Seismic Reflection Survey: Health and Safety Plan

Kansas Geological Survey
Exploration Services Section

Douglas County, Kansas
Exxon Production Research
November 1997

Open-file Report #97-40

Kansas Geological Survey
Open-file Report

Disclaimer

The Kansas Geological Survey does not guarantee this document to be free from errors or inaccuracies and disclaims any responsibility or liability for interpretations based on data used in the production of this document or decisions based thereon. This report is intended to make results of research available at the earliest possible date, but is not intended to constitute final or formal publication.

KANSAS GEOLOGICAL SURVEY EXPLORATION SERVICES
ACCIDENT PREVENTION PLAN

I. PROJECT DESCRIPTION

Project Name: Seismic Deployment Experiments

Location: Douglas County, Kansas

Site Safety Officer: Richard D. Miller

Plan Prepared By: Richard D. Miller

Estimated Duration of Field Work: 3-5 days

II. STATEMENT OF WORK

Development and evaluation of seismic data enhancement and attenuation methods using spread geometries could lead to significant improvements in the signal-to-noise ratio of some seismic data sets. The unique arrival patterns of the various acoustic waves provides opportunities during the generation and recording of these waves to filter through modifications of source and/or receiver geometries. The Kansas Geological Survey proposes to collaboratively develop, design, and evaluate several seismic recording deployment strategies for the study of acoustic wave propagation patterns. Thorough study of acoustic waves patterns will mandate the use of several test sites with similar geologic settings but different near-surface characteristics. The proposed experimentation will incorporate state-of-the art equipment with careful design criteria.

Several source/receiver configurations will be tested to evaluate the ratio of various body wave and surface wave arrivals. The testing will take place at one or more of the KGS Douglas County test sites. Fixed as well as rolling area geophone spreads will be studied with various low energy acoustic sources. To minimize the effects of variable geologic characteristics the experimental data will be acquired at test sites with relatively no dip and a very cyclic stratigraphic sequence. The lithologic section is highly conducive to shallow seismic reflection imaging consisting of alternating limestones, shales, and sandstones generally overlain by a thin (1 to 3 m) soil veneer (Miller and Weis, 1996). To observe the full effects and development of the acoustic wavefield, incremental movement of specific receivers relative to source locations will require open areas with dimensions on the order of 0.1 km by 0.5 km.

The experimentation will require source testing to determine the source that provides the optimum ratio of surface waves to body waves. Comparison of the various types of body waves generated by each source will also be an important criteria for

selection of the optimum source for these acquisition geometry studies. The sources available for testing will include 30.06 downhole, 50-caliber downhole, sledge hammers of various weights, accelerated weight drop, auger gun, IVI Minivib, Bolt LSS-6 air gun, and drive hammer. Optimum source determination will consider spectral properties, body wave to surface wave ratio, and total energy characteristics.

Recording equipment will be research quality with minimum noise characteristics. The seismograph will be a Geometrics StrataView possessing 24-bit dynamic range and 96 recording channels. It will be interfaced to the deployed receivers through a 240-channel roll-along switch. Appropriate time zero conditioning will be necessary to ensure a precise zero start time for each of the uniquely different acoustic energy sources. The cable and geophones will be in good condition, permitting a number of unique layout geometries. Geophones available for testing will include L-28E 40 Hz, L-40A 100 Hz, L-28A 30 Hz, and GS-20D 10 Hz (40 strings). Depending on the specifics of some layouts, as many as three roll-along switches may be necessary to acquire some of the experimental data.

The equipment and recorded data will be continuously monitored during acquisition to ensure the highest quality. 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 monitored. The system will be subject to a series of pre-acquisition tests designed to ensure the integrity of the time break system, consistency in system noise, and security of digitally stored data. Visual analysis of signal-to-noise ratio, environmental noise types and levels, DC bias, and variations in the optimum recording window will be routinely performed on field plots.

It is anticipated that testing will require 5 days to complete at all of the selected test sites. The acquisition of the data for this test will require at least three different configurations of sources and receivers. The quality of the recorded data at each site will determine the total number of sites necessary to obtain definitive results. It is anticipated that around 200 shots per site for each deployment may be necessary. Estimates suggest it will require one day per spread geometry to acquire sufficient data for conclusive analysis.

Reference

Miller, R.D., and T.V. Weis, 1995, Feasibility and resolution of shallow seismic reflection techniques in northwestern Franklin, southeastern Douglas, and Osage counties in Kansas: in N.L. Anderson and D.E. Hedke, eds., *Geophysical Atlas of Selected Oil and Gas Fields in Kansas*: Kansas Geological Survey Bulletin 237, p. 83-87.

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 Exxon Production Research (EPR) 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° < 30° F), continuous day operations will be modified to minimize chances for heat- or cold-related medical problems.

3. Appropriate field boots will be worn and due caution will be exercised with respect to snakes, ditches, swampy areas, and ground debris.

4. At least one gallon of fresh water will be on hand at the beginning of each day for each crew member.

5. In the case of excessive cold weather, a sheltered area will be available with inside temperatures above 32° F.

6. The seismic crew will operate with an established written protocol for initiating seismic sources. The safety plan will be approved by the EPR Representative prior to initiation of field operations.

7. Appropriate drivers licenses will be held by operators of vehicles at all times (DOT regulations).

IV. SAFETY PERSONNEL

Safety Personnel and Emergency Contacts

1. Rick Miller (KGS)—Site Safety Officer
2. David Laflen (KGS)—Operations
3. Young Kim (EPR)—Delegated Representative and Site Consultant
4. Joe Anderson (KGS)—Line Chief
5. Jianghai Xia (KGS)—Technical Specialist

Safety Meeting at Survey Site Date: _____

- ☐ Gun/explosives safety (handling of ammo, use of sources, cleaning and maintenance)
- ☐ Environmental hazards (heat, cold, plants, animals [snakes, etc.])
- ☐ Vehicle safety (road travel, warning signs, traffic control)
- ☐ Civilian/bystander safety (safe distances, visitor check-in)
- ☐ Site requirements (PPC) (gloves, hats, shoes)
- ☐ Emergency procedures (injuries, property damage, potential problems)
- ☐ Equipment hazards (safe use of ATV, loader, augers, etc.)
- ☐ First Aid (heat stroke, frostbite, animal bites, etc.)

The following people were present today:

Name (PRINT)	Company	Signature

_____
Site Safety Officer

Safety Meeting at Survey Site Date: _____

- ❒ Gun/explosives safety (handling of ammo, use of sources, cleaning and maintenance)
- ❒ Environmental hazards (heat, cold, plants, animals [snakes, etc.])
- ❒ Vehicle safety (road travel, warning signs, traffic control)
- ❒ Civilian/bystander safety (safe distances, visitor check-in)
- ❒ Site requirements (PPC) (gloves, hats, shoes)
- ❒ Emergency procedures (injuries, property damage, potential problems)
- ❒ Equipment hazards (safe use of ATV, loader, augers, etc.)
- ❒ First Aid (heat stroke, frostbite, animal bites, etc.)

The following people were present today:

Name (PRINT)	Company	Signature

_____
Site Safety Officer

Safety Meeting at Survey Site Date: _____

- ☐ Gun/explosives safety (handling of ammo, use of sources, cleaning and maintenance)
- ☐ Environmental hazards (heat, cold, plants, animals [snakes, etc.])
- ☐ Vehicle safety (road travel, warning signs, traffic control)
- ☐ Civilian/bystander safety (safe distances, visitor check-in)
- ☐ Site requirements (PPC) (gloves, hats, shoes)
- ☐ Emergency procedures (injuries, property damage, potential problems)
- ☐ Equipment hazards (safe use of ATV, loader, augers, etc.)
- ☐ First Aid (heat stroke, frostbite, animal bites, etc.)

