# Seismic Site Safety and Accident Prevention Plan

Kansas Geological Survey
Exploration Services Section

U.S. Army Corps of Engineers, Seattle
Mud Mountain Dam
Enumclaw, Washington
August 1994

Open-file Report #94-41

KANSAS GEOLOGICAL SURVEY EXPLORATION SERVICES
ACCIDENT PREVENTION PLAN

## I. PROJECT DESCRIPTION

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|---|---|
| Project Name: | High Resolution Seismic Reflection Survey to Image Channels in the Bedrock Surface near Mud Mountain Dam, Enumclaw, Washington |
| Location: | Enumclaw, Washington |
| Site Safety Officer: | Richard D. Miller |
| Plan Prepared By: | Richard D. Miller |

Estimated Duration of Field Work: 3 days

## II. STATEMENT OF WORK

The high resolution seismic survey will consist of a single line approximately 2000 ft long. The proposed primary targets are the bedrock surface at between 300 and 600 ft beneath the ground surface and any acoustically significant features on or within a sequence of lake deposit approximately 200 ft deep. The goal is to improve the understanding of both the primary long path bedrock channel (Big Springs Channel) and short path channels (unconfined channels in the lake bed sequence above bedrock and in-filled with sands and gravels). Proven high resolution techniques (Steeples and Miller, 1990) will be used to acquire data on this survey. Any production data will be acquired in a standard CDP format (Mayne, 1962) using roll-along acquisition techniques similar to conventional petroleum exploration data acquisition. The geophone spacing, analog filtering, seismic source, geophone type, spread geometry, sampling interval, total samples, shots/point, and acquisition philosophy will be based on extensive pre-production tests.

Mud Mountain Dam was originally designed in the 1930s for flood control on the White River which heads at Carbon Glacier on the flanks of Mt. Rainier. Springs, seeps, and increased material saturations were observed during periods of elevated pool levels. King and Pierce counties have proposed to increase down stream flood plain usage through reduced limits on water release from the dam. This would require elevated pool levels more frequently and the elevated levels would be sustained for longer periods of time. The potential of a seepage-induced failure of the reservoir rim similar to the 1918 landslide at Masonry Pool on the Cedar River has prompted concern for the integrity of the Mud Mountain Dam.

The proposed 2000 ft seismic line is located along a haul road north and east of the dam and approximately parallel to the current river channel. The long path channel (Big Springs) is at least 150 ft deep and represents an interglacial course of the ancestral White River bedrock surface (U.S. Army Corps of Engineers, 1986). The unconsolidated material that overlies bedrock, as well as the topography of the bedrock surface, has been influenced by multiple episodes of Pleistocene glaciation combined with periodic deposition of pyroclastic mudflows originating from the present and ancestral Mount Rainier volcanic center (Galster, unknown). The maximum depth to bedrock within the 350 ft wide long path channel is 550 ft as defined by U.S. Corps of Engineers drill information. The proposed seismic line intersects the Big Springs channel at an oblique angle. The primary short path channel is suggested to be within the Vashon outwash overlying the drill confirmed 200 ft deep and 100 ft thick Vashon lake bed and deltaic deposits. Shallow seismic reflection should possess the necessary resolution and penetration at this site to image the bedrock surface at 350 to 550 ft and cut and fill features on the order of 10 ft.

The project will consist of two major phases: testing and production. The testing phase will commence as soon as a mutually agreed time can be arranged between the Kansas Geological Survey (KGS) and United States Army Corps of Engineers Seattle District (CESD). The testing phase will consist of about one day of walkaway tests near the planned survey line. The walkaway noise tests will be gathered according to common shot station and receiver offset and separated into distinct groups according to recording parameters. The quality and potential of the test data will determine whether the production portion of the project is feasible and should be undertaken. If both KGS and CESD agree that the data quality obtained warrants continuation of the project, the production phase will commence.

The production phase of the project will begin upon joint approval of the test results by CESD and KGS representatives. Acquisition of the production data will entail about two days. Acquisition of the production data will follow well established procedures, but will be somewhat dynamic with respect to specific parameters. The basic structure of both the acquisition and processing flow will be roughly designed around the findings of the preliminary testing. Uphole surveys (if possible) will consist of downhole hydrophones recording information at the base of a water filled monitor well or at the approximate depth of the bedrock surface in the water filled monitor well. Step-by-step analysis during the acquisition and processing phases of the survey will be continuous with modifications made at any stage of the survey if deemed necessary to ensure the quality of the final product.

## EXPERIMENTAL (TESTING) PHASE

The testing will involve two parts: uphole survey (if possible), and walkaway noise tests. The uphole surveys and walkaway noise tests will be run coincident with each other and will represent the first operation to take place after the appropriate safety briefing and site inspections. The walkaway noise tests and uphole survey should be completed within the first day, allowing selection of the optimum acquisition

parameters and equipment for the production portion of the project based on test data reduced to proper display format. The entire testing phase should be completed in the first day.

The uphole surveys will involve downhole hydrophones and the optimum surface source for conditions. Shots will be recorded at least 50 ft beneath the top of water table. The uphole information will be used to determine a true average velocity and represent ground truth for the time to depth conversions.

