy produced by a .50-caliber round goes into accelerating the projectile and into exhaust gases. Previously, with above-ground sources, we have silenced and dispersed the exhaust gases in hopes of eliminating or at least greatly reducing the effects of the air-coupled wave on seismic data. The downhole .50-caliber rifle nearly simultaneously excites the earth with a projectile and with exhaust gases while containing most of the air-coupled wave, resulting in increased frequency and signal-to-noise ratio on seismic record sections.

The downhole .50-caliber seismic source consists of a .50-caliber rifle bolted to a 0.6-cm-thick steel plate. The rifle itself is a standard .50-caliber breech and bolt, built by Texas Gun and Machine Company, attached to a standard .50-caliber machine-gun barrel. Machined grooves in the barrel are used in conjunction with a pressure clamp to attach the rifle to a 30-cm by 90-cm steel plate. The rifle barrel is lowered into a 60- to 80-cm-deep borehole 4 cm in diameter until the plate is flush with the ground surface. This steel plate acts as a ground seal and a platform to stand on while firing the gun. The weight of the shooter on the plate and the snug fit of the barrel to the borehole walls help seal the gun to the ground. The rifle can be equipped with a source sensor or closure switch to generate a time break. Firing can be done either electrically by solenoid or manually by pulling the trigger. The downhole .50-caliber weighs about 30 kg and is easily two-person portable.

FREQUENCY AND AMPLITUDE

The downhole .50 caliber produces from 6 to 12 dB greater recordable seismic energy at equivalent offsets than the silenced surface .50 caliber (fig. 1). The increased recorded energy boosts the signal-to-noise enough to substantially clean up the record section. The source-to-closest geophone offset in fig. 1 is 43 m. Besides this noticeable increase in recorded seismic energy, a consistent 20-40 Hz boost in the dominant frequency of the source wavelet is characteristic.

In previous shallow-source comparisons (Miller et al., 1986), the surface .50-caliber performed comparably to Mini-Primacord and a 10-gauge Buffalo gun in total energy and frequency spectrum. The noted increase in frequency and energy would make the downhole .50-caliber rifle comparable to the 8-gauge Buffalo gun which was among the best sources tested for reflection energy versus ground roll, total energy, and frequency content.

SAFETY

Safety should be of the utmost concern in any operation involving seismic sources. The rifle is

mounted on a 0.6-cm-thick steel plate to protect the operator from fragments and to help hold the gun securely in place. Since the projectile is fired from a bolt and breech, originally designed as a standard firearm, the utmost in safety has already been designed into the actual firing mechanism. The bolt and breech manufacturer designed the apparatus not to fragment even if the barrel was completely obstructed. The barrel is in standard use by the U. S. military on .50-caliber machine guns. The extra thickness of a machine-gun barrel serves to dissipate heat and, especially in our case, protects from blow-out if foreign material gets into the barrel. This makes continuous operations safe and consistent.

CASE STUDY

Silenced surface .50-caliber vs Downhole .50-caliber.

The direct comparison of the surface and the downhole .50-caliber rifles was performed near Winter Park, Colorado, in an attempt to detect the Moffat railroad tunnel, 85 m below the surface. The receivers were single 100-Hz geophones with a 1.2-m station interval. The sources were 43 m from the closest receiver station. The resulting recorded field files plotted, using true amplitude, clearly show the increased amplitude and the increased signal-to-noise ratio of the downhole rifle as compared to the surface source (fig. 1). A glaring difference is the absence of air-coupled wave on the field file using the downhole rifle. The frequency difference is obvious on the amplitude spectra (fig. 1).

Downhole .50-caliber Field Files and Spectrum

The downhole .50-caliber rifle can produce a source pulse with a dominant reflection frequency in excess of 180 Hz (fig. 2) when used with analog low-cut filters that have a -3 dB point of 220 Hz and a 24 dB/octave rolloff. Clean minimum-phase reflection wavelets, easily in excess of 150 Hz, can be identified down to 270 msec directly off the field file (fig. 3). The spectrum of the reflector at 85 msec is almost 3 octaves across with corner frequencies of 40 and 290 Hz (fig. 3).

The downhole .50-caliber rifle has not only been proven to be a useful shallow high-resolution reflection-seismic source, it also possesses the capability to penetrate as much as 1,100 m of sedimentary veneer overlain by 15 to 30 m of weathered alluvium (fig. 4). The reflection at 720 msec on the field file is Arbuckle dolomite at a depth of 1,100 m in central Kansas. This eight-shot stack was recorded with 30-Hz low-cut filters and ten 40-Hz geophones. The dominant frequency of the reflection energy is about 100 Hz.

ACKNOWLEDGMENTS

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Downhole 50-caliber Rifle
Field File

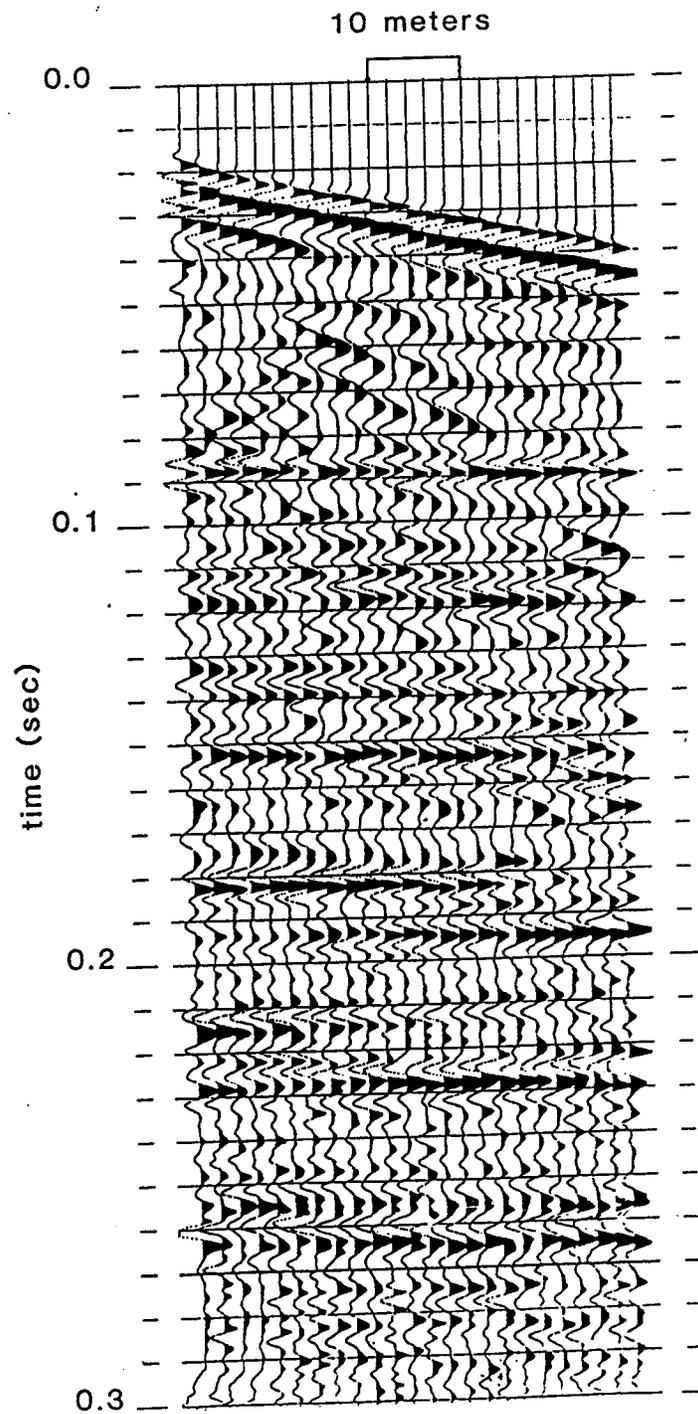


FIG. 2. -This single-shot field file with an AGC applied illustrates the high frequencies and therefore the resolution easily obtainable with a downhole .50-cal.