The following people were present today:

Name (PRINT)	Company	Signature

_____
Site Safety Officer

Safety Meeting at Survey Site Date: _____

- ❒ Gun/explosives safety (handling of ammo, use of sources, cleaning and maintenance)
- ❒ Environmental hazards (heat, cold, plants, animals [snakes, etc.])
- ❒ Vehicle safety (road travel, warning signs, traffic control)
- ❒ Civilian/bystander safety (safe distances, visitor check-in)
- ❒ Site requirements (PPC) (gloves, hats, shoes)
- ❒ Emergency procedures (injuries, property damage, potential problems)
- ❒ Equipment hazards (safe use of ATV, loader, augers, etc.)
- ❒ First Aid (heat stroke, frostbite, animal bites, etc.)

The following people were present today:

Name (PRINT)	Company	Signature

_____
Site Safety Officer

Safety Meeting at Survey Site Date: _____

- ❒ Gun/explosives safety (handling of ammo, use of sources, cleaning and maintenance)
- ❒ Environmental hazards (heat, cold, plants, animals [snakes, etc.])
- ❒ Vehicle safety (road travel, warning signs, traffic control)
- ❒ Civilian/bystander safety (safe distances, visitor check-in)
- ❒ Site requirements (PPC) (gloves, hats, shoes)
- ❒ Emergency procedures (injuries, property damage, potential problems)
- ❒ Equipment hazards (safe use of ATV, loader, augers, etc.)
- ❒ First Aid (heat stroke, frostbite, animal bites, etc.)

The following people were present today:

Name (PRINT)	Company	Signature

_____
Site Safety Officer

Specific Safety Requirements

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

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 available in a 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 EPR 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 project vehicles. Emergency call numbers and evacuation routes are included in the safety plan available in the seismic trailer.

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:	**Douglas County Ambulance Service**	843-7777
	Emergency	911
Hospital Emergency Room:	**Lawrence Memorial Hospital**	
	24-hour Emergency Department	749-6162
	Patient Room Information	749-6105
Poison Control Center:	1-800-332-6633	
	To report toxic chemical and oil spills	
	(National Response Center)	1-800-424-8802
Police:	**Lawrence Police Department**	
	Emergency	911
	Dispatch	832-7650
	Highway Patrol (Topeka)	1-785-296-3102
	FBI (Topeka)	1-785-235-3811
	(if no answer call KCMO 1-816-691-8200)	
	KU Police Department	
	Emergency	911
	Police Department	864-5900
	Office of Public Safety	864-5901
	Emerg Communications and Records	864-5913
	Security and Emergency Planning Dept	864-5908
	Lawrence Fire Department	832-7600
	Douglas County Sheriff	841-0007
Explosives Unit:	**Lawrence Fire Department**	832-7600
State Environmental Agency:	**Kansas Department of Health and Environment**	
	Division of Environment	
	Ron Hammerschmidt, Director	
	Forbes Bldg 740	785-296-1535
Client:	Young Kim, Exxon Production Research	
	Ph. (713) 966-6156 / Fax (713) 966-6333	

Emergency Contacts

Safety Coordinator and Project Manager
Rick Miller, Kansas Geological Survey
Office: 785-864-3965
Cellular (in the field): 785-766-8636
Home: 785-748-0842

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

The fold-out map following this page shows routes from each site to Lawrence Memorial Hospital. Narrative of directions from each site to Lawrence Memorial Hospital are below.

From 15th and Kasold Site
15th Street is along the North side of this site. Go East on 15th to Iowa Street. Turn North (Left) onto Iowa and go to 6th Street. At 6th Street turn East (Right). At Maine Street intersection turn North (Left). There are stoplights at all pertinent intersections within the Lawrence city limits. Lawrence Memorial Hospital is between 3rd and 4th Streets on Maine. Follow signs to the Emergency Room.

From Model Airplane Field Site
Douglas County Road 458 is along the South side of this site. Follow 458 East to US 59. Turn North (Left) from 458 onto US 59 and go to 6th Street (approx 4 1/2 miles) (US 59 becomes Iowa Street within city limits). At 6th Street turn East (Right). From 6th turn North (Left) onto Maine. There are stoplights at all pertinent intersections within the Lawrence city limits. Lawrence Memorial Hospital is between 3rd and 4th Streets on Maine. Follow signs to the Emergency Room.

From Miller Farm Site
From the road on the North side of the site go East 1/2 mile, South 1/2 mile to Douglas County Road 458. Follow 458 East to US 59 (there are several turns to the North and East, total distance from site to US 59 approx 10 miles) (US 59 becomes Iowa Street within city limits). Turn North (Left) from 458 onto US 59 and go to 6th Street. At 6th Street turn East (Right). From 6th turn North (Left) onto Maine. There are stoplights at all pertinent intersections within the Lawrence city limits. Lawrence Memorial Hospital is between 3rd and 4th Streets on Maine. Follow signs to the Emergency Room.

Procedures

Accidents/Injury: If any serious injury does occur, the appropriate authorities shall be notified immediately. All accidents will also be reported.

Several members of the KGS crew have certification in CPR/First Aid through 12/21/97. This certification was received through participation in the "Standard First Aid" and "CPR for the Professional Rescuer" programs presented by the Red Cross of Lawrence, Kansas. These classes are approved by the U.S. Department of Labor, Mine Safety, and Health Administration and meet or exceed OSHA requirements.

The following persons are certified as indicated (please circle area[s] of certification):

Certified in:	First Aid	CPR	Rick Miller
Certified in:	First Aid	CPR	David Laflen
Certified in:	First Aid	CPR	Joe Anderson
Certified in:	First Aid	CPR	Jianghai Xia
Certified in:	First Aid	CPR	

Fire/Explosion: Upon notification of a fire or accidental explosion on site, the fire department shall be notified and all personnel shall leave the area. Since only Class "C" shotgun ammunition may be used as part of the program, local fire, police, and other governing authorities will not be contacted prior to the use of such devices. In the case Class "A" explosives are used, prior consultation and contact will be made with the appropriate emergency response groups.

At least one KGS vehicle will be on-site during the performance of all work. This vehicle will be used for medical evacuation of project personnel, if necessary.

VI. TASK SPECIFIC HAZARDS

The purpose is to evaluate different source-receiver geometries.

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.

The downhole .50-caliber seismic source consists of a .50-cal. rifle bolted to a 0.6 cm thick steel plate. The rifle itself is a standard .50-cal. breech and bolt, built by Texas Gun and Machine Company, attached to a standard .50-cal. 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 cm 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-cal. weighs about 30 kg and is easily two-person portable. Safety rules for the use of the .50-cal. seismic gun are presente 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.

ACTIVITY HAZARD ANALYSIS

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, David Laflen, or Joe Anderson 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, David Laflen, or Joe Anderson 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 50-cal., auger guns 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: ***Traffic Control***

All regulation concerning right-of-way and traffic directions will be observed.

Specific Hazards–The specific hazard involves accidents with vehicular traffic within the survey area.

Control Measures–All personnel will minimize activity along trafficked roadways to the extent possible. Traffic cones will be used to identify and buffer the work area with respect to on-coming traffic. Care will be used while working on or around driveways. If appropriate, signs and/or flagmen will be used to alert and slow traffic through the survey area.