The walkaway noise tests will be conducted along the proposed seismic lines and as near to a control well as possible. The walkaway will consist of source-to-receiver offsets ranging from 4 ft to approximately 770 ft. To avoid spatial aliasing of noise, the receiver interval will be 4 ft. The downhole 30.06 firing rod (Miller et al., 1989) and the 12 and 8 gauge auger gun (Healey et al., 1991) (both require only class C explosives and will therefore not need permitting) as well as the sledge hammer weight drop source will be tested to determine the optimum source for the near-surface conditions. The auger gun will most likely prevail at this site. The downhole placement of sources greatly reduces the amount of recorded ground roll and other seismic noise and all but eliminates the higher frequency air-coupled wave prominent on weight drop seismograms.

The receivers available for testing will include both single Mark Products L-40A 100 Hz geophones and triple 40 Hz Mark Product L-28E geophones wired in series. The 40 Hz geophones will be tested first, and from previous experience will probably produce the best response. The need for a strong signal from the geophones is paramount and from previous experience; lower quality geophones will not produce the desired high output within the desired frequency band. Analog low-cut filter tests will include: low-cut out (all-pass), 50 Hz, 100 Hz, 200 Hz, and 400 Hz. If at any time during the low-cut filter testing the signal-to-noise ratio drops below acceptable levels, the upward progression of settings to be tested will be terminated. The low-cut filters will have an 18 dB/octave roll-off. If at any point during the noise testing an optimum parameter or component is identified, the affected portions of the remaining tests at that site could be by-passed.

Data collected during the experimental phase of this survey will be reduced to the appropriate final display format on site. All walkaway noise tests will be displayed according to source-to-receiver offset with separate displays for each source, receiver type, and low-cut filter tested. The final walkaway sections will be trace balanced and displayed in a variable-area wiggle trace format. The uphole velocity files will be trace balanced and displayed individually in variable area wiggle trace format.

Final decisions concerning feasibility of continuation of the survey will be made after completion of the testing phase. The data will be sorted, bandpass filtered, AGC scaled, and displayed in wiggle trace format. These plots should possess sufficient information for a qualitative judgment concerning the feasibility of shallow high resolution CDP seismic reflection methods to delineate the structural and stratigraphic

features of interest in this area. Combining the walkaway noise tests and uphole surveys should allow confident, well-informed decisions to be made concerning the feasibility of collecting usable data at each site as well as the feasibility of the entire project.

## PRODUCTION PHASE

The production acquisition phase of this project will begin as soon after the testing phase as is agreeable to both CESD and KGS. The data should be acquired in less than three days. The field parameters and equipment will be dictated by the results of the walkaway noise tests performed during the testing phase.

The particular source and receivers, as well as station spacing, shot interval, source/receiver geometry, and repeat shot count, as well as the optimum recording window, station interval, and shot interval will be determined after evaluation of analog field files recorded during the walkaway tests and evaluation of uphole information. The source and receiver selection will be a qualitative choice dependent on frequency, quantity of ground roll relative to body waves, and physical site and near-surface constraints.

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

The results of the walkaway noise tests will be used to determine specific optimum parameters used to record the CDP lines. Parameters such as sampling interval, record length, and analog filtering will be determined after careful examination of the dominant frequency and usable bandwidth of reflection energy recorded during the walkaway noise tests. The sampling interval will be chosen to ensure at least 10 samples/wavelength of the dominant reflection energy. The total number of samples will be chosen based on maximum time (depth) of interest as determined by both the sampling interval and the uphole surveys. The analog low-cut filtering will be determined based on qualitative evaluation of the recorded reflection energy using the various low cut filters. The analog low-cut as well as high-cut filters will balance the spectrum toward the higher frequency while maintaining the largest possible bandwidth (Steeples, 1990). If deemed necessary, spectral analysis of the walkaway data will be done to determine the spectral characteristics of the recorded information. Once the seismograph's variable settings are selected, the settings will not change for the duration of the particular line being acquired. This is to ensure consistency in phase and to avoid confusion relating to plotting scales, alias values, and system response. The

parameters chosen to record the CDP lines will incorporate the results of both the walkaway noise tests and the uphole surveys.

The data will be acquired using a standard CDP roll-along technique which will result in a nominal 24-fold CDP stack. The geophone station interval will be confirmed by computations and qualitative judgments made from data acquired during the testing phase. The most probable geophone spacing is 8 ft, which will result in a 4 ft horizontal subsurface sample interval. The data will probably be acquired using a split-spread source/receiver geometry to enhance dip control and increase the redundancy of close offset traces. The source-to-nearest receiver will probably be on the order of 50 ft with a maximum source-to-receiver offset of approximately 250 ft. Modification to the source/receiver geometries and offsets may be necessary after analysis of the data acquired during the testing phase.

The equipment used to acquire the production lines will be based on the results of the individual walkaway tests performed at each of the proposed line locations during the testing phase of the survey. The data will be acquired on a 48-channel, 15-bit Geometrics 2401x seismograph. Provided sufficient energy can be generated, the 12-gauge auger gun will be the preferred seismic source for the production lines. However, the 8-gauge auger gun, 20 lb sledge hammer, and 30.06 downhole firing rod will be available if conditions require their use. The triple L-28E 40 Hz geophones with variable damping capability will be the preferred choice for the receivers on the production line. If the 40 Hz geophones prove incapable of producing acceptable signal-to-noise and clean high frequency signal, the single L-40A 100 Hz Mark Products geophones connected in series will be available.