Surface 50-caliber Rifle -vs- Downhole 50-caliber Rifle

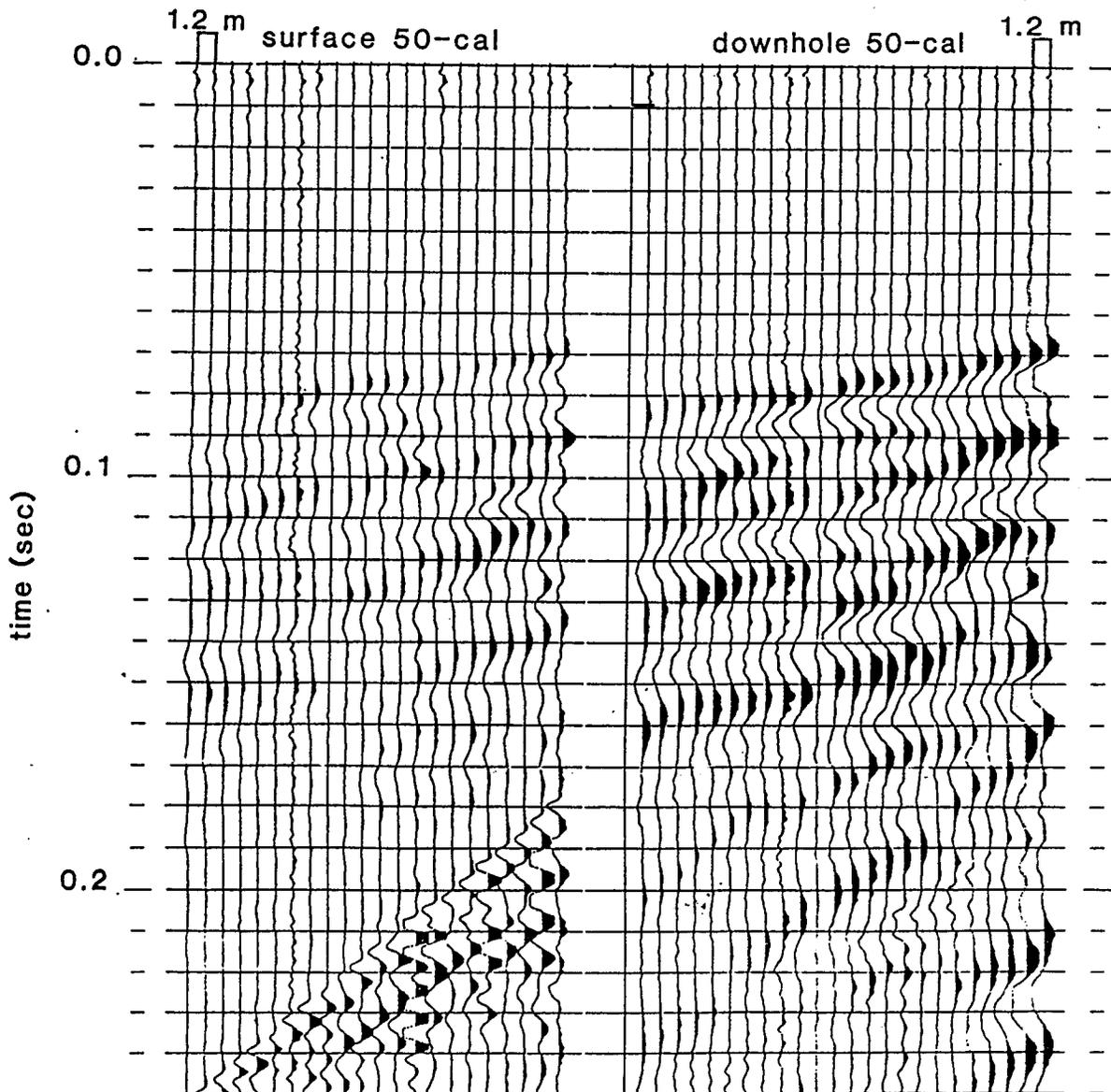
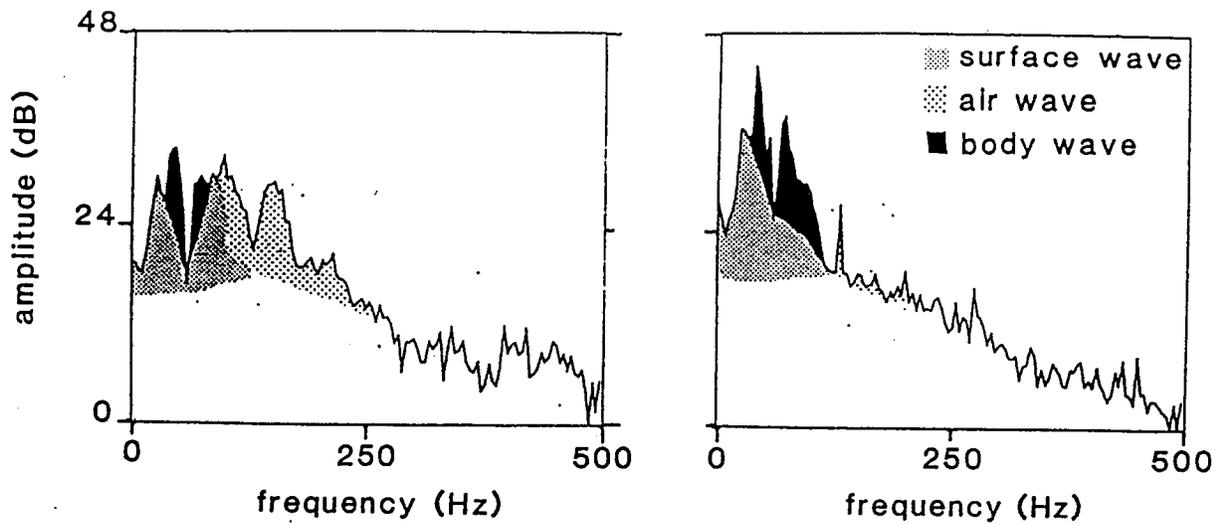


Figure Captions:

-This single shot comparison plotted true amplitude with identical recording parameters clearly shows the increased signal-to-noise and the improved frequency

85 msec Reflector Wavelet
Amplitude Spectrum

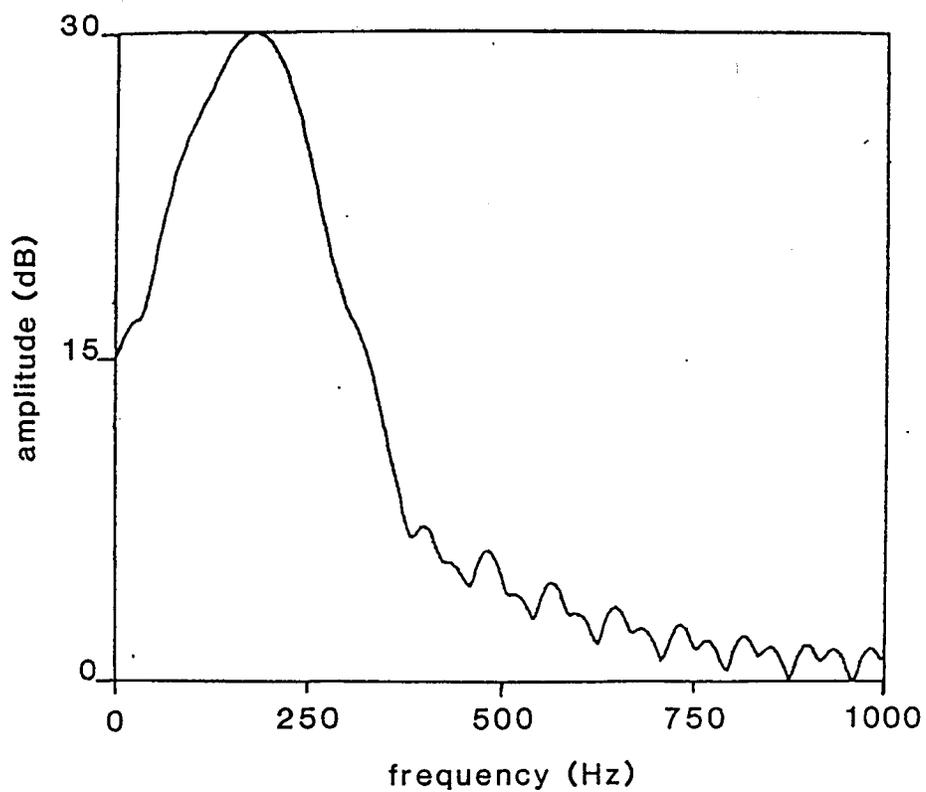


FIG. 3. -The amplitude spectrum of the reflection pulse at 85 msec is almost 3 octaves

Eight Shot Vertical Stack
Downhole 50-caliber Rifle

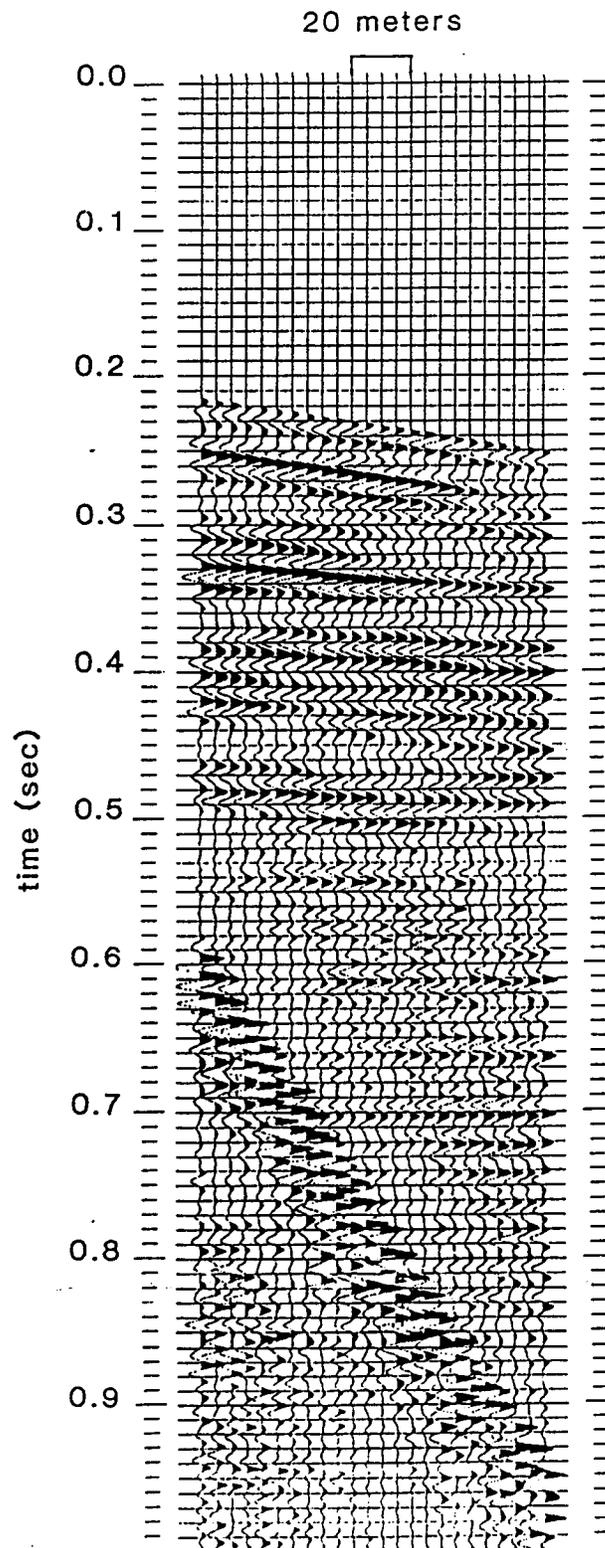


FIG. 4. This stacked field file has 100 Hz reflection energy as deep as 1100 meters.