C. Work Item: ***Bolt LSS-6 Land Air Gun***

The Bolt Land Air Gun has been in routine use in oil exploration for more than 20 years. The device consists of a 3-cylinder diesel engine, a four-stage air compressor, and an enclosed water filled chamber (housing the "gun"). The safe operation of the gun is well documented in the operator's manual. The entire device is transported as the bed of an F-350 4-wheel drive truck. The 3-cylinder diesel engine powers not only the air compressor but also a hydraulic system designed to raise and lower the gun chamber to the ground. The gun chamber is hydraulically lowered to the ground with the weight of the truck used to hold the device to the ground. The gun is electrically detonated from the cab of the truck with no moving parts exposed during detonation. The engine and air compressor are enclosed in a protective shroud. The gun generates a thump to the ground surface approximately equivalent to 1/8 of a pound of high explosive buried 3 to 4 ft beneath the ground surface.

Control Measures

1) The careful and safe operation of the standard 4 wheel drive truck is well documented in the owners manual.
2) It is critical to always be aware of anyone near the device.

3) The raising of the gun for transport and lowering of the gun just prior to detonation is done with only part of the gun visible to the operator. It is critical that no one comes within 50 ft of the gun while in operation.
4) Hearing protection (down 30 dB) is required by anyone within 50 ft of the truck.

D. Work Item: *MiniVib*

The MiniVib is a hydraulically powered vibrator designed to shake the ground in a very controlled fashion over about a 4 to 8 second time duration. The device is hydraulically powered with no moving parts that possess an entanglement potential. Energy is delivered to the ground by this device through a hydraulically powered pad approximately 3 ft in diameter mounted on the belly of the vehicle. The pad is lowered from beneath the vehicle using the vehicle's weight as hold-down pressure. The pad is vibrated by a hydraulic servo delivering frequency-varying energy to the plate over a preset time duration. No moving parts are exposed with the maximum movement of the pad relative to the vehicle less than 2 in.

Control Measures
1) This vehicle is center articulating and requires care when turning that no one is within 20 ft of the vehicle.
2) Safe operation of the vehicle is documented in the operator's manual provided by the manufacturer.
3) Hearing protection is required within 50 ft of the vehicle.
4) All shields are to remain in place while the vehicle is in operation
5) Hydraulic pressures of more than 1500 psi are routine during operation. No maintenance or service will take place while vehicle engine is running.
6) Quick inspection is necessary prior to lowering the pad.

E. 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 impacting an 18 in diameter steel plate held to the ground surface by the weight of a skid-steer style loader. The weight is accelerated within an enclosed steel guide. The drive mechanism consists of a hydraulic motor turning a set of sprockets that deliver power to a cycling lift arm that pulls the weight against the resisting force of an industrial rubber band. Simply envisioned, this device is analogous to a sling-shot. All moving parts are shielded, with the contact area between the weight and plate sufficiently enclosed to avoid and possibility of debris becoming airborne and representing a risk to the operator or bystanders.

Control Measures
1) The operator wears hearing protection (30 dB down) while the loader is running.
2) No bystanders can be within 30 ft of the device while it is in operation and within 50 ft without hearing protection.
3) All shields are to remain in place while in operation. Routine maintenance, requiring removing shields, can take place only when the loader engine is off.

4) The operator can exit the vehicle only when the weight drop is in the full down position and solid contact is made with the ground surface.
5) Operation of the loader will be consistent with those published in the owner manual of the Case 1225 Uni-Loader.

F. **Work Item:** ***All Terrain Vehicles (ATVs)***

ATVs that could be on site include the Yamaha Terra Pro, Kawasaki Mule, and Polaris 4x6. These ATVs all serve a very specific purpose and are critical to smooth and efficient operations. The ATVs never obtain speeds in excess of 15 mph and therefore do not represent risk of injury due to excessive speeds. The tip-over potential is minimized by the 4-wheel design of the vehicles, but tip-over potential does exist. Care is always taken to properly load the vehicles and only traverse grades within the acceptable limits of the vehicle as defined by the manufacturer.

1) The Yamaha has a specially designed cable winding device. The Yamaha has a Power Take-Off that is used to power a winding device mounted on the front of the vehicle and is used for the rolling of seismic cable. Operation of the PTO requires the operator to be on the seat and traveling in the lowest speed range (this is controlled by safety overrides that "kill" the engine when these conditions are not met).

2) The Gator is designed to carry the seismograph and 12-volt batteries. This vehicle never travels more than 10 mph and spends over 99% of its time parked along the survey line.

3) The Polaris is the primary work horse of the ATVs. It transports cables and geophones in a 3x3 steel box mounted behind the seat. The vehicle has 6 wheels with 4 drive wheels. The 6-wheel design makes the vehicle very stable with a large safe payload capacity (>700 lbs). This vehicle never travels more than 15 mph and is therefore at low risk of injury from excessive speed.

All ATVs have blinking yellow lights for increased visibility by other traffic.

VII. 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 and yearly 8-hour refresher training.

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. The prescribed working uniform for all personnel engaged in activities related to the project is a modified EPA level D and shall consist of:

Long-sleeved shirts and full-length pants
Leather steel toed safety boots
Hard hat (when site requires)
Eye protection
Hearing protection as required by OSHA
Orange vests along roadways

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.

IX. SAFETY ANALYSIS

The attached analysis list postulated hazards, consequences of those hazards, and the means of prevention or mitigation of each hazard associated with this survey activity (Attachment 4).

X. ENVIRONMENTAL IMPACT ANALYSIS

The environmental impact of this activity has been evaluated and determined minimal at more than six 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) as well as BLM and DOD.

XI. 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.

XII. 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*

SAFETY ANALYSIS

Potential Hazard	Consequences	Mitigation/Prevention Mechanism
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.
During Loading/Unloading:		
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.
During Firing:		
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.

Potential Hazard	Consequences	Mitigation/Prevention Mechanism
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.
During Transport		
Accidental discharge	Injury to unintended target.	Assure that operating procedures permit loading only after seismic gun is installed in borehole.

Potential Hazard	Consequences	Mitigation/Prevention Mechanism
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.

5/10/92

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 devise 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 (Steeples 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, malls, 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 (Steeples 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 solinoid.

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.

REFERENCES

Miller, R. D., Pullan, S. E., Waldner, J. S., and Haeni, F. P., 1986, Field comparison of shallow seismic sources: Geophysics, 51, 2067-2092.

Miller, R. D., Steeples, D. W., and Mazzella, A., 1990,

Reflections from geologic interfaces shallower than 30 m at the Pittman Lateral, Henderson, Nevada [Exp. Abs.]: Soc. Explor. Geophys., 1, 393-396.

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

Steeples, 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.

Steeples, D. W., and Miller, R. D., 1990, Seismic-reflection methods applied to engineering, environmental, and ground-water problems: *in* Geotechnical and Environmental Geophysics, v. I, Review and Tutorial, Ward, S. H. (ed.), Soc. Explor. Geophys., Tulsa, OK, 1-30.