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

The principal CDP lines will be processed with commercial processing software into a CDP stacked format at KGS's Lawrence, Kansas facility. The basic architecture and sequence of steps to be followed during the generation of the final stacked sections will be similar to conventional petroleum exploration processing flows with exceptions relating to the step-by-step QC necessary for the generation of a finished stacked section allowing confident interpretation of shallow features (Miller et al., 1989, Miller et al., 1990, Miller and Steeples, 1991, Miller et al., 1990). The main distinctions relate to the emphasis placed on velocity analysis (Miller, 1992), lack of extensive wavelet processing, care and precision placed on muting, step-by-step analysis of effects of each operation on reflected energy, limiting statics operations to maximum shifts no greater than

1/4 wavelength of the dominant reflection energy, and coincident iterative velocity and statics analysis.

Each analysis step in the processing flow will be available to CESD for critique. Any addition information requested by CESD during the processing flow will be generated within a reasonable amount of time (amount of time determined jointly). All digital information requested by CESD will be delivered by KGS on the requested magnetic media (if available at the KGS). All hardcopy printouts of analysis steps as well as any special request data will be delivered to CESD on 11" fanfold from a 180 dpi, HP PaintJet printer, or, if necessary, a 300 dpi HP LaserJet. Horizontal and vertical scale on hardcopy printouts will be set to maximize the analysis potential and will be discussed and agreeable with CESD staff.

Special emphasis will be placed on all the analysis portions of the processing flow. It has been proved necessary and most effective to do velocity, spectral, and on certain occasions deconvolution on every CDP (Steeples and Miller, 1990). Many times variability in near-surface materials and/or conditions require changes in processing parameter over distances of less than 50 ft (Steeples et al., 1990). To insure the highest quality, geologically representative stacked section, velocity analysis of every CDP is necessary. In association with point-by-point analysis, care must be taken to ensure that all coherent events on stacked sections interpreted as reflections are reflections. Biasing processing parameters to enhance events interpreted as reflections that are actually coherent noise must be avoided at all cost. Differentiating reflections from direct wave, refractions, air wave, and ground roll in the early portion of a stacked section is an extremely difficult task and must not be taken lightly (Steeples and Miller, 1990).

## REFERENCES


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## III. RESPONSIBILITIES

The responsibility for employee safety rests with each employee's respective employer. This plan, therefore, applies only to KGS for the survey activities. Each employee of KGS will strive to identify and mitigate any safety hazards encountered. All parties will cooperate in working as safely as possible and will comply with all applicable safety requirements as set forth by the CESD 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 of lightning strikes are closer than three miles (determined by 15 second count between lightning and thunder).

2. Appropriate field boots will be worn and due caution will be exercised with respect to snakes. Copperheads and water moccasins have been observed.

3. A 100 foot rope capable of hoisting 500 pounds will be carried by the field crew. Although not anticipated, this may be required for hoisting in event holes or crevices are encountered.

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

## IV. SAFETY PERSONNEL

### Safety Personnel and Emergency Contacts

1. Rick Miller (KGS)—Site Safety Officer

2. Joe Anderson (KGS)—Operations

3. Bill Hancock (US Army Corps of Engineers, Seattle District [CESD])—Delegated Representative and Site Consultant

4. David Laflen (KGS)—Line Chief

**Safety Meeting at Survey Site** Date: _____

- ❒ Gun/explosives safety (handling of ammo, use of sources, cleaning and maintenance)
- ❒ Environmental hazards (heat, 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:

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Site Safety Officer

**Safety Meeting at Survey Site** Date: _____

- ❒ Gun/explosives safety (handling of ammo, use of sources, cleaning and maintenance)
- ❒ Environmental hazards (heat, plants, animals [snakes, etc.])
- ❒ Vehicle safety (road travel, warning signs, traffic control)
- ❒ Civilian/bystander safety (safe distances, visitor check-in)
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The following people were present today:

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Site Safety Officer

**Specific Safety Requirements**

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

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

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

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

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

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

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

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

1. Accidents or injuries must be reported immediately to the site safety officer, no matter how minor they seem.

2. Know how to do your job. Check your work area to determine what problems or hazards may exist. Review the safety requirements of each assigned job with your supervisor. Your activity may endanger other persons or nearby equipment or property. Take necessary steps to safeguard them. Be aware of what others are doing insofar as their actions may affect your safety.

3. Always maintain a safe distance away from any of the explosive seismic materials and devices unless you are specifically authorized or trained to handle these materials. Keep persons not authorized in the use of these materials away

from the explosive work area at all times. Those authorized to prepare explosives shall use every reasonable precaution including, but not limited to, visual and audible warning signals, flags, or barricades to ensure safety.

4. Report unsafe equipment, hazardous conditions, and unsafe acts.

5. Use the safety equipment specified for the job.

6. Practice good housekeeping in the work area.

7. For your protection, obey all warning signs such as "Keep Out," "No Smoking," "Eye Protection Required," and "Authorized Personnel Only." Become familiar with site specific emergency response plans.

8. Do not take shortcuts. Use ladders, ramps, stairways, and designated paths.

9. Do not engage in horseplay or roughhousing at any time. To do so may lead to injury and/or be cause for discharge.

10. No KGS staff person is permitted to use intoxicants or to be under the influence of any intoxicant or drug while on the job. This includes any time when operating a company vehicle. Failure to obey this policy may result in immediate termination of employment with KGS.

11. When in doubt about safety equipment or procedures required to do your job, ask your Supervisor, Department Head, Site Safety Officer, or the Survey Health and Safety Officer.

12. Failure to follow practices relating to your safety or that of fellow staff or failure to properly safeguard equipment, tools, or materials may lead to discharge.