MATERIAL SAFETY DATA

OCEAN® Network
EMERGENCY PHONE 1-800-OLIN-911

SECTION I - IDENTIFICATION

CHEMICAL NAME & SYNONYMS Industrial Ammunition 8 Gauge (Small Arms Ammunition)		
CHEMICAL FAMILY Not applicable	FORMULA Mixture	TRADE NAME Not applicable
DESCRIPTION Container with powders and projectile		CAS NO. Not assigned

SECTION II - NORMAL HANDLING PROCEDURES

PRECAUTIONS TO BE TAKEN IN HANDLING AND STORAGE
 Store in a cool, well-ventilated place away from all sources of ignition. If damaged, do not get dust in eyes, on skin or on clothing. Do not take internally. Avoid breathing dust or fumes. Upon contact with skin or eyes wash off with water. Avoid breathing fumes during discharge.

PROTECTIVE EQUIPMENT	VENTILATION REQUIREMENTS
Eyes Safety glasses or goggles Gloves None necessary Other Hearing protection recommended during discharge	Local mechanical exhaust ventilation recommended during confined space discharge.

SECTION III - HAZARDOUS INGREDIENTS

BASIC MATERIAL	OSHA PEL	LD 50	LC 50	SIGNIFICANT EFFECTS
Lead	50 ug/m ³	No Data	No Data	Eye irritation, fatigue disturbance of sleep

SECTION IV - FIRE AND EXPLOSION HAZARD DATA

FLASH POINT Method Not Applicable	OSHA CLASSIFICATION Explosive	FLAMMABLE EXPLOSIVE LIMITS LOWER - UPPER -
EXTINGUISHING MEDIA Deluge with water, material is self-oxidizing. Flood with water to fight fire and to cool shells.		
SPECIAL FIRE HAZARD & FIRE FIGHTING PROCEDURES Evacuate area. Fight fire from an explosion resistant location.		

SECTION V - HEALTH HAZARD DATA

THRESHOLD LIMIT VALUE None established. (Inorganic recm. std.-air: TWA 0.15 mg (Pb)m ³ (ACGIH 1984-85))	
SYMPTOMS OF OVER EXPOSURE Eye irritation, fatigue, disturbance of sleep.	
EMERGENCY FIRST-AID PROCEDURES	
SKIN	Contact of skin with shells presents no health hazard.
EYES	Flush thoroughly with water. If an irritation occurs, call a physician.
INGESTION	Ingestion of shells not a possible route of exposure.
Remove victim to fresh air.	

Chemical

Industrial Ammunition 8 Gauge

CAS No.

Not assigned

SECTION VI - TOXICOLOGY (Product) (Small Arms Ammunition)

ACUTE ORAL LD 50	Not applicable	CARCINOGENICITY	Not carcinogenic
ACUTE DERMAL LD 50	> 2 g/kg	MUTAGENICITY	May be mutagenic
ACUTE INHALATION LC 50	Not known	EYE IRRITATION	May be an irritant
		PRIMARY SKIN IRRITATION	Not an irritant
PRINCIPAL ROUTES OF ABSORPTION Inhalation, dermal			
EFFECTS OF ACUTE EXPOSURE Fatigue, disturbance of sleep, eye irritation.			
EFFECTS OF CHRONIC EXPOSURE Anemia, central nervous system depression, toxicity to kidneys, reproductive system and fetus.			

SECTION VII - SPILL AND LEAKAGE PROCEDURES (Control Procedures)

ACTION FOR MATERIAL RELEASE OR SPILL Remove all sources of ignition. Wear goggles and gloves. Use non-sparking utensils during cleanup. If containers are damaged, wear NIOSH/MSHA approved dust respirator. Follow OSHA regulations for respirator use. (See 29 CFR 1910.134). Minimize powder contamination. Clean up and place in an approved DOT container. Isolate and do not seal. Label "Small Arms Ammunition". Wash all contaminated clothing before reuse. In the event of a large spill use the emergency telephone number shown on the front of this sheet. TRANSPORTATION EMERGENCY, CONTACT CHEMTREC 800-424-9300
WASTE DISPOSAL METHOD Dispose of contaminated product, empty containers and materials used in cleaning up spills or leaks in a manner approved for this material. Consult appropriate federal, state and local regulatory agencies to ascertain proper disposal procedures.

SECTION VIII - SHIPPING DATA

D.O.T. CLASS	Class C Explosive	ORM-D
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SECTION IX - REACTIVITY DATA

STABLE	<input checked="" type="checkbox"/> UNSTABLE	AT _____ °C _____ °F	HAZARDOUS POLYMERIZATION	MAY OCCUR
CONDITIONS TO AVOID				WILL NOT OCCUR <input checked="" type="checkbox"/>
INCOMPATIBILITY (Material to Avoid)			Acids, alkalis, oxidizing materials (contents)	
HAZARDOUS DECOMPOSITION PRODUCTS			Lead fume, carbon monoxide	

SECTION X - PHYSICAL DATA

MELTING POINT	N/A	VAPOR PRESSURE	N/A	VOLATILES	N/A
BOILING POINT	N/A	SOLUBILITY IN WATER	N/A	EVAPORATION RATE	N/A
SPECIFIC GRAVITY (H ₂ O = 1)	N/A	PH	N/A	VAPOR DENSITY (Air = 1)	N/A

INFORMATION FURNISHED BY: C. C. Noonan
(203) 789-5436

DATE November 16, 1985

Department of Environmental Hygiene and Toxicology
(203) 789-5436

Material Safety Data Sheet

May be used to comply with OSHA's Hazard Communication Standard, 29 CFR 1910.1200. Standard must be consulted for specific requirements.

U.S. Department of Labor

Occupational Safety and Health Administration
(Non-Mandatory Form)

Form Approved
OMB No. 1218-0072



IDENTITY (As Used on Label and List)
All Shotshell Ammunition

Note: Blank spaces are not permitted. If any item is not applicable, or no information is available, the space must be marked to indicate that.

Section I "Small Arms Ammunition"

Manufacturer's Name Remington Arms Co., Inc.	Emergency Telephone Number (501) 676-3161
Address (Number, Street, City, State, and ZIP Code) I-40 & Highway 15 Lonoke, Arkansas 72086	Telephone Number for Information (501) 374-2246
	Date Prepared 8-12-86
	Signature of Preparer (optional) W.G. Bell, Chem Lab - Technical Section <i>WGB</i>

Section II - Hazardous Ingredients/Identity Information

Hazardous Components (Specific Chemical Identity; Common Name(s))	OSHA PEL	ACGIH TLV	Other Limits Recommended	% (optional)
Lead; Inorganic and lead compounds	50mg/M ³			
Arsenic and compounds	10mg/M ³			
Antimony and compounds	500 mg/M ³			
Barium and compounds	500 mg/M ³			
Nitroglyerin (0.05 ppm skin) 500 micrograms/M ³ of air				

DOT - "Small Arms Ammunition"
Class C Explosive

UPS : ORM-D

Section III - Physical/Chemical Characteristics

Boiling Point Not applicable	Specific Gravity (H ₂ O = 1) Not applicable
Vapor Pressure (mm Hg.) Not applicable	Melting Point Not applicable
Vapor Density (AIR = 1) Not applicable	Evaporation Rate (Butyl Acetate = 1) NOT APPLICABLE

Solubility in Water
Lead & Lead Styphnate - Insoluble; Lead Nitrate - 127 gm/100cc Water - 100°C

Appearance and Odor
Grayish, Gray, Silvery Material - No odor

Section IV - Fire and Explosion Hazard Data

Flash Point (Method Used) Not applicable	Flammable Limits Not applicable	LEL NA	UEL NA
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Extinguishing Media
Material is self oxidizing; flood with water to fight fire and cool shells.

Special Fire Fighting Procedures
Evacuate immediate area and deluge with water. wear protective clothing for shrapnel.

Unusual Fire and Explosion Hazards
Shells will detonate when exposed to flame and high temperatures.

Section V — Reactivity Data

Stability	Unstable		Conditions to Avoid Flames, sparks, percussion or shock and high temperatures (130°C)
	Stable	X	

Incompatibility (Materials to Avoid) .. Strong mineral acids and alkalis

Hazardous Decomposition or Byproducts Oxides of carbon, nitrogen and lead fumes.