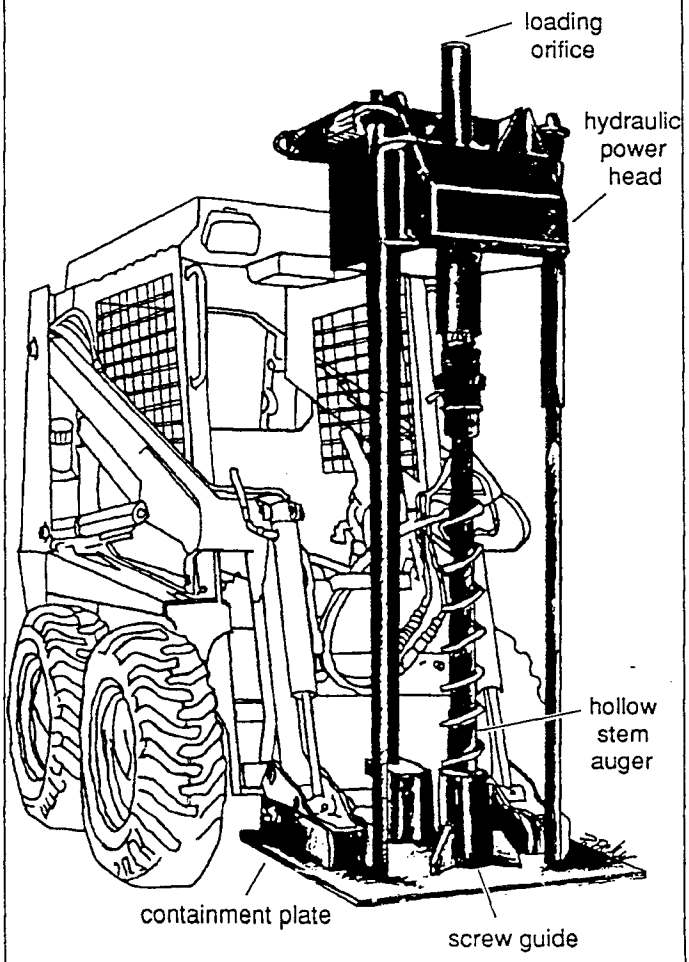


Fig. 1 Diagram represents the auger gun in above-ground position. Modified buffalo-gun portion of the auger gun is not shown, but is conceptually the same as previously documented (Pullan and MacAulay, 1987).

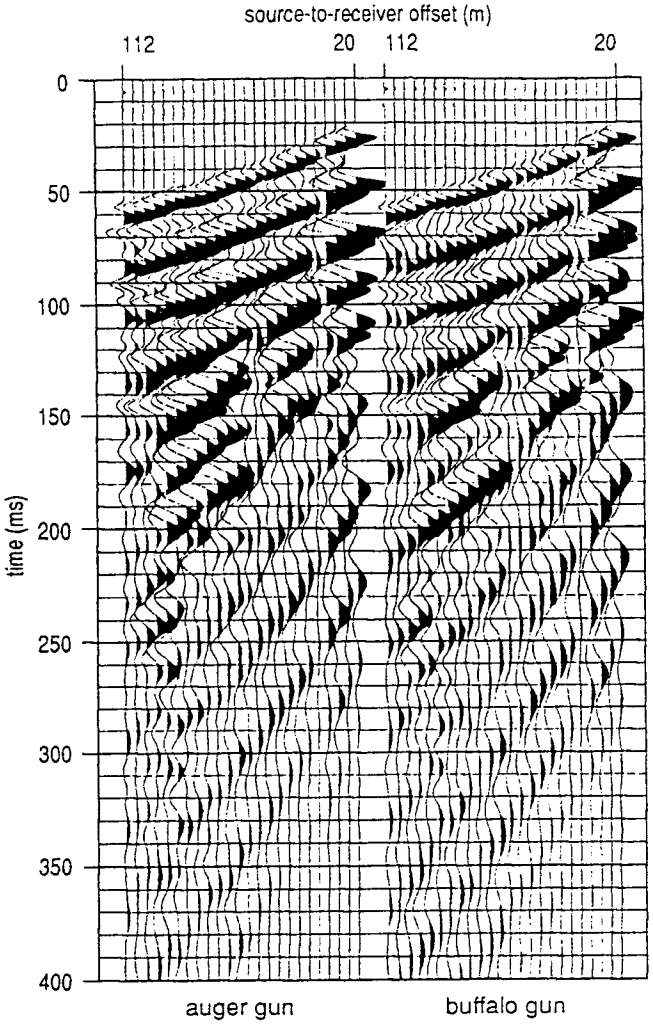


Fig. 2 Auger gun field file (left) compared to the buffalo gun (right).

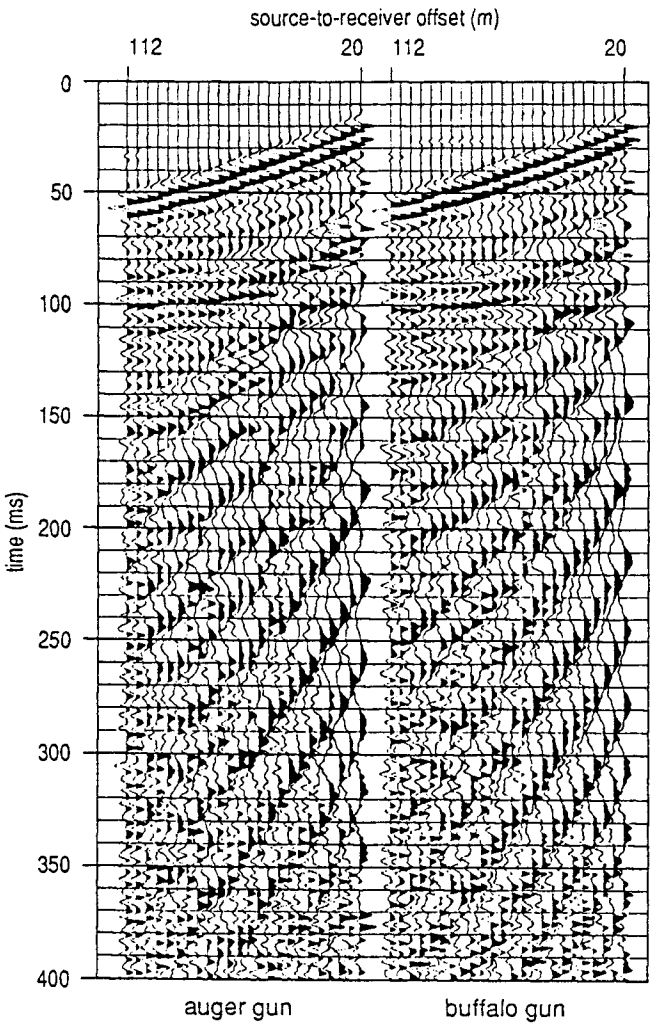


Fig. 3 A 150 Hz digital low-cut filter enhanced the 80 ms reflection event on both the auger (left) and buffalo (right) guns.

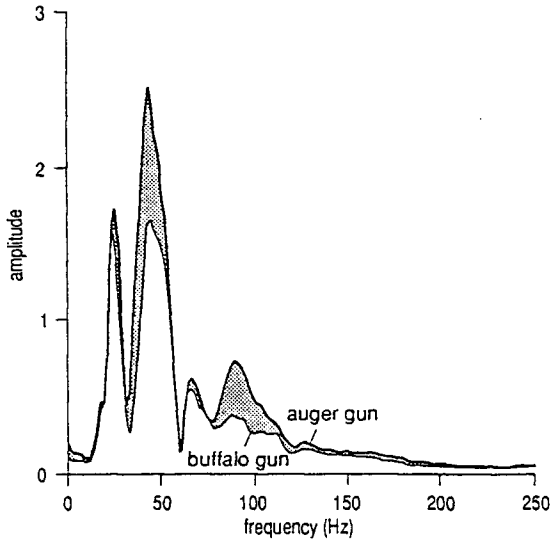


Fig. 4 The darkened area represents the difference between the lower curve (buffalo gun) and the upper curve (auger gun).

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 (Steeples 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

Funding for this research was provided in part by National Science Foundation Grant No. EAR-8218735. We appreciate Esther Price's efforts in manuscript preparation and Marla Adkins-Heljeson's editorial suggestions.

REFERENCES

Miller, R.D., Pullan, S.E., Waldner, J.S., and Haeni, F.P., 1986, Field comparison of shallow seismic sources: Geophysics, v. 51, p. 2067-2092.

Miller, R.D., and Steeples, D.W, 1986, Shallow structure from a seismic reflection profile across the Borah Peak, Idaho, fault scarp: Geophysical Research Letters, v. 13, p. 953-956.