## V. EMERGENCY INFORMATION

Ambulance: _____

Hospital Emergency Room: _____

Poison Control Center: _____

Police: _____

Fire Department: _____

Airport: _____

Explosives Unit: _____

State Environmental Agency: _____

Client: _____

**Emergency Contacts**

Safety Coordinator: Phone _____ - _____

Project Manager: Phone _____ - _____

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

Hospital:

**Procedures**

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

Rick Miller of KGS is First Aid and CPR certified. The following persons are also certified as indicated (please circle area[s] of certification):

Certified in: First Aid CPR _____

Certified in: First Aid CPR _____

Certified in: First Aid CPR _____

Certified in: First Aid CPR _____

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 Class "C" shotgun ammunition may be used as part of the program, local fire, police, and other governing authorities will be contacted and consulted prior to the use of any such devices.

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. 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 two kinds of 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 as follows:

- Storage: All shotgun ammunition will be stored in a locked metal container. The storage container will have proper DOT labels for Class "C" shotgun ammunition.

- Transportation: The ammunition vehicle will carry proper DOT labels and will be operated by Rick Miller on or near site. The vehicle will contain a fire extinguisher and will be parked far enough off any road to minimize the potential for a collision with other vehicles.

- Handling: Only Rick Miller or other KGS persons specifically authorized by the KGS will be allowed to access, handle, and load the shotguns. Shotgun loading and firing will be conducted in accordance with the attached seismic gun operating procedures.

- Firing Communication: Rick Miller shall establish a series of warning signals to be used prior to and following each shot. One short horn blast, whistle blow, or other audio signal will indicate the beginning of a blast. 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.

B. Work Item: Seismic Gun Safety Rules

Documents entitled "Mandatory Safety Rules for Use of the .50-Caliber Seismic Gun" and "Operations/Safety Rules and Regulations for the Auger Gun" are attached. These rules will be followed at all times during the collection of survey data. Following these rules minimizes the potential hazard of operating the seismic gun. Hearing protection will be required for the seismic gun operator(s) if sound pressure levels exceed legal limits during firing.

Operating Environment. The .50-caliber seismic gun is a single-shot rifle that fires standard military ball ammunition into the ground. The projectile is fired into a hole 30 to 36 inches deep and two inches in diameter. The barrel of the rifle projects about 24 inches below the ground into the hole. The nominal diameter of the hole and of the barrel differ only by about 1/8 of an inch so the ground provides an effective seal for most of the air-blast from the muzzle and prevents ricochet of rocks and bullet fragments at the earth's surface. The barrel is firmly bolted to a steel plate that is 1/4 to 1/2 inch thick, 12 inches wide, and 38 inches long. Two crew members stand on the plate to hold the gun in the ground when the gun is fired. The seal of the air-blast is good enough that a casual observer located 100 meters from the shot would not necessarily notice the noise.

On some projects, the gun is fired above the earth's surface vertically downward through an air-blast and shrapnel containment device that weighs about 400 pounds. For this survey, the plan is to fire all of the shots below the ground as described above, provided the tpower auger can drill holes to a depth of three feet at the test site.

Energy Release. The energy release of the projectile is approximately 14,300 footpounds at the bottom of the hole. The gas pulse energy is not known, but there is very little audible sound at the earth's surface. Under most soil conditions, the bullet penetrates 24 to 36 inches beyond the depth of the hole. If the bullet were to strike a hard object at the bottom of the hole, it is highly unlikely that it could come out at the surface. First of all, the bullet would be deformed upon contact with hard materials. Secondly, the collision would be less than perfectly elastic, so some energy would be lost in the collision. Thirdly, projecting to the surface at angles that would not strike the plate would require a less energetic, deformed bullet to traverse more than 36 inches of undisturbed soil, which is highly unlikely. In previous experience, when the bullets have hit hard materials such as solid limestones or cemented sandstones, examination revealed that either the bullet disintegrated, or the rock shattered, or both.

Transportation. Transportation of the auger gun, the seismic gun, and ammunition is on a standard one-ton flat-bed four wheel drive truck. 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 gun is transported with the bolt removed. A steel tube is bolted under the frame of the truck to hold the gun. The gun is locked in the tube and is not visible during transportation. The ammunition is classified as "Class C Explosive" by the U.S. Department of Transportation. No more than 2000 rounds of each type of ammunition will be transported to this project, packed in 160 per ammo can.

C. Work Item: Traffic Control

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.

## VII. 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).

## VIII. ENVIRONMENTAL IMPACT ANALYSIS

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

## IX. 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.

## X. 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*

We, as members or visitors of the Seismic Reflection Survey conducted by the Kansas Geological Survey on contract with United States Army Corps of Engineers Seattle District, have read the previous accident prevention plan and understand its content in whole.

| Name (PRINT) | Date | Company | Signature |
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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. |
| <u>During Transport</u> | | |
| 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.