Hazardous Polymerization	May Occur		Conditions to Avoid Heat, fire, static, friction and percussion.
	Will Not Occur	X	

Section VI — Health Hazard Data

Route(s) of Entry: Inhalation? Fumes Skin? Cuts or abrasions - Ingestion? Particles

Health Hazards (Acute and Chronic)
Anemia, fatigue, nocturia, embryotoxin, malnutrition, weakness, mental confusion, pallor -
treat per general lead exposure; headache and nausea

Carcinogenicity: Not known NTP? IARC Monographs? OSHA Regulated? Lead - Yes

Signs and Symptoms of Exposure Refer to health hazard above.

Medical Conditions Generally Aggravated by Exposure Gastrointestinal tract; kidneys; blood and central nervous system. (CNS)

Emergency and First Aid Procedures Skin - flush with water; if swallowed seek medical attention immediately.

Section VII — Precautions for Safe Handling and Use

Steps to Be Taken in Case Material is Released or Spilled

Use non-sparking equipment to cleanup and store shells - avoid ignition sources.

Waste Disposal Method Material may be burned per appropriate federal, state and local regulatory agency - contact

Precautions to Be Taken in Handling and Storing

Refer to released or spilled data above.

Other Precautions

Label containers - "Small Arms Ammunition" wear gloves and shrapnel protection.

Section VIII — Control Measures

Respiratory Protection (Specify Type) OSHA SA/HiE/SCBA

Ventilation	Local Exhaust	Not required	Special	Not applicable
	Mechanical (General)	Not required	Other	Not applicable

Protective Gloves Not applicable Eye Protection Safety glasses when shooting

Other Protective Clothing or Equipment Use hearing protection when discharging cartridges.

Work/Hygenic Practices Wash hands after skin contact with cartridges.

GENERAL MOTORS CORPORATION MATERIAL SAFETY DATA SHEET

SECTION I

PRODUCT NAME OR NUMBER (as it appears on label) ALL MODELS OF DELCO BATTERIES		GM COMMON CODE
MANUFACTURER'S NAME Delco Remy Division, GMC		EMERGENCY TELEPHONE NO. (317) 646-3080
ADDRESS (Number, Street, City, State and Zip Code) 2401 Columbus Avenue, Anderson, IN 46018		MANUFACTURER'S D-U-N-S NO.
HAZARDOUS MATERIAL DESCRIPTION, PROPER SHIPPING NAME, HAZARD CLASS, HAZARD ID NO. (49 CFR 172.101) Battery, Wet, Filled with Acid, (Corrosive Material) Class 8 - UN2794		
ADDITIONAL HAZARD CLASSES (as applicable)		
CHEMICAL FAMILY Liquid Content - Sulfuric Acid	FORMULA Liquid Content - H2SO4	

SECTION II — INGREDIENTS (list all ingredients)

CAS REGISTRY NO.	%W	%V	CHEMICAL NAME(S)	Listed as a Carcinogen in NTP, IARC or OSHA 1910(a) (specify)
7664939		37	Sulfuric Acid	NA
7732185		Bal.	Water	NA
7439921		90	Lead	NA
			Separator:	
			Dramic	
			Case and Cover: Polypropylene (Plastic)	

SECTION III — PHYSICAL DATA

BOILING POINT 233 °F <input type="checkbox"/> °C	SPECIFIC GRAVITY (H ₂ O = 1) Varies with battery size	Average 1.280 ± .01	
VAPOR PRESSURE 27 °F 25 °C <input checked="" type="checkbox"/> mm Hg <input type="checkbox"/> psi	PERCENT VOLATILE BY VOLUME (%)	NA	PERCENT SOLID BY WEIGHT (%)
VAPOR DENSITY (AIR = 1)	EVAPORATION RATE (= 1)	NA	NA
SOLUBILITY IN WATER Miscible	pH =	< 1.0	
APPEARANCE AND ODOR Water - white liquid (acid content)	IS MATERIAL: <input type="checkbox"/> GAS <input type="checkbox"/> PASTE <input checked="" type="checkbox"/> LIQUID <input type="checkbox"/> SOLID <input type="checkbox"/> POWDER		

SECTION IV — FIRE AND EXPLOSION HAZARD DATA

FLASH POINT NA °F <input type="checkbox"/> °C	method used	FLAMMABLE LIMITS	LEL NA	UEL NA
EXTINGUISHING MEDIA				
SPECIAL FIRE FIGHTING PROCEDURES Recommended self-contained breathing apparatus if batteries are involved in fire due to toxic fumes from burning plastic and acid fumes and vapors.				
UNUSUAL FIRE AND EXPLOSION HAZARDS While batteries are being charged, hydrogen gas is generated. Avoid open flames, spark or lighted matches. Acid, powerful oxidizers, can ignite combustible upon contact.				

EFFECTS OF OVEREXPOSURE - Conditions to Avoid
 CONTACT with sulfuric acid results in rapid
 destruction of body tissue (burns).
 THRESHOLD LIMIT VALUE TLV=1 mg/m3
 PERMISSIBLE EXPOSURE LIMIT Sulfuric Acid
 OTHER LIMIT

PRIMARY ROUTES OF ENTRY Inhalation Skin Contact Other (specify) Ingestion

EMERGENCY AND FIRST AID PROCEDURES Do not exceed 1 mg/m3 TWA. Remove to fresh air. Get
 medical attention. EYE OR SKIN CONTACT: Flush with large volumes of water. Get
 medical attention. INGESTION: DO NOT induce vomiting. Give milk mixed with egg
 white if conscious.

SECTION VI-REACTIVITY DATA

STABILITY	UNSTABLE	CONDITIONS TO AVOID
	STABLE	
	X	
INCOMPATIBILITY (materials to avoid) Oxidizing or reducing materials.		
HAZARDOUS DECOMPOSITION PRODUCTS: When heated, can emit highly toxic fumes.		
HAZARDOUS POLYMERIZATION	MAY OCCUR	CONDITIONS TO AVOID
	WILL NOT OCCUR	
	XX	

SECTION VII-SPILL OR LEAK PROCEDURES

STEPS TO BE TAKEN IN CASE MATERIAL IS RELEASED OR SPILLED
 Lime or soda may be used to neutralize and/or flush with large volumes of water.
 Contain spill.
 WASTE DISPOSAL METHOD
 According to local, state, and federal regulations for acid or lead scrap.
 CERCLA (Superfund) REPORTABLE QUANTITY (in lbs) 1,000 lbs.
 RCRA HAZARDOUS WASTE NO. (40 CFR 261.33) D002
 VOLATILE ORGANIC COMPOUND (VOC) (as packaged, minus water) NA
 Theoretical 4 lb/gal Analytical NA lb/gal

SECTION VIII-SPECIAL PROTECTION INFORMATION

RESPIRATORY PROTECTION (specify type)
 Use NIOSH approved respiratory protection if 1 mg/m3 TWA is exceeded (acid).

VENTILATION	LOCAL EXHAUST (Specify Rate) Yes at charging stations	SPECIAL NA
	MECHANICAL (General) (Specify Rate)	OTHER NA

PROTECTIVE GLOVES (specify type) Rubber EYE PROTECTION (specify type) splash-proof safety g
 OTHER PROTECTIVE EQUIPMENT
 Use rubber boots and acid-proof clothing for major spills.

SECTION IX-SPECIAL PRECAUTIONS

PRECAUTIONS TO BE TAKEN IN HANDLING AND STORING
 Avoid skin contact. When charging batteries, avoid placing in areas where hydrogen
 can build up. DO not place near open flames, sparks, or lighted matches.
 OTHER PRECAUTIONS

Seller agrees not to assert any claim (other than a claim for a patent infringement)
 against General Motors Corporation for any use or disclosure of any technical data
 or information disclosed in connection with this questionnaire.

PLEASE COMPLETE QUESTIONNAIRE AND RETURN TO:	Name (print) Robert A. Chisman
	Signature <i>Robert A. Chisman</i>
	Title Senior Industrial Hygienist
	Date May 8, 1991

MATERIAL SAFETY DATA SHEET

PRODUCT SA 825 0012
ELL-BEE LITHIUM M-P GREASE

HAZARD RATING N F P A	4 - EXTREME	Fug Reactivity Toxicity Special
	3 - HIGH	
	2 - MODERATE	
	1 - SLIGHT	
	0 - INSIGNIFICANT	

SECTION I

WITCO MANUFACTURING DIVISION OR SUBSIDIARY		EMERGENCY TELEPHONE	
1 ADDRESS (NUMBER, STREET, CITY, STATE, ZIP CONF)		MANUFACTURER 782-5800	
2		CHEM TREC 1-(800) 424-9300	
3 CHEMICAL NAME OR FAMILY Petroleum Hydrocarbon		4 FORMULA NA	

SECTION II - CHEMICAL AND PHYSICAL PROPERTIES

HAZARDOUS DECOMPOSITION PRODUCTS 6 Carbon monoxide, carbon dioxide INCOMPATIBILITY (KEEP AWAY FROM): Strong oxidizing agents such as: hydrogen peroxide, 6 chromic acid, bromine LIST ALL TOXIC AND HAZARDOUS INGREDIENTS 7 None	FORM 8 Semi-solid ODOR 9 Mineral Oil APPEARANCE 10 Grease COLOR 11 Amber SPECIFIC GRAVITY 12 (WATER = 1) RT 0.924 BOILING PT. 13 NDA °C °F MELTING PT. 14 NA °C °F SOLUBILITY IN WATER AT 25 °C Negligible 15 % VOLATILE (BY WT %) 18 NA EVAP. RATE 17 (= 1) NA VAPOR PRESSURE 18 (mm Hg at 20 °C) NA VAPOR DENSITY (AIR = 1) 19 NA pH AS IS 20 pH 1
--	--