Seeber, M.D., and Steeples, D.W., 1986, Seismic data obtained with a .50-caliber machine gun as a high-resolution seismic source: AAPG Bull., v. 70, p. 970-976.

Steeples, D.W., and Knapp, R.W., 1982, Reflections from 25 feet or less: Paper presented at 1982 SEG Convention (Exp. Abs.), SEG program volume, p. 469-471.

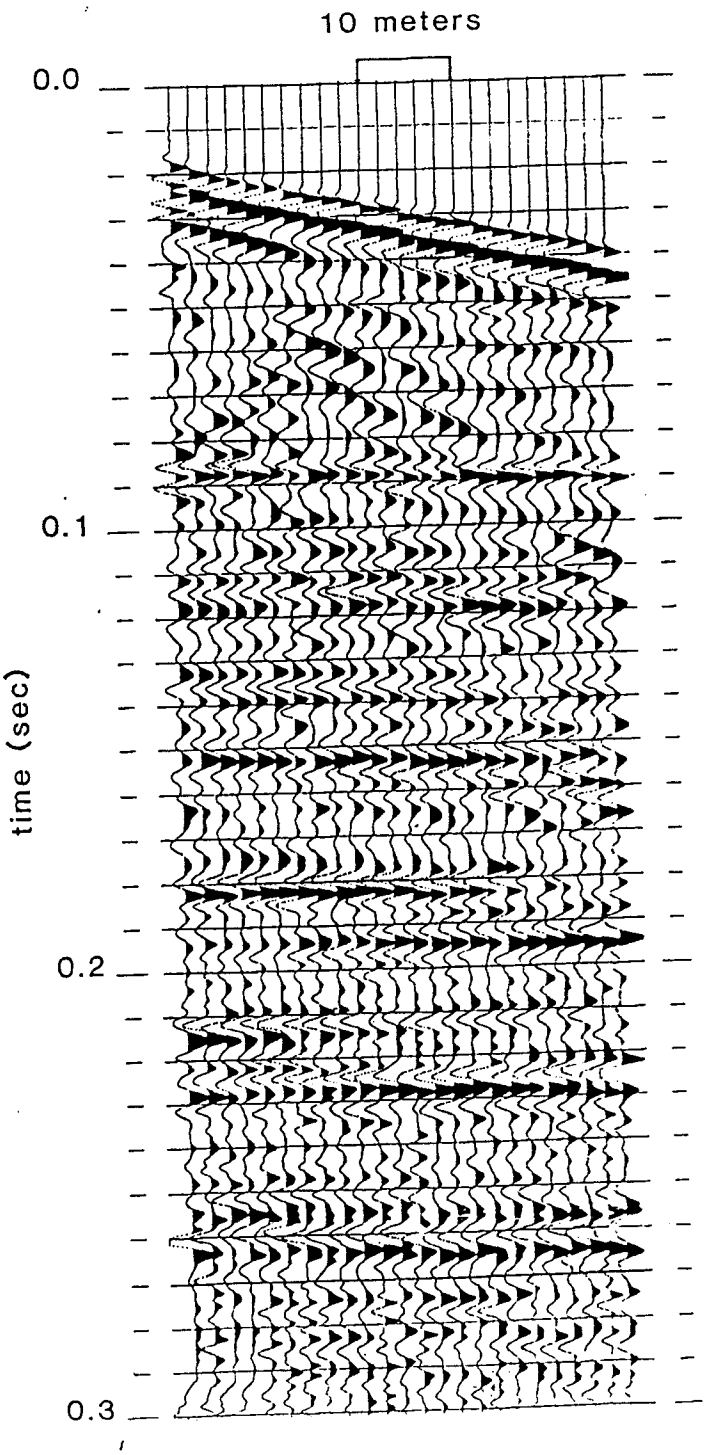


FIG. 2. This single-shot field file with an AGC applied illustrates the high frequencies and therefore the resolution easily obtainable with a downhole .50-cal.

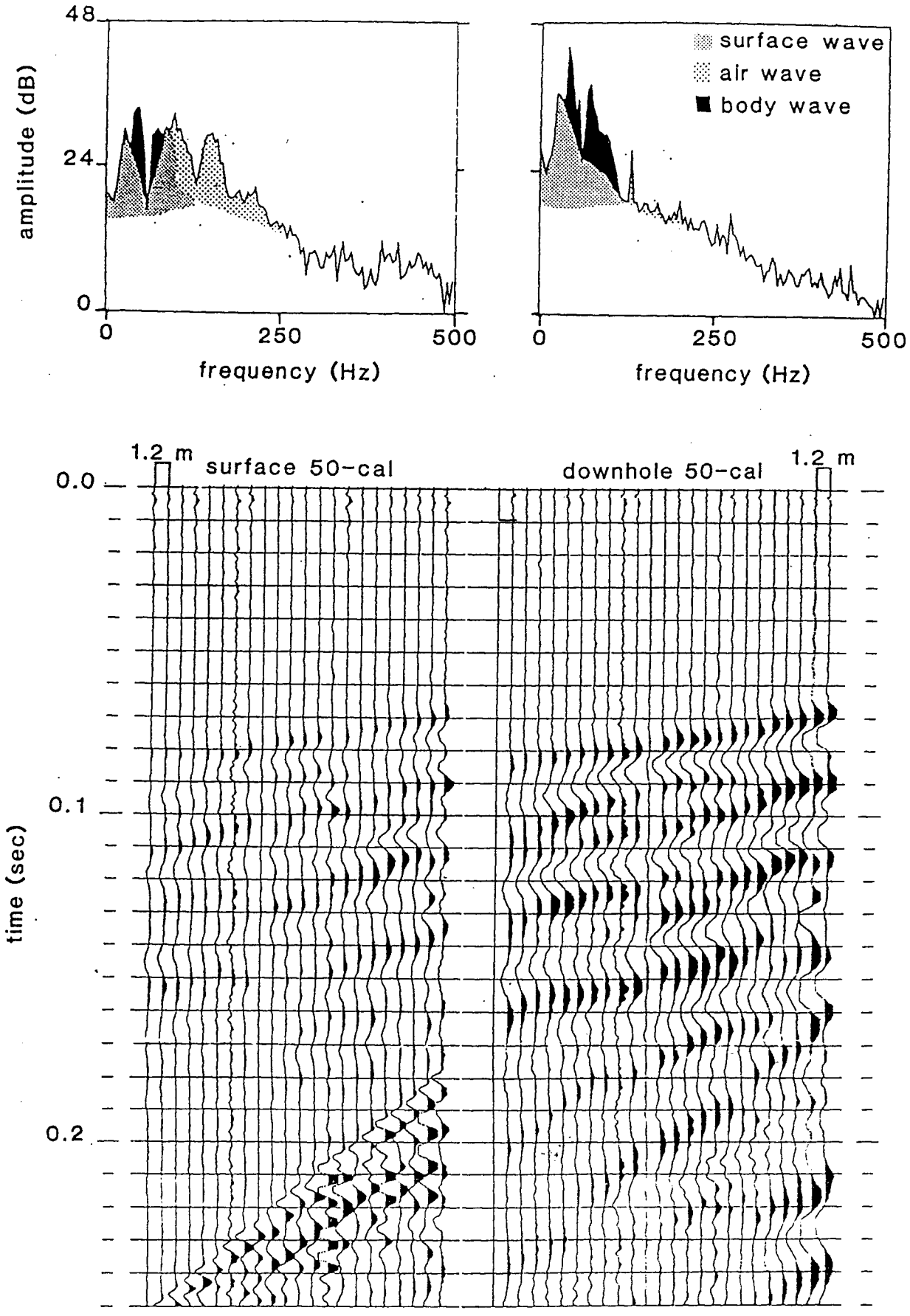


Figure captions:

-This single shot comparison plotted true amplitude with identical recording

the increased signal-to-noise and the improved frequ

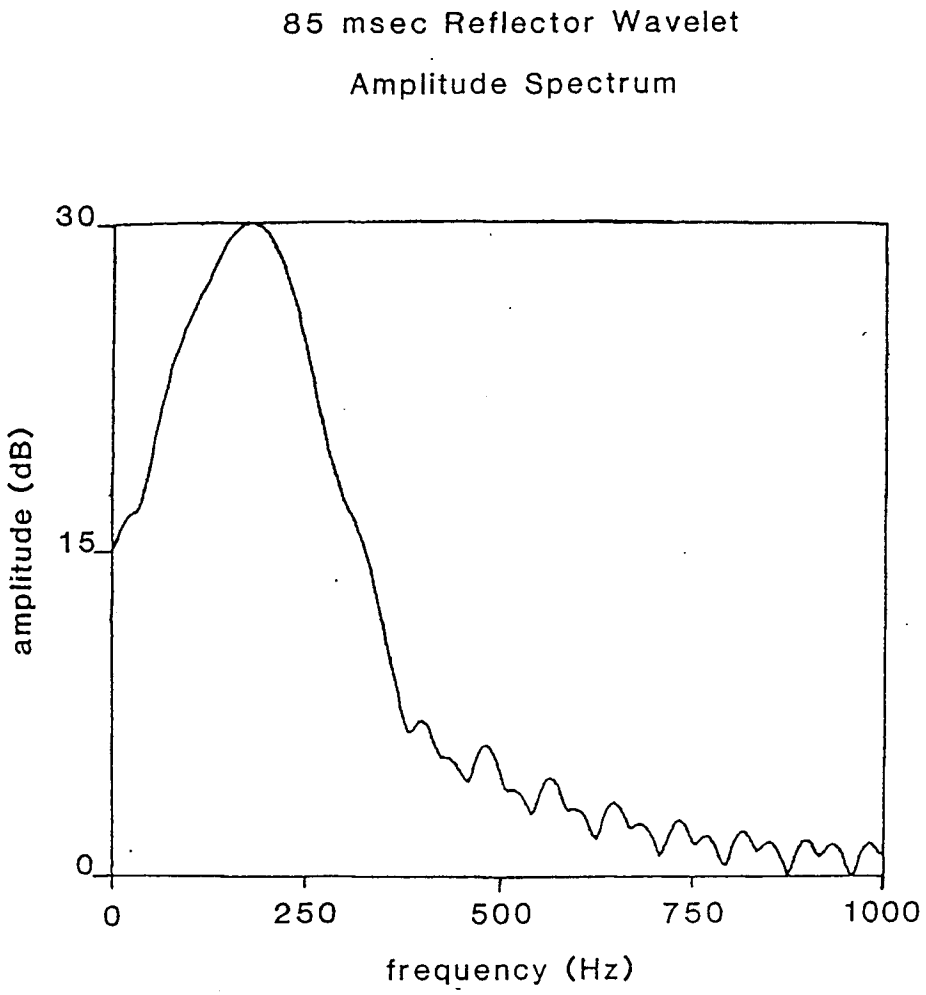


FIG. 3. -The amplitude spectrum of the reflection pulse at 85 msec is almost 3 octaves

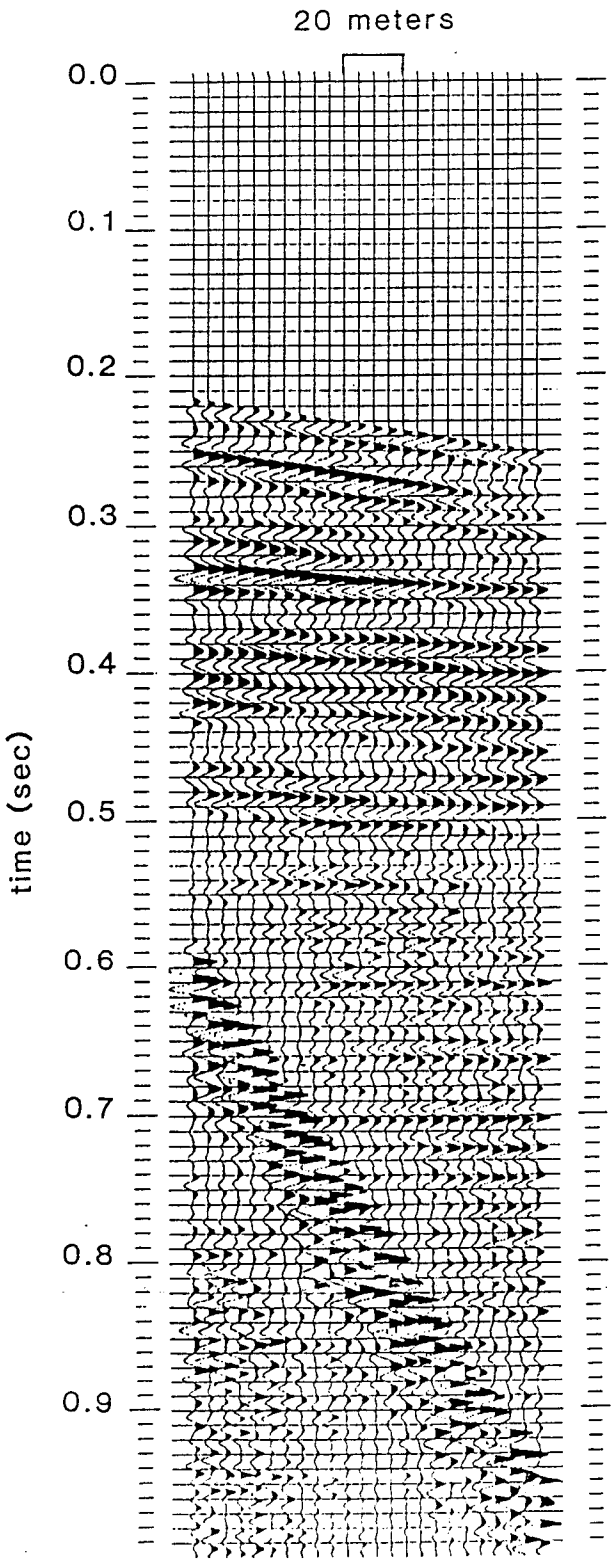


FIG. 4. This stacked field file has 100 Hz reflection energy as deep as 1100 meters.

Olin 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	FORMULA	TRADE NAME
Not applicable	Mixture	Not applicable
DESCRIPTION		CAS NO.
Container with powders and projectile		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	Local mechanical exhaust ventilation recommended during confined space discharge.
Gloves	None necessary	
Other	Hearing protection recommended during 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	OSHA CLASSIFICATION	FLAMMABLE EXPLOSIVE LIMITS	LOWER	UPPER
Not Applicable	Explosive		-	-

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.

[illegible] 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
		MUTAGENICITY	May be mutagenic
ACUTE DERMAL LD 50	> 2 g/kg	EYE IRRITATION	May be an irritant
		PRIMARY SKIN IRRITATION	Not an irritant
ACUTE INHALATION LC 50	Not known		

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

SECTION IX - REACTIVITY DATA

STABLE X UNSTABLE AT ____ °C ____ °F	HAZARDOUS POLYMERIZATION	MAY OCCUR	
		WILL NOT OCCUR	X

CONDITIONS TO AVOID: Open flame, heat, sparks, shock or percussion, pressure

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,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 Toxic
(203) 789

1475

Olin CORPORATION
120 Long Ridge Road, Stamford, Connecticut 0690
OCEAN® Network
EMERGENCY PHONE 1-800-OLIN-911

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)	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.
All Shotshell Ammunition	

Section I "Small Arms Ammunition"

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

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		Specific Gravity (H_2O = 1)	
Not applicable		Not applicable	
Vapor Pressure (mm Hg.)		Melting Point	
Not applicable		Not applicable	
Vapor Density (AIR = 1)		Evaporation Rate (Butyl Acetate = 1)	
Not applicable		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)	Flammable Limits	LEL	UEL
Not applicable	Not applicable	NA	NA

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

Incompatibility (*Materials to Avoid*): Strong mineral acids and alkalis

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

Hazardous Polymerization			Conditions to Avoid
	May Occur		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 - location? particles

Health Hazards (*Acute and Chronic*)
Anemia, fatigue, noctoria, 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		Eye Protection	
	Not applicable		Safety glasses when shooting

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

Work/Hygienic Practices: Wash hands after skin contact with cartridges.