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

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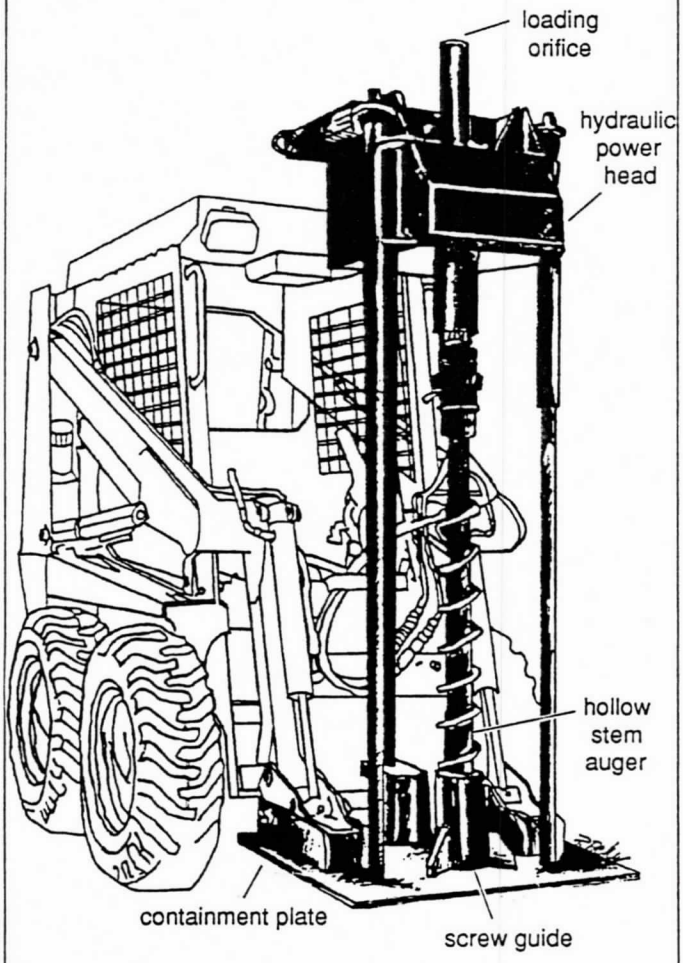


Fig. 1 Diagram represents the auger gun in above-ground position. Modified buffalo-gun portion of the auger gun is not shown, but is conceptually the same as previously documented (Pullan and MacAulay, 1987).

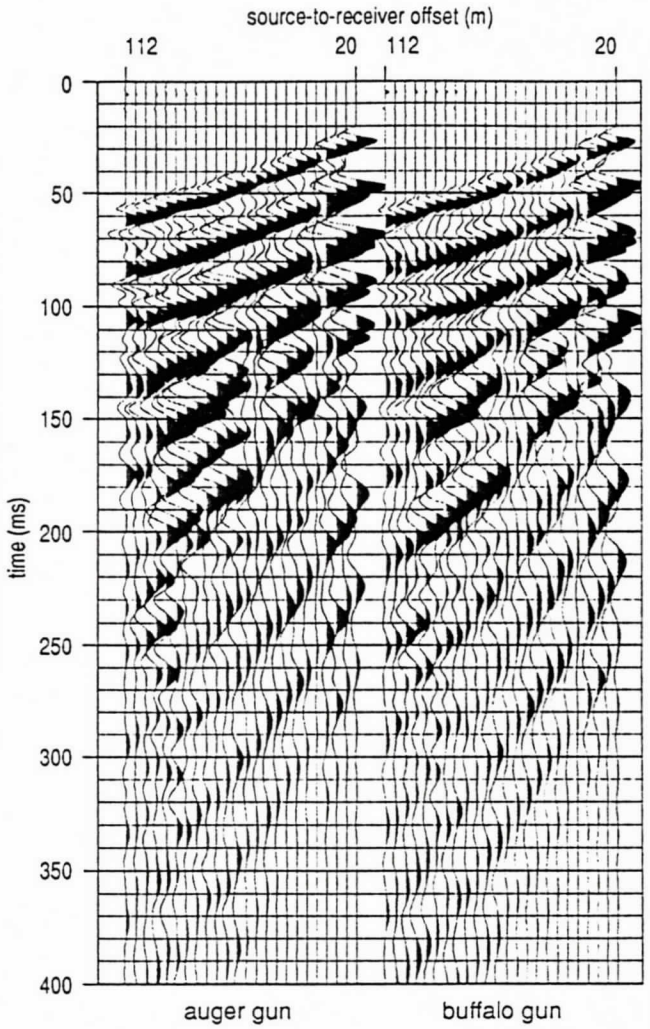


Fig. 2 Auger gun field file (left) compared to the buffalo gun (right).

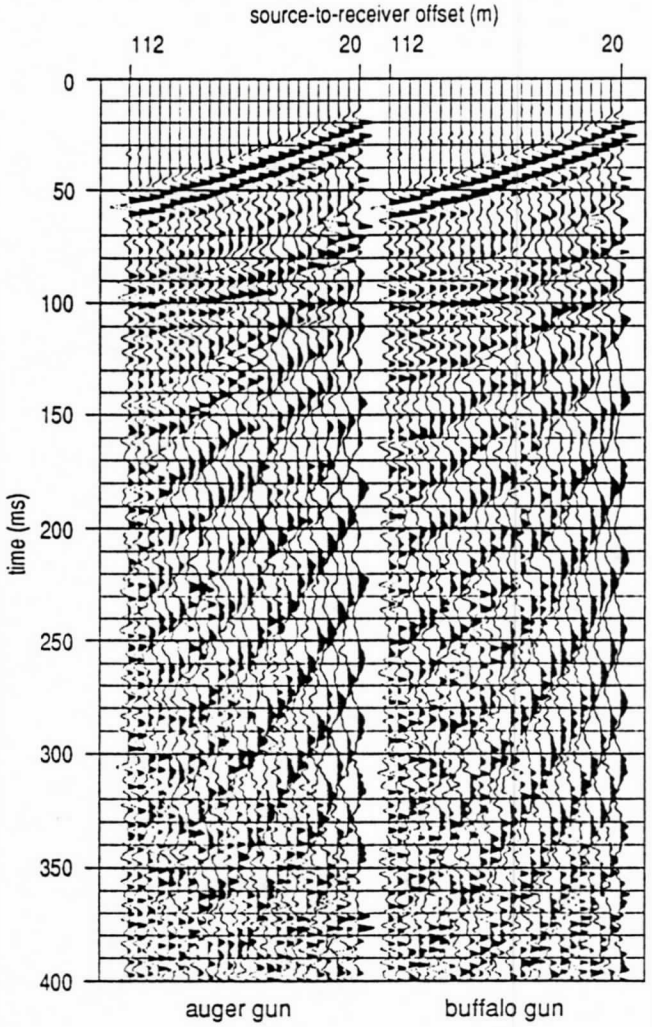


Fig. 3 A 150 Hz digital low-cut filter enhanced the 80 ms reflection event on both the auger (left) and buffalo (right) guns.