SECTION III - FIRE AND EXPLOSION DATA

SPECIAL FIRE FIGHTING PROCEDURES 24 Fire fighters should wear an approved self contained breathing apparatus.	FLASH POINT (METHOD USED) Above C.O.C. 26 190 °C 374 °F FLAMMABLE LIMITS % 27 LOWER NDA UPPER UNUSUAL FIRE AND EXPLOSION HAZARDS 25 Dense smoke EXTINGUISHING AGENTS X DRY CHEMICAL X CO ₂ WATERSPRAY X FOAM WATERFOG X SAND/EARTH 28 OTHER
--	---

SECTION IV - HEALTH HAZARD DATA

PERMISSIBLE CONCENTRATIONS (AIR) 29 NDA EFFECTS OF OVEREXPOSURE 30 May cause skin & eye irritation with prolonged contact. TOXICOLOGICAL PROPERTIES 31 NDA EMERGENCY FIRST AID PROCEDURES 32 EYES Flush with large amounts of water for at least 15 min. Call a physician immediately. 33 SKIN CONTACT Wash thoroughly with soap and water. 34 INHALATION NDA 35 IF SWALLOWED Call a physician immediately.	STRONG ACID _____ : STRONG BASE _____ : STABLE _____ X UNSTABLE _____ : 21 VISCOSITY SUS < 100 AT 100 °F 100 OR > XX 22 23 NA
---	--

NA = NOT APPLICABLE

NDA = NO DATA AVAILABLE

< = LESS THAN

> = MORE THAN

MATERIAL SAFETY DATA SHEET

PRODUCT SA 825 0012

SECTION V - SPECIAL PROTECTION INFORMATION

VENTILATION TYPE REQUIRED (LOCAL, MECHANICAL, SPECIAL) None Required	PROTECTIVE GLOVES Rubber or plastic oil resistant
RESPIRATORY PROTECTION (SPECIFY TYPE) None Required	EYE PROTECTION Safety goggles and full face shield OTHER PROTECTIVE EQUIPMENT None Required

SECTION VI - HANDLING OF SPILLS OR LEAKS

PROCEDURES FOR CLEAN-UP
 Transfer bulk of material into another container. Absorb remaining residue with proper absorbents such as sand, earth, vermiculite. Sweep up and dispose as solid waste in accordance to local, state and federal regulations.

WASTE DISPOSAL
 By methods consistent with local, state and federal regulations.

SECTION VII - SPECIAL PRECAUTIONS

PRECAUTIONS TO BE TAKEN IN HANDLING AND STORAGE
 Keep containers closed.

SECTION VIII - TRANSPORTATION DATA

UNREGULATED BY D.O.T. <input checked="" type="checkbox"/>	U.S. D.O.T. PROPER SHIPPING NAME 47	
REGULATED BY D.O.T. <input type="checkbox"/>	U.S. D.O.T. HAZARD CLASS 48	I.D. NUMBER 49
TRANSPORTATION EMERGENCY INFORMATION CHEM TREC 1-(800) 424-9300	RC 50	LABEL(S) REQUIRED 51
	FREIGHT CLASSIFICATION Petroleum Lubricating Grease	
	SPECIAL TRANSPORTATION NOTES 52 53	

SECTION IX - COMMENTS

KEEP OUT OF REACH OF CHILDREN!!

SIGNATURE *Ray E. Leonard* TITLE Manager Technical Compliance

REVISION DATE _____ SENT TO ATTN: _____ DATE 3/05/84

SUPERSEDES _____

We believe the statements, technical information and recommendations contained herein are reliable, but they are given without warranty or guarantee of any kind, express or implied, and we assume no responsibility for any loss, damage, or expense, direct or consequential, arising out of their use.

MATERIAL SAFETY DATA SHEET

PRODUCT SA 825 0012

SECTION V - SPECIAL PROTECTION INFORMATION

VENTILATION TYPE REQUIRED (LOCAL, MECHANICAL, SPECIAL) None Required	PROTECTIVE GLOVES Rubber or plastic oil resistant
RESPIRATORY PROTECTION (SPECIFY TYPE) None Required	EYE PROTECTION Safety goggles and full face shield OTHER PROTECTIVE EQUIPMENT None Required

SECTION VI - HANDLING OF SPILLS OR LEAKS

PROCEDURES FOR CLEAN-UP

Transfer bulk of material into another container. Absorb remaining residue with proper absorbents such as sand, earth, vermiculite. Sweep up and dispose as solid waste in accordance to local, state and federal regulations.

WASTE DISPOSAL

By methods consistent with local, state and federal regulations.

SECTION VII - SPECIAL PRECAUTIONS

PRECAUTIONS TO BE TAKEN IN HANDLING AND STORAGE

Keep containers closed.

SECTION VIII - TRANSPORTATION DATA

UNREGULATED BY D.O.T. <input checked="" type="checkbox"/>	U.S. D.O.T. PROPER SHIPPING NAME	
REGULATED BY D.O.T. <input type="checkbox"/>	U.S. D.O.T. HAZARD CLASS	I.D. NUMBER
TRANSPORTATION EMERGENCY INFORMATION CHEM TREC 1-(800) 424-9300	RQ	LABEL(S) REQUIRED
	FREIGHT CLASSIFICATION Petroleum Lubricating Grease	
	SPECIAL TRANSPORTATION NOTES	
	(Empty)	

SECTION IX - COMMENTS

KEEP OUT OF REACH OF CHILDREN!!

SIGNATURE *Ray G. Leonard* TITLE Manager Technical Compliance

REVISION DATE _____ SENT TO ATTN: _____ DATE 3/05/84

SUPERSEDES _____

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MATERIAL SAFETY DATA SHEET

Tox no. : 042840



Page 1

Print Date : 04/02/90

Last Reviewed : 05/03/89

Part Type and Number	Part name
Ford - U.S. BATTERY - ALL	BATTERY ELECTROLYTE
Motorcraft - U.S. BATTERY - ALL	BATTERY ELECTROLYTE

----- CHEMICAL AND PHYSICAL PROPERTIES -----

Material type	LIQUID
Specific Gravity	1.250
Boiling Point	>135 C
Flash Point	Not Applicable
pH	2.0

----- HAZARDOUS AND OTHER DISCLOSED INGREDIENTS -----

Percent Range	Exposure Limits - TWA ACGIH/OSHA (where-est.)	CAS number	Chemical Name
>30-60	1/1 mg/m3	7664-93-9	SULFURIC ACID

Exposure Limit Abbreviations

TWA=Time Weighted Average	C=Ceiling
S=Short Term Exposure	Sk=Skin
Sol=Soluble Compounds	Fu=Fumes
Insol=Insoluble Compounds	Du=Dust

----- REGULATORY INFORMATION -----

This product contains a toxic chemical or chemicals subject to the reporting requirements of Section 313 of Title III of the Superfund Amendments and Reauthorization Act of 1986 and 40 CFR Part 372.

----- SIGNAL WORD -----

DANGER -- CORROSIVE

----- HAZARDS -----

Contact with this material will cause burns to the skin, eyes and mucous membranes.
 When this material comes into contact with the eyes, serious damage may occur.
 This product is harmful by Inhalation, when in contact with the skin and if it is swallowed.
 This product is irritating to the eyes, respiratory system and skin.
 This product may be fatal if it is swallowed.

M S D S
(CONTINUED)

Tox no. : 042840

Page 2
Print Date : 04/02/90

----- TARGET ORGANS AND MEDICAL CONDITIONS -----

Overexposure to some hazardous ingredients in this product has been found to affect certain body organs and systems in experimental animals and/or humans. These include:

Lungs
Teeth
Skin, Eyes, and Respiratory System

----- ACUTE TOXICITY INFORMATION -----

Based on the composition of the product identified by the supplier, selected portions of the acute toxicity information from RTECS are as follows:

7664-93-9 SULFURIC ACID
Inhalation, adult rat, LC50 = 510 mg/m³ (2 Hours)
Oral, adult rat, LD50 = 2140 mg/kg

----- SAFE HANDLING AND STORAGE -----

Do not breathe gas/fumes/vapor/spray.
Use this product with adequate ventilation.
Do not get this material in your eyes, on your skin, or on your clothing.
This is an oxidizing agent - avoid bringing it into contact with an organic material.
Store this product in air-tight containers away from sources of heat and light.

----- FIRE, EXPLOSION AND REACTIVITY INFORMATION -----

Bringing this product into contact with combustible material may cause a fire.
EXTINGUISHER INFORMATION: Dry chemical, foam, carbon dioxide.
Use water to cool fire-exposed containers and to protect personnel.
Wear self-contained breathing apparatus.
This product can react violently with reducing agents and organic materials.
Explosive HYDROGEN GAS may be released if aqueous solutions of this material come into contact with reactive metals (IRON, ZINC, ALUMINUM).
Irritating and/or toxic fumes and gases may be emitted upon heating of this product.
The decomposition of this product will release toxic gases.



Tox no. : 042840

Page 3
Print Date : 04/02/90

----- PROTECTIVE MEASURES AND TREATMENTS -----

Use of an impervious apron is recommended.
 Use general ventilation and use local exhaust, where possible, in confined or enclosed spaces.
 Wear chemical goggles and face shield.
 The use of neoprene gloves is recommended.
 In case of contact with eyes, rinse immediately with plenty of water and seek medical advice.
 Immediately take off all contaminated clothing.
 If the material is swallowed, get immediate medical attention or advice --
 Give several glasses of water or milk.
 If gas/fume/vapor/dust/mist from the material is inhaled, remove the affected person immediately to fresh air.
 For skin contact flush with large amounts of water.
 Wash thoroughly after handling.