• USGPO 1988-491-529/61773

GENERAL MOTORS CORPORATION
MATERIAL SAFETY DATA SHEET

SECTION I

PRODUCT NAME OR NUMBER (as it appears on label)	GM COMMON CODE
ALL MODELS OF DELCO BATTERIES	
MANUFACTURER'S NAME	EMERGENCY TELEPHONE NO.
Delco Remy Division, GMC	(317) 646-3080
ADDRESS (Number, Street, City, State and Zip Code)	MANUFACTURER'S D-U-N-S NO.
2401 Columbus Avenue, Anderson, IN 46018	
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	FORMULA
Liquid Content • Sulfuric Acid	Liquid Content - H_2SO_4

SECTION II — INGREDIENTS (list all ingredients)

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

SECTION III — PHYSICAL DATA

BOILING POINT 233 °F ___ °C		SPECIFIC GRAVITY (H_2O = 1) Varies with battery size		Average 1.280 ± .01	
VAPOR PRESSURE (at 77 °F 25 °C) ☒ 2.730 mm Hg ☐ psi		PERCENT VOLATILE BY VOLUME (%)	NA	PERCENT SOLID BY WEIGHT (%)	NA
VAPOR DENSITY (AIR = 1)	NA	EVAPORATION RATE (= 1)	NA		
SOLUBILITY IN WATER Miscible		pH =	< 1.0		
APPEARANCE AND ODOR Water - white liquid (acid content)				IS MATERIAL: ☒ LIQUID ☐ SOLID ☐ GAS ☐ PASTE ☐ POWDER	

SECTION IV — FIRE AND EXPLOSION HAZARD DATA

FLASH POINT NA °F ___ °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.			

SECTION V-HEALTH HAZARD DATA

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 whites 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 Robert A. Chisman

Title Senior Industrial Hygienist

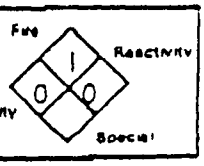
Date May 8, 1991

MATERIAL SAFETY DATA SHEET

PRODUCT SA 825 0012

ELL-BEE LITHIUM M-P GREASE

NFPA HAZARD RATING
4 — EXTREME
3 — HIGH
2 — MODERATE
1 — SLIGHT
0 — INSIGNIFICANT



SECTION I

1 WITCO MANUFACTURING DIVISION OR SUBSIDIARY

2 ADDRESS (NUMBER, STREET, CITY, STATE, ZIP CODE)

EMERGENCY TELEPHONE
MANUFACTURER (915) 782-5800
CHEMTREC 1-(800) 424-9300

3 CHEMICAL NAME OR FAMILY: Petroleum Hydrocarbon

4 FORMULA: NA

SECTION II — CHEMICAL AND PHYSICAL PROPERTIES

CHEMICAL

5 HAZARDOUS DECOMPOSITION PRODUCTS: Carbon monoxide, carbon dioxide

6 INCOMPATIBILITY (KEEP AWAY FROM): Strong oxidizing agents such as: hydrogen peroxide, chromic acid, bromine

7 LIST ALL TOXIC AND HAZARDOUS INGREDIENTS: None

PHYSICAL

8 FORM: Semi-solid

9 ODOR: Mineral Oil

10 APPEARANCE: Grease

11 COLOR: Amber

12 SPECIFIC GRAVITY (WATER = 1) RT: 0.924

13 BOILING PT.: NDA °C / °F

14 MELTING PT.: NA °C / °F

15 SOLUBILITY IN WATER AT 25 °C: Negligible

16 % VOLATILE (BY WT %): NA

17 EVAP. RATE (= 1): NA

18 VAPOR PRESSURE (mm Hg at 20 °C): NA

19 VAPOR DENSITY (AIR = 1): NA

20 pH AS IS: NA
pH ( )

21
STRONG ACID —
STRONG BASE —
STABLE X
UNSTABLE —

22 VISCOSITY SUS AT 100 °F: <100 / 100 OR >XX

23 NA

SECTION III — FIRE AND EXPLOSION DATA

24 SPECIAL FIRE FIGHTING PROCEDURES: Fire fighters should wear an approved self contained breathing apparatus.

25 UNUSUAL FIRE AND EXPLOSION HAZARDS: Dense smoke

26 FLASH POINT (METHOD USED): Above C.O.C. 190 °C 374 °F

27 FLAMMABLE LIMITS %: NDA LOWER ____ UPPER ____

28 EXTINGUISHING AGENTS
☒ DRYCHEMICAL ☒ CO₂
☐ WATERSPRAY ☒ FOAM
☒ WATERFOG ☒ SAND/EARTH
☐ OTHER ____

SECTION IV — HEALTH HAZARD DATA

29 PERMISSIBLE CONCENTRATIONS (AIR): NDA

30 EFFECTS OF OVEREXPOSURE: May cause skin & eye irritation with prolonged contact.

31 TOXICOLOGICAL PROPERTIES: 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.

NA = NOT APPLICABLE NDA = NO DATA AVAILABLE < = LESS THAN > = MORE THAN

FORM NO. 551-14-5

MATERIAL SAFETY DATA SHEET

PRODUCT SA 825 0012

SECTION V — SPECIAL PROTECTION INFORMATION

VENTILATION TYPE REQUIRED (LOCAL, MECHANICAL, SPECIAL) — 36: None Required	PROTECTIVE GLOVES 36: Rubber or plastic oil resistant
RESPIRATORY PROTECTION (SPECIFY TYPE) 37: None Required	EYE PROTECTION 38: Safety goggles and full face shield
	OTHER PROTECTIVE EQUIPMENT 40: None Required

SECTION VI — HANDLING OF SPILLS OR LEAKS

PROCEDURES FOR CLEAN-UP

41: 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

42: By methods consistent with local, state and federal regulations.

SECTION VII — SPECIAL PRECAUTIONS

PRECAUTIONS TO BE TAKEN IN HANDLING AND STORAGE

43: Keep containers closed.

SECTION VIII — TRANSPORTATION DATA

44 UNREGULATED BY D.O.T. [X]	U.S. D.O.T. PROPER SHIPPING NAME 47:
45 REGULATED BY D.O.T [ ]	U.S. D.O.T. HAZARD CLASS 48: — I.D. NUMBER 49:
TRANSPORTATION EMERGENCY INFORMATION: CHEM TREC 1-(800) 424-9300 — 46	RQ 50: — LABEL(S) REQUIRED 51:
	FREIGHT CLASSIFICATION 52: Petroleum Lubricating Grease
	SPECIAL TRANSPORTATION NOTES 53:

SECTION IX — COMMENTS

54: KEEP OUT OF REACH OF CHILDREN!!