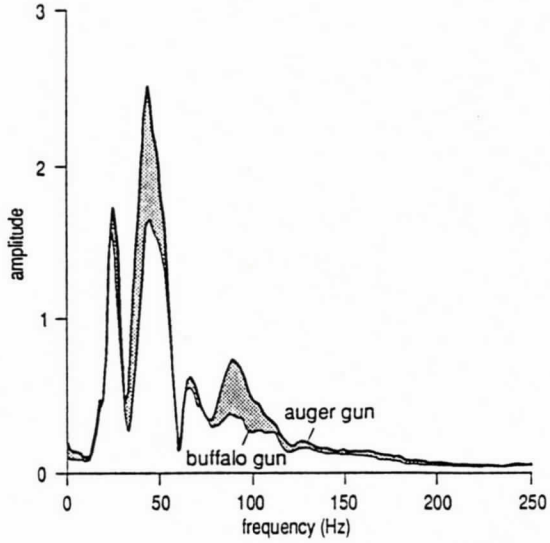


Fig. 4 The darkened area represents the difference between the lower curve (buffalo gun) and the upper curve (auger gun).

# Downhole .50-caliber Rifle—an Advance in High-resolution Seismic Sources

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

## SUMMARY

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

## INTRODUCTION

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

Recent seismic source advances at the Kansas Geological Survey (KGS) have mainly revolved around surface projectile-type sources (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

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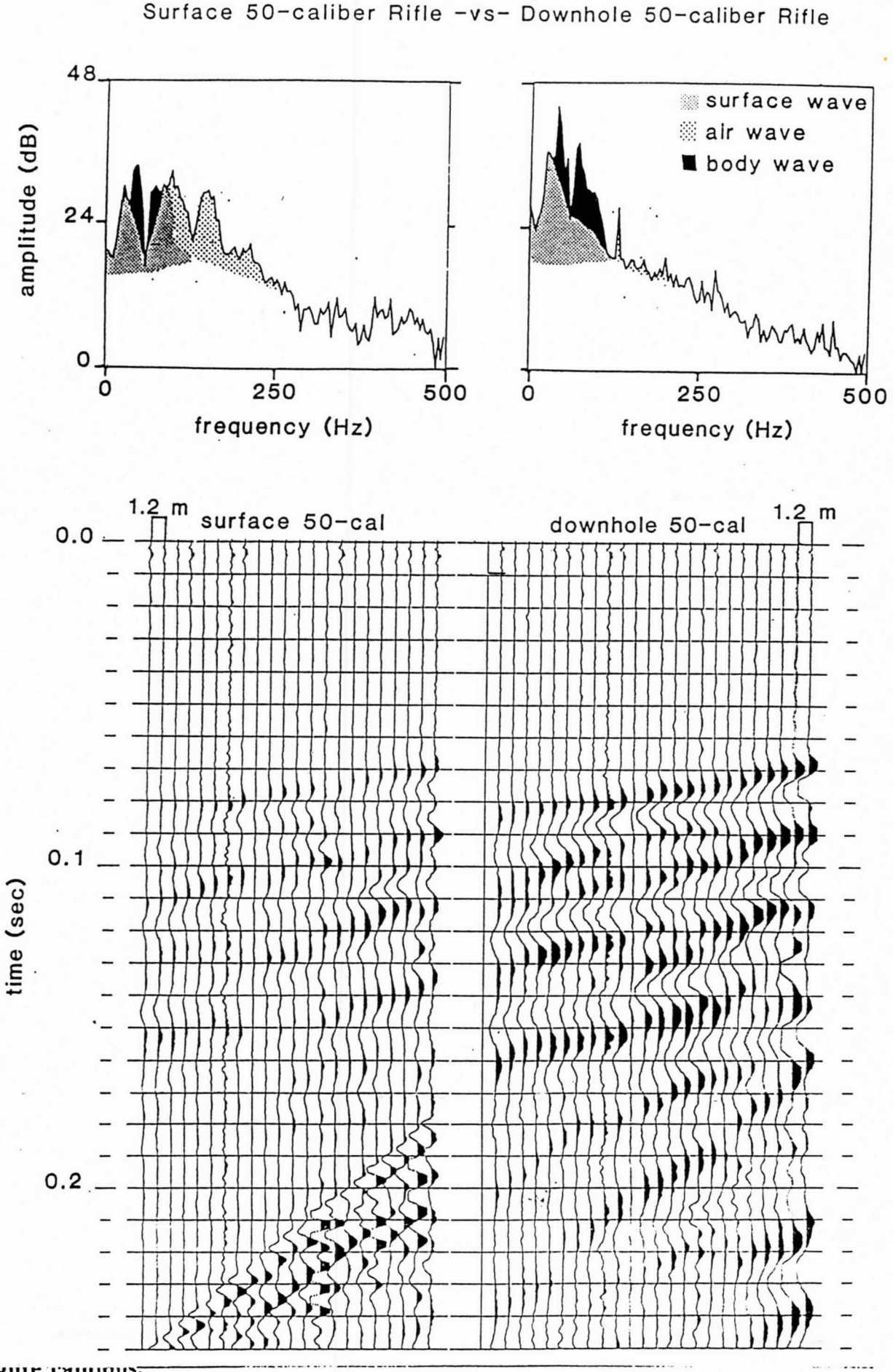