----- NOTES TO PHYSICIANS -----

If the product is ingested, probable mucosal damage may contraindicate the use of gastric lavage. Treat the affected person appropriately.

----- SPILLS, LEAKS AND DISPOSAL -----

Eliminate all sources of ignition or flammables that may come into contact with a spill of this material.
 Avoid skin contact and inhalation of vapors during disposal of spills.
 Dispose of waste material according to Local, State, and Federal Environmental Regulations.
 In case of large spills, follow all facility Emergency Response Procedures.

----- SPECIAL REMARKS -----

This is an acidic material.

----- U. S. DEPARTMENT OF TRANSPORTATION INFORMATION -----

Shipping name: BATTERY FLUID, ACID UN: 2796
 Hazard Class: Corrosive material Hazard Label: Corrosive

The chemical name(s) appearing below under "NAME" must appear as part of shipping name IF the amount being shipped in each container exceeds the quantity shown under "RQ" below. The letters "RQ" must also appear as part of the shipping name, in the form:

shipping name, chemical name, RQ.

For U.S. shipments from Ford Facilities, consult the "Ford Hazardous Material Transportation Control Program" Manual, otherwise consult 49CFR172.

-----CAS-- RQ(lbs) -NAME-----

7664-93-9 2777 SULFURIC ACID

M S D S
(CONTINUED)

Tox no. : 042840

Page 4
Print Date : 04/02/90

----- PREPARATION INFORMATION -----

Health and safety information has been evaluated by:

Environmental & Occupational Toxicology, Occupational Health & Safety,
Ford Motor Company
900 Parklane Towers West, Dearborn, MI 48126

For emergency call: (313) 337-3182 -or- (313) 323-0045 (for 24 hour service)

This is the last page of this MSDS.



MATERIAL SAFETY
DATA SHEET

AMOCO REGULAR LEAD-FREE GASOLINE

MSDS NO: 02003992

MANUFACTURER/SUPPLIER:
Amoco Oil Company
200 East Randolph Drive
Chicago, Illinois 60601

EMERGENCY HEALTH INFORMATION: (800) 447-8735
EMERGENCY SPILL INFORMATION: (800) 424-9300
CHEMTREC, U.S.A.
OTHER PRODUCT SAFETY INFORMATION: (312) 856-3907

IMPORTANT COMPONENTS: Gasoline (CAS 8006-61-9) ACGIH TLV 300 ppm, STEL 500 ppm;
OSHA PEL 300 ppm, STEL 500 ppm.
Benzene (CAS 71-43-2) ACGIH TLV 10 ppm; OSHA PEL 1 ppm
(8-hr. TWA), STEL 5 ppm (15 min.).
*See Supplemental Information Section.

WARNING STATEMENT: Danger! Extremely flammable. High vapor concentrations can cause headaches, dizziness, drowsiness and nausea. Harmful if swallowed and/or aspirated into lungs. Can produce skin irritation on prolonged or repeated contact. Use as motor fuel only. Long-term exposure to vapors has caused cancer in laboratory animals.

HMIS/NFPA CODES:(HEALTH;1)(FLAMMABILITY;3)(REACTIVITY;0), Chronic health hazard

APPEARANCE AND ODOR: Clear, bright liquid. Characteristic odor.

HEALTH HAZARD INFORMATION

EYE

EFFECT: High concentrations of vapor/mist may cause eye discomfort.
FIRST AID: Flush eyes with plenty of water. Get medical attention if irritation persists.
PROTECTION: None required; however, use of eye protection is good industrial practice.

SKIN

EFFECT: Prolonged or repeated contact can defat the skin and lead to irritation and/or dermatitis.
FIRST AID: Wash exposed skin with soap and water. Remove contaminated clothing, including shoes, and thoroughly clean and dry before reuse. Get medical attention if irritation develops.
PROTECTION: Avoid prolonged or repeated skin contact. Wear protective clothing and gloves if prolonged or repeated contact is likely.

INHALATION

EFFECT: Vapour harmful. High vapor concentrations can cause headaches, dizziness, drowsiness and nausea. See Toxicology Section.
FIRST AID: If adverse effects occur, remove to uncontaminated area. Give artificial respiration if not breathing. Get medical attention.
PROTECTION: Use with adequate ventilation. Avoid breathing vapor and/or mist. If ventilation is inadequate, use NIOSH/MSHA certified respirator which will protect against organic vapor/mist.

PAGE 02 OF 05

HEALTH HAZARD INFORMATION - CONTINUED

INGESTION

EFFECT: Low viscosity product. Harmful or fatal if aspirated into lungs.

FIRST AID: If swallowed, do NOT induce vomiting. Get immediate medical attention.

FIRE AND EXPLOSION INFORMATION

FLASHPOINT: -45°F

FLAMMABLE LIMITS: UPPER: 7.6% LOWER: 1.3%

AUTOIGNITION TEMPERATURE: 495°F

EXTINGUISHING MEDIA: Agents approved for Class B hazards (e.g., dry chemical, carbon dioxide, halogenated agents, foam, steam) or water fog.

UNUSUAL FIRE AND EXPLOSION HAZARDS: Extremely flammable vapor/air mixtures form. Extinguishment of fire before source of vapor is shut off can create an explosive mixture in air.

PRECAUTIONS: Keep away from ignition sources (e.g., heat, sparks and open flames). Keep container closed. Use with adequate ventilation.

REACTIVITY INFORMATION

DANGEROUS REACTIONS: Avoid chlorine, fluorine and other strong oxidizers.

HAZARDOUS DECOMPOSITION: Burning can produce carbon monoxide and/or carbon dioxide and other harmful products.

STABILITY: Burning can be started easily.

CHEMICAL AND PHYSICAL PROPERTIES

BOILING POINT: 80°F TO 430°F, Range

SOLUBILITY IN WATER: Negligible, below 0.1%.

SPECIFIC GRAVITY (WATER = 1): 0.75

VAPOR PRESSURE: 7-15 lb RVP (ASTM D-323)

VAPOR DENSITY (AIR = 1): 3 TO 4

PAGE 03 OF 05

STORAGE AND ENVIRONMENTAL PROTECTION

STORAGE REQUIREMENTS: Store in flammable liquids storage area. Keep container closed. Store away from heat, ignition sources, and open flame in accordance with applicable federal, state, or local regulations.

SPILLS AND LEAKS: Remove or shut off all sources of ignition. Use water spray to disperse vapors. Increase ventilation, if possible. Contain on an absorbent material (e.g., sand, sawdust, dirt, clay). Keep out of sewers and waterways.

WASTE DISPOSAL: Residues and spilled material are hazardous waste due to ignitability. Disposal must be in accordance with applicable federal, state, or local regulations. Enclosed-controlled incineration is recommended unless directed otherwise by applicable ordinances.

SPECIAL PRECAUTIONS: Keep out of sewers and waterways. Avoid strong oxidizers. Report spills to appropriate authorities. USE AS MOTOR FUEL ONLY.

TOXICOLOGICAL INFORMATION

EYE: Primary eye irritation score 0.0/110.0 (rabbits).

SKIN: Primary dermal irritation score 1.1/8.0 (rabbits). Acute dermal LD50 greater than 5ml/kg (rabbits). Practically nontoxic for acute exposures by this route.

INHALATION: Acute LC50 20.7mg/l (rats).

INGESTION: Acute oral LD50 18.8ml/kg (rats). Practically nontoxic for acute exposures by this route.

Excessive exposure to vapors may produce headaches, dizziness, nausea, drowsiness, irritation of eyes, nose and throat and central nervous system depression.

In a long-term inhalation study of whole unleaded gasoline vapors, exposure-related kidney damage and kidney tumors were observed in male rats. Similar kidney effects were not seen in female rats or in mice. At the highest exposure level (2056 ppm), female mice had an increased incidence of liver tumors. Results from subsequent scientific studies suggest that the kidney damage and probably the kidney tumor response are unique to the male rat. The significance of the mouse liver tumor response in terms of human health is questionable.

Inhalation of whole unleaded gasoline vapors did not produce birth defects in laboratory animals.

Gasoline is a complex mixture of hydrocarbons and contains benzene (up to 4 volume %), toluene and xylene. Chronic exposure to high levels of benzene has been shown to cause cancer (leukemia) in humans and other adverse blood effects (anemia). Benzene is considered a human carcinogen by IARC, NTP and OSHA. Overexposure to xylene and toluene can cause irritation to the upper respiratory tract, headache and narcosis. Some liver damage and lung inflammation were seen in chronic studies on xylene in guinea pigs but not in rats.

Aspiration of this product into the lungs can cause chemical pneumonia and can be fatal. Aspiration into the lungs can occur while vomiting after ingestion of this product.

REGULATORY INFORMATION

CERCLA REPORTABLE QUANTITY:

This product is exempt from the CERCLA reporting requirements under 40 CFR Part 302.4. However, if spilled into waters of the United States, it may be reportable under 40 CFR Part 153 if it produces a sheen.

DOT PROPER SHIPPING NAME: Gasoline, Flammable Liquid, UN1203.

OSHA HAZARD COMMUNICATION STANDARD: Flammable liquid. Irritant. Contains components listed by ACGIH. Contains components listed by OSHA. Contains a carcinogenic component.