SIGNATURE Ricky G. Thomas TITLE Manager Technical Compliance

REVISION DATE _____ SENT TO ATTN: _____ DATE 3/05/94

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) — 36: None Required	PROTECTIVE GLOVES 38: Rubber or plastic oil resistant
	EYE PROTECTION 39: Safety goggles and full face shield
RESPIRATORY PROTECTION (SPECIFY TYPE) 37: None Required	OTHER PROTECTIVE EQUIPMENT 40: None Required

SECTION VI — HANDLING OF SPILLS OR LEAKS

PROCEDURES FOR CLEAN-UP (41)

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 (42)

By methods consistent with local, state and federal regulations.

SECTION VII — SPECIAL PRECAUTIONS

PRECAUTIONS TO BE TAKEN IN HANDLING AND STORAGE (43)

Keep containers closed.

SECTION VIII — TRANSPORTATION DATA

44 UNREGULATED BY D.O.T. [X]	U.S. D.O.T. PROPER SHIPPING NAME 47
45 REGULATED BY D.O.T [ ]	U.S. D.O.T. HAZARD CLASS 48 — I.D. NUMBER 49
TRANSPORTATION EMERGENCY INFORMATION: CHEM TREC 1-(800) 424-9300 (46)	RQ 50 — LABEL(S) REQUIRED 51
	FREIGHT CLASSIFICATION 52: Petroleum Lubricating Grease
	SPECIAL TRANSPORTATION NOTES 53

SECTION IX — COMMENTS

54: KEEP OUT OF REACH OF CHILDREN!!

SIGNATURE Ricky L. Thomas TITLE Manager Technical Compliance

REVISION DATE _____ SENT TO ATTN. _____ DATE 3/05/94

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

Tox no. : 042840

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

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.

M S D S
(CONTINUED)

Tox no. : 042840

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

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.

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

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.

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. Chebanse, Il. 60922	
CHEMICAL NAME AND SYNONYMS	TRADE NAME AND SYNONYMS: Windshield Washer
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 (H2O=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.C.C. 112 F	FLAMMABLE LIMITS	Lel	Uel
EXTINGUISHING MEDIA Dry chemical, CO_2 or Alcohol foam			
SPECIAL FIRE FIGHTING PROCEDURES Wear self-contained breathing apparatus			
UNUSUAL FIRE AND EXPLOSION HAZARDS Vapor is heavier than air and may travel considerable distance to an ignition source.			

(Continued on reverse side)

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	

INCOMPATABILITY (Materials to avoid)
None

HAZARDOUS DECOMPOSITION PRODUCTS
Thermal decomposition may produces 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 IF CASE MATERIAL IS RELEASED OR 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: When appropriate to control employee exposure.	SPECIAL
	MECHANICAL (General)	OTHER

PROTECTIVE GLOVES: Neoprene or rubber gloves
EYE PROTECTION: Chemical safety goggles
OTHER PROTECTIVE EQUIPMENT

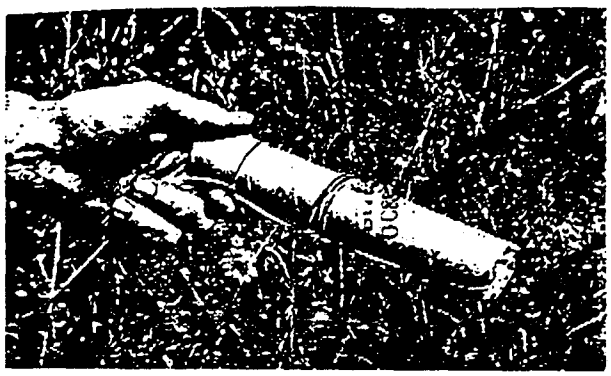
SECTION IX SPECIAL PRECAUTIONS

PRECAUTIONS TO BE TAKEN IN HANDLING AND STORING
Cannot be made non-poisonous.

OTHER PRECAUTIONS

Revised 1-9-90

seisPRIME/E® Emulsion Seismic Explosive



EXCELLENT FOR "MINI-HOLES" AND VERTICAL STACKING

These non-nitroglycerin emulsion products are packaged in convenien one-pound, one-half, one-third, and one-quarter pound cartridges an 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 o impact.

Spiral-wound 1/4 to 1/2-pound paper cartridges are easily capped an 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

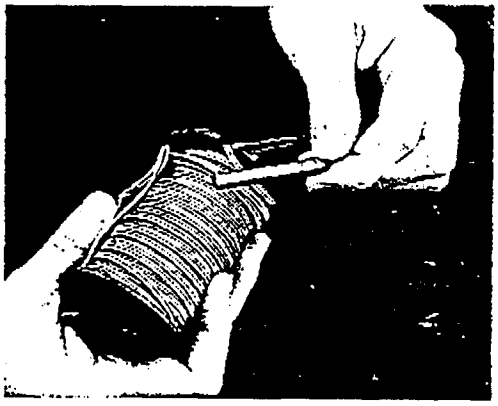
PACKAGING

Available in four sizes to meet vertical stacking an "mini-hole" applications. seisPRIME/E in the one-poun size is packaged in thin-walled, easy couplin cartridges for vertical stacking or larger downhol shots.

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

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

STATICMASTER® Electric Detonators for Seismic Exploration



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

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

WATER AND WEATHER-PROOF - Legwire insulation is designed to withstar extremes of heat and cold and the severe conditions encountered in deep-hole loadin All detonators contain a double-crimped rubber plug to provide a water-tight sea 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

REDUCED SENSITIVITY TO EXTRANEOUS ELECTRICITY

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

OPERATING AIDS

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

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

PACKAGING

STATICMASTER electric detonators come with spoole duplex copper lead wires (yellow color) in lengths of 40', 60', 8(100', 120', 150', 160', 200', 250', 300', and 400'; and in short legwire lengths (folded duplex wires, yellow) measuring 12', 2(and 24'.

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 Liqui
Mixture	Neg.	nd	nd	125	1.1 to 1.3	NA	None	White Greas

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
Corrosive	N	N
Highly Toxic	N	N
Irritant	N	N
Sensitizer	N	N
Toxic	N	N
Target Organ Effects	N	N

Ref: Registry of Toxic Effects of Chemical Substances (RTECS)
N = No Criteria Match
Y = Positive Criteria Match per RTECS
nd = No Data

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

INVOICE DATE	INVOICE NO.	PAGE
11/18/91	40649	1

Van Amburgh/Alamo, Inc.
12900 Preston Road
1220 North Dallas Bank Tower
Dallas, TX 75230
(214) 239-9000

MSDS

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

SHIP TO
Fort Bend Co. Delivery

ORDER NO.	ORDER DATE	CUSTOMER NO	SALES PERSON	PURCHASE ORDER NO.	SHIP VIA	SHIP DATE	TERMS
40649	11/15/91	S30			Our Truck	11/15/91	Net 30 Days

ITEM NO.	ITEM DESCRIPTION					
QUANTITY ORDERED	QUANTITY SHIPPED	STK UNIT	UNIT PRICE	PRICE UNIT	DISCOUNT	EXTENDED PRICE
550408000	80' SW STATICMASTER CHRS					
12.000	12.000	EACH	816.50	CU		97.98
10812533	SEISPRIME E 1-1/8 X 1/3 HE					
4.000	4.000	LB	164.00	CLB		6.56
900000051	HAZARDOUS MATRL HNDLG CHG					
1.000	1.000	%SAL	3.14	%SAL		3.14
900000001	E.R.C.C.- HIGH EXPLOSIVES					
4.000	4.000	LB	6.50	CLB		.26
900000006	E.R.C.C. - DETONATORS					
12.000	12.000	EACH	6.50	CU		.78

PAID 12/5/91
GOODS RECD 11/91
INVOICE RECD 12/91

SALES AMOUNT	108.72
MISC. CHARGES	.00
FREIGHT	.00
SALES TAX	~~8.80~~
TOTAL	~~117.52~~
PAYMENT REC'D	
BALANCE DUE	