Figure captions:

FIG. 1. -This single shot comparison plotted true amplitude with identical recording parameters clearly shows the increased signal-to-noise and the improved freque

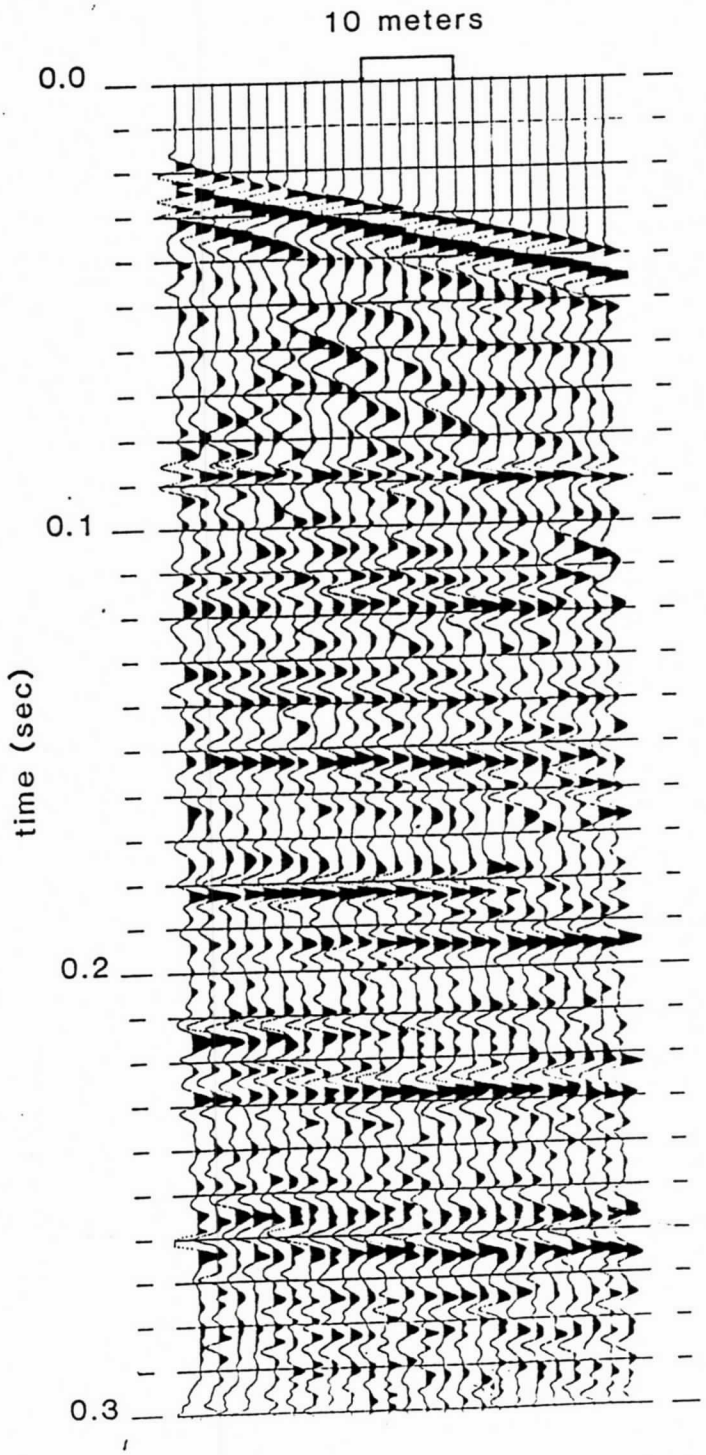



FIG. 2. This single-shot field file with an AGC applied illustrates the high frequencies and therefore the resolution easily obtainable with a downhole .50-cal.