RCRA STATUS:

This product is subject to the 40 CFR Part 268.30 land ban on the disposal of certain hazardous wastes because it contains the following substance(s):

COMPONENT/CAS NUMBER

Ethylbenzene (100-41-4)
Toluene (108-88-3)
Xylene (1330-20-7)

SARA STATUS:

This product is regulated under the following section(s) of SARA Title III, 42 USC 9601. Spills or releases of the product may be reportable as determined by the information given below:

SECTIONS 311 AND 312 OF SARA AND 40 CFR PART 370:

This product is defined as hazardous by OSHA under 29 CFR Part 1910.1200(d).

SECTION 313 OF SARA AND 40 CFR PART 372:

This product contains the following substances, which are on the Toxic Chemicals List in 40 CFR Part 372:

COMPONENT/CAS NUMBER	WEIGHT PERCENT
Benzene (71-43-2)	4
Ethylbenzene (100-41-4)	2
Toluene (108-88-3)	22
Cyclohexane (110-82-7)	5
Xylene (1330-20-7)	10
MTBE (1634-04-4)	7

TSCA STATUS: All of the components of this product are listed on the TSCA Inventory.

SUPPLEMENTAL INFORMATION

Gasoline is a complex mixture of hydrocarbons. Those major components having occupational exposure limits are:

Butane (CAS 106-97-8) ACGIH TLV 800 ppm; OSHA PEL 800 ppm.

Cyclohexane (CAS 110-82-7) ACGIH TLV 300 ppm; OSHA PEL 300 ppm.

Ethylbenzene (CAS 100-41-4) ACGIH TLV 100 ppm, STEL 125 ppm;
OSHA PEL 100 ppm, STEL 125 ppm.

PAGE 05 OF 05

SUPPLEMENTAL INFORMATION - CONTINUED

n-Heptane (CAS 142-82-5) ACGIH TLV 400 ppm, STEL 500 ppm;
OSHA PEL 400 ppm, STEL 500 ppm.

n-Hexane (CAS 110-54-3) ACGIH TLV 50 ppm; OSHA PEL 50 ppm.

Pentane (CAS 109-66-0) ACGIH TLV 600 ppm, STEL 750 ppm;
OSHA PEL 600 ppm, STEL 750 ppm.

Toluene (CAS 108-88-3) ACGIH TLV 100 ppm, STEL 150 ppm;
OSHA PEL 100 ppm, STEL 150 ppm.

Trimethyl benzene (CAS 25551-13-7) ACGIH TLV 25 ppm; OSHA PEL 25 ppm.

Xylene (CAS 1330-20-7) ACGIH TLV 100 ppm, STEL 150 ppm;
OSHA PEL 100 ppm, STEL 150 ppm.

ISSUE INFORMATION

BY:



R. G. Farmer, Director,
Product Safety & Toxicology

ISSUED: June 09, 1989
SUPERSEDES: March 18, 1988

This material safety data sheet and the information it contains is offered to you in good faith as accurate. We have reviewed any information contained in this data sheet which we received from sources outside our company. We believe that information to be correct but cannot guarantee its accuracy or completeness. Health and safety precautions in this data sheet may not be adequate for all individuals and/or situations. It is the user's obligation to evaluate and use this product safely and to comply with all applicable laws and regulations. No statement made in this data sheet shall be construed as a permission or recommendation for the use of any product in a manner that might infringe existing patents. No warranty is made, either express or implied.

**U.S. DEPARTMENT OF LABOR
Occupational Safety and Health Administration**

MATERIAL SAFETY DATA SHEET

SECTION I

MANUFACTURER'S NAME Clifton Chemical Co.		EMERGENCY TELEPHONE NO. (815) 697-2123
ADDRESS (Number, Street, City, State, and Zip Code) 160 So. Locust St., Champaign, IL 60922		
CHEMICAL NAME AND SYNONYMS Windshield Washer		TRADE NAME AND SYNONYMS
CHEMICAL FAMILY	FORMULA Mixture	

SECTION II - HAZARDOUS INGREDIENTS

PAINTS, PRESERVATIVES, & SOLVENTS	%	TLV (Units)	ALLOYS AND METALLIC COATINGS	%	TLV (Units)
PIGMENTS	N/A		BASE METAL	N/A	
CATALYST	N/A		ALLOYS	N/A	
VEHICLE	N/A		METALLIC COATINGS	N/A	
SOLVENTS	N/A		FILLER METAL PLUS COATING OR CORE FLUX	N/A	
ADDITIVES	N/A		OTHERS	N/A	
OTHERS	N/A				
HAZARDOUS MIXTURES OF OTHER LIQUIDS, SOLIDS, OR GASES				%	TLV (Units)
Methyl Alcohol				38	200ppm
Nonylphenol Surfactant CAS # 68412-54-4				001	
Triphenylmethane CAS # 2650-18-2 EPA TSCA List- Yes				Tr.	

SECTION III PHYSICAL DATA

BOILING POINT (°F.)	N/A	SPECIFIC GRAVITY (H ₂ O=1)	.951
VAPOR PRESSURE (mm Hg)	N/A	PERCENT VOLATILE BY VOLUME (%)	N/A
VAPOR DENSITY (AIR=1)	N/A	EVAPORATION RATE	N/A
SOLUBILITY IN WATER	Complete		
APPEARANCE AND ODOR	Blue-aromatic		

SECTION IV FIRE AND EXPLOSION HAZARD DATA

FLASH POINT (Method used)	T.O.C. 112 F	FLAMMABLE LIMITS	Let	Uel
EXTINGUISHING MEDIA	Dry chemical, CO ₂ or Alcohol foam			
SPECIAL FIRE FIGHTING PROCEDURES	Wear self-contained breathing			
ADDITIONAL INFORMATION	UNUSUAL FIRE AND EXPLOSION HAZARDS			
Vapor is heavier than air and may travel considerable distance to an ignition source.				

SECTION V HEALTH HAZARD DATA	
THRESHOLD LIMIT VALUE Methyl Alcohol- 200ppm, 8 hour time-weighted average	
EFFECTS OF OVEREXPOSURE Ingestion- Poisonous, causes blindness, perhaps death. Inhalation- Narcosis, headache, nausea, loss of consciousness. Skin- Drying, irritation. Eye- Burning.	
EMERGENCY AND FIRST AID PROCEDURES Ingestion- Induce vomiting of conscious person, call M.D. Inhalation- Remove person to fresh air. Skin- Remove contaminated clothing and wash with water. Eyes- Flush eyes with water for at least 15 min. Contact a physician immediately.	

SECTION VI REACTIVITY DATA			
STABILITY	UNSTABLE		CONDITIONS TO AVOID Sparks, heat and flames.
	STABLE	X	
INCOMPATIBILITY (Materials to avoid) None			
HAZARDOUS DECOMPOSITION PRODUCTS Thermal decomposition may produce carbon dioxide and/or carbon monoxide.			
HAZARDOUS POLYMERIZATION	MAY OCCUR		CONDITION TO AVOID
	WILL NOT OCCUR	X	

SECTION VII SPILL OR LEAK PROCEDURES	
STEPS TO BE TAKEN IN CASE MATERIAL IS MELT / SPILL / OIL SPILLED Place leaking container in well ventilated areas, eliminate ignition sources. Avoid run-off into storm sewers and ditches which lead to natural waterways	
WASTE DISPOSAL METHOD Incineration, biological treatment of dilute solution.	

SECTION VIII SPECIAL PROTECTION INFORMATION			
RESPIRATORY PROTECTION (Specify type)			
VENTILATION	LOCAL EXHAUST	SPECIAL OTHER	
	MECHANICAL (General)		
PROTECTIVE GLOVES Neoprene or rubber gloves		EYE PROTECTION Chemical safety goggles	
OTHER PROTECTIVE EQUIPMENT			

SECTION IX SPECIAL PRECAUTIONS	
PRECAUTIONS TO BE TAKEN IN HANDLING AND STORING Cannot be made non-poisonous.	
OTHER PRECAUTIONS	

seisPRIME/E[®] Emulsion Seismic Explosive



EXCELLENT FOR "MINI-HOLES" AND VERTICAL STACKING

These non-nitrolycerin emulsion products are packaged in convenient: one-pound, one-half, one-third, and one-quarter pound cartridges and formulated to provide a seismic pulse equal to dynamite for clear, sharp seismic records.

Although classified as high explosive, seisPRIME/E emulsions are non-headache and have excellent resistance to accidental detonation by friction or impact.

Spiral-wound 1/4 to 1/2-pound paper cartridges are easily capped and waxed to sleep well.

PROPERTIES AND SPECIFICATIONS

PRODUCT	E-1	E-1/2	E-1/3	E-1/4
Weight	One Pound	1/2 Pound	1/3 Pound	1/4 Pound
Size	2 1/4 x 8 1/2	1 1/2 x 8	1 1/8 x 8	1 x 8
Style	49	SW	SW	SW
Density (gm/cc)	1.18	1.15	1.15	1.15
Velocity (fps) (unconfined)	16,500	16,000	15,000	14,500
Detonation pressure (kilobars)	100	100	100	100
Absolute Bulk Strength (cal/cc)	885	775	775	775
Relative Bulk Strength (ANFO=100)	120	105	105	105

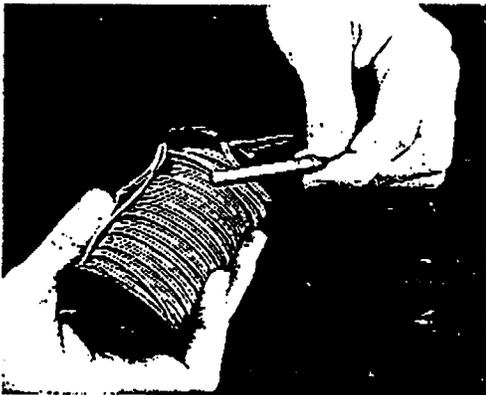
PACKAGING

Available in four sizes to meet vertical stacking and "mini-hole" applications, seisPRIME/E in the one-pound size is packaged in thin-walled, easy coupling cartridges for vertical stacking or larger downhole shots.

In the 1/2 to 1/4-pound sizes, seisPRIME/E is packaged in spiral-wound paper cartridges.

All sizes have excellent water resistance and can be initiated with a #8 strength STATICMASTER detonator.

STATICMASTER[®] Electric Detonators for Seismic Exploration



DESIGNED FOR SEISMIC WORK - Exclusive Atlas electric match provides reliable detonation with minimum lag time and scatter. Full #8 strength explosive output to help insure initiation of the seismic charge, even under severe conditions.

UNEXCELLED PERFORMANCE - Rigid statistical quality control tests are performed on all components and on the completed detonator to assure reliable and consistent performance. A tough, hard enamel coating under the plastic outer insulation provides additional protection against shorting of legwires under extreme conditions.

WATER AND WEATHER-PROOF - Legwire insulation is designed to withstand extremes of heat and cold and the severe conditions encountered in deep-hole loading. All detonators contain a double-crimped rubber plug to provide a water-tight seal. Excellent firing characteristics permit use in single-hole or multiple-hole pattern shooting.

PROPERTIES AND SPECIFICATIONS

- Detonator strength - #8
- Functioning time scatter - Less than 0.001 second; even lower as firing current is increased
- Recommended firing current - 3 to 10 amps DC, 4 to 10 amps AC
- Water immersion depth (max. tested) - 500 feet
- Bridgewire resistance - 0.9 Ohms
- Detonator shell - Gilding metal

OPERATING AIDS

With recommended firing currents, STATICMASTER electric detonators meet all requirements for series firing.

WARNING - Do not use STATICMASTER electric detonators in the same circuit with other types or brands of electric detonators.

PACKAGING

STATICMASTER electric detonators come with spooled duplex copper lead wires (yellow color) in lengths of 40', 60', 80', 100', 120', 150', 160', 200', 250', 300', and 400'; and in shorter legwire lengths (folded duplex wires, yellow) measuring 12', 20', and 24'.

REDUCED SENSITIVITY TO EXTRANEEOUS ELECTRICITY

A special bridgewire and the SF feature in the electric match provide reduced sensitivity to static electricity.

HAZARDOUS CHEMICAL MATERIAL SAFETY DATA SHEET

(Conforms to the Requirements of 29 CFR 1910.1200)

PRODUCT CATEGORY: EMULSIONS AND EMULSION / ANFO BLENDS - BLASTING AGENTS, ALL GRADES

1. NAME AND ADDRESS OF MANUFACTURER:

ATLAS POWDER COMPANY
 15301 DALLAS PARKWAY
 SUITE 1200
 DALLAS, TEXAS 75248
 TWX 910-860-5237

2. PREPARED BY: P.E. Therriault DATE: 06-24-88 REVISION: One

3. MEDICAL EMERGENCY TELEPHONE NUMBERS:

EAST OF THE MISSISSIPPI: 717 - 386 - 4121
 WEST OF THE MISSISSIPPI: 417 - 624 - 0212

4. THE MATERIALS DESCRIBED IN THIS DATA SHEET ARE:

HAZARDOUS CHEMICAL INGREDIENTS

5. CHEMICAL AND COMMON NAME(S) OF HAZARDOUS CHEMICAL MIXTURE/INGREDIENTS:

Apex-All Grades, RXL 614, RXL 615, PowerAN-All Grades, Bulk Emulsions-All Grades

Major Hazardous Ingredients Include:	TSCA LISTED	CAS NO.	RTECS NO.
Ammonium Nitrate	Y	6484-52-2	BR9050000
Diesel Oil (In Some Formulas)	Y	68334-30-5	No Listing

Note: See MSDS for Ammonium Nitrate Plus Fuel Oil

6. PHYSICAL AND CHEMICAL CHARACTERISTICS:

	Vapor Pressure	Flash Point	Melting Point °C	Boiling Point °C	Specific Gravity	Mol. Wt.	Odor	Appearance
Ammonium Nitrate	0	d	155	190	1.725	83	None	White Solid
Diesel Oil	nd	nd	nd	147.371	0.87	nd	Pungent	Brown Liquid
Mixture	Neg.	nd	nd	125	1.1 to 1.3	NA	None	White Grease

nd = No Data d = Dissociates na = Not Applicable

7. PHYSICAL HAZARDS:

Ammonium Nitrate - DOT: Oxidizer Diesel Oil: Flammable
 Mixture DOT Explosive, Blasting Agent

8. HEALTH HAZARDS:

	A.N.	D.O.	
Carcinogen	N	N	Ref: Registry of Toxic Effects of Chemical Substances (RTECS) N = No Criteria Match Y = Positive Criteria Match per RTECS nd = No Data
Corrosive	N	N	
Highly Toxic	N	N	
Irritant	N	N	
Sensitizer	N	N	
Toxic	N	N	
Target Organ Effects	N	N	

9. PRIMARY ROUTE(S) OF ENTRY: No Data

10. PERMISSIBLE EXPOSURE LIMITS: No Data

11. LISTINGS:

MATERIAL	NTP ANNUAL REPORT ON CARCINOGENS	IARC MONOGRAPHS	OSHA CARCINOGEN
AN	No	No	No
SN	No	No	No
SP	No	No	No
EDDN	No	No	No
DO	No	No	No

12. GENERALLY APPLICABLE PRECAUTIONS FOR SAFE HANDLING AND USE:

HYGIENIC PRACTICES:

Avoid Skin and Eye Contact. Avoid Breathing Blasting Fumes.

PROTECTIVE MEASURES DURING REPAIR AND MAINTENANCE OF CONTAMINATED EQUIPMENT:

Use non sparking tools, avoid open flame, wear normal safety equipment, such as safety glasses and hard hat.

PROCEDURES FOR CLEANUP OF SPILLS AND LEAKS:

Bulk Product: Isolate and contain spilled material. Contact Distributor or Atlas Powder for Spill Response Assistance. The disposal of damaged or deteriorated explosives must be carried out in accordance with all Federal and State Regulations. In the event of a major spill, contact the National Response Center (800-424-8802) and the local Police.

13. CONTROL MEASURES:

ENGINEERING: Follow BATF standards for storage (27 CFR 151 Subpart 3) Except for Bulk products, see "Do's and Don'ts - Instructions and Warnings" - found in every shipping case. See Institute of Makers of Explosives Publications.

WORK PRACTICES: Follow OSHA Standards for Storage and Use (29 CFR 1910.109) Except for Bulk products, see "Do's and Don'ts - Instructions and Warnings" - found in every shipping case. See Institute of Makers of Explosives Publications.

PERSONAL PROTECTIVE EQUIPMENT:

Avoid toxic fumes from blasting, wear normal protective equipment, such as safety glasses, hard hats, etc.

14. EMERGENCY AND FIRST AID PROCEDURES:

Do not attempt to fight fires involving explosives. Immediately evacuate the area. Avoid toxic fumes from fires. In case of skin contact, wash affected area with water. Eye contact - flush eyes for at least 15 minutes and consult a Physician.

15. DISCLAIMER: The above information taken from various published and unpublished sources is believed to be accurate and represents the best information currently available to us. However, we make no warranty of the accuracy of such information, express or implied, and assume no liability resulting from its use. Users should make their own investigations to determine the suitability of the information for their particular purposes.

INVOICE

Van Amburgh/Alamo, Inc.

12900 Preston Road
1220 North Dallas Bank Tower
Dallas, TX 75230
(214) 233-8000

INVOICE DATE	INVOICE NO.	PAGE
11/18/91	40849	1

MSDS

OLD TO Soc. of Explor. Geophysic
c/o Ks. Geological Survey
1930 Constant Ave.
Lawrence, KS 66046

SHIP TO Fort Bend Co. Delivery

R

ORDER NO.	ORDER DATE	CUSTOMER NO.	SALES PERSON	PURCHASE ORDER NO.	SHIP VIA	SHIP DATE	TERMS
40849	11/15/91	S30			Our Truck	11/15/91	Net 30 Days

ITEM NO.	QUANTITY ORDERED	QUANTITY SHIPPED	STK UNIT	UNIT PRICE	PRICE UNIT	DISCOUNT	EXTENDED PRICE
50408000	12.000	12.000	80' SW STATICMASTER EACH	816.50	CU		97.98
10812533	4.000	4.000	SEISPRIME E 1-1/8 X 1/3 LB	164.00	CLB		6.56
300000051	1.000	1.000	HAZARDOUS MATRL HNDLG CHG %SAL	3.14	%SAL		3.14
300000001	4.000	4.000	E.R.C.C. - HIGH EXPLOSIVES LB	6.50	CLB		.26
300000006	12.000	12.000	E.R.C.C. - DETONATORS EACH	6.50	CU		.78

DATE 12/15/91
GOODS REC'D 11/19/91
INVOICE REC'D 12/19/91

SALES AMOUNT	108.72
MISC. CHARGES	.00
FREIGHT	.00
SALES TAX	8.20
TOTAL	115.52
PAYMENT REC'D	
BALANCE DUE	

NC docum