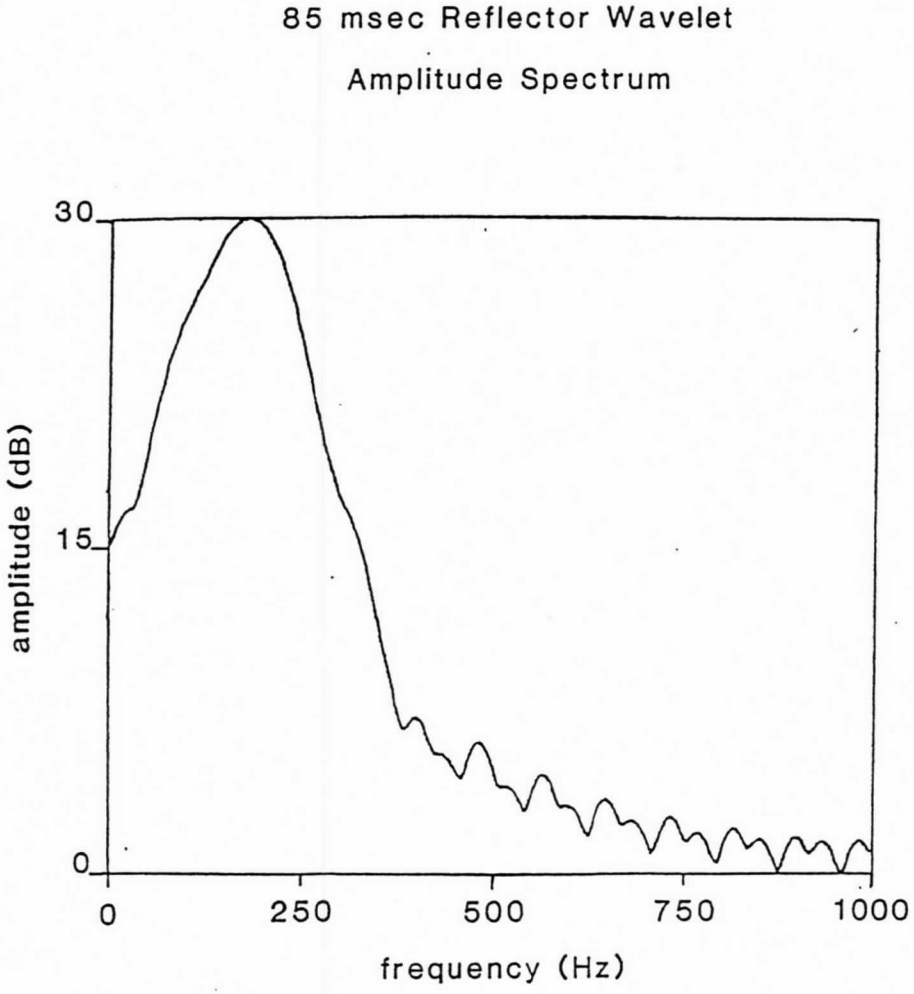



FIG. 3. —The amplitude spectrum of the reflection pulse at 85 msec is almost 3 octaves

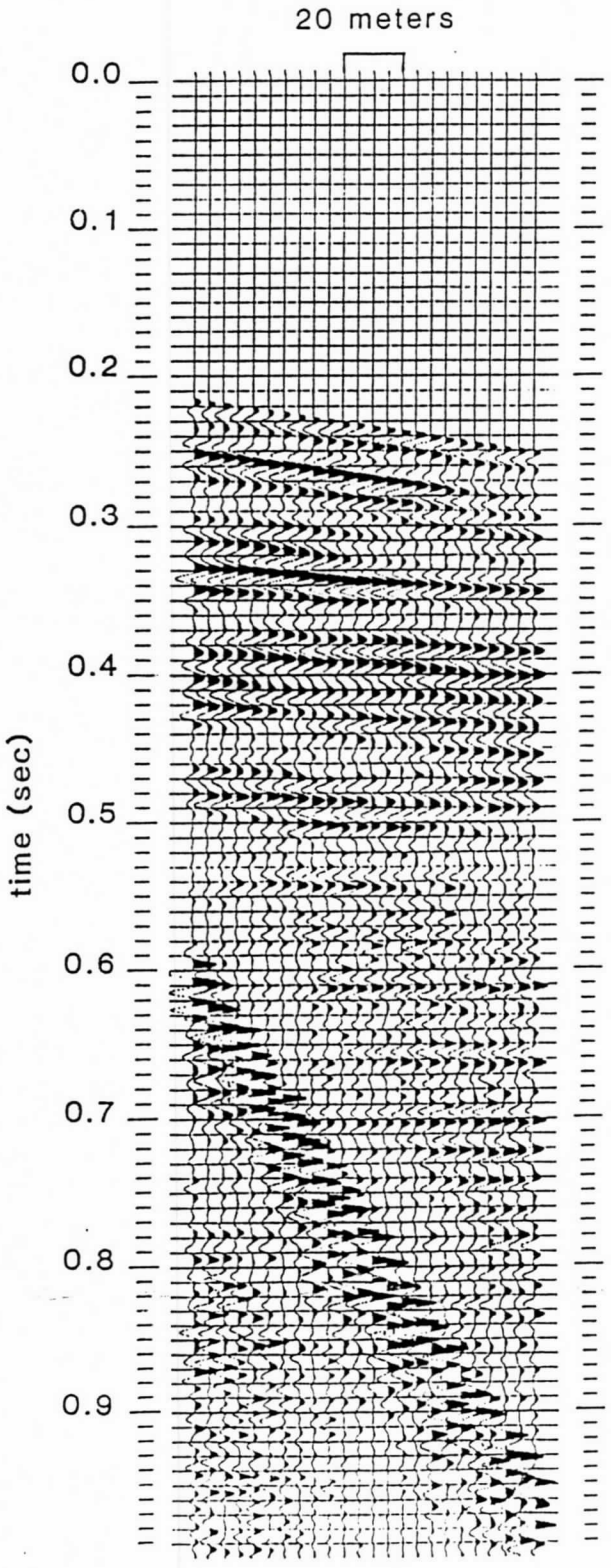



FIG. 4. —This stacked field file has 100 Hz reflection energy as deep as 1100 meters.

# 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.

INHALATION: Remove victim to fresh air.

Chemical Industrial Ammunition 8 Gauge CAS No. Not assigned

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

| | | | |
|---|---|---|---|
| ACUTE ORAL LD 50 | Not applicable | CARCINOGENICITY | Not carcinogenic |
| | | 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 ($H_2O$ = 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 | Unstable | | Conditions to Avoid: Flames, sparks, percussion or shock and high temperatures (130°C) |
| | Stable | X | |

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

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

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

## Section VI — Health Hazard Data

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

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: Not applicable Eye Protection: 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: 1988-491-529/45775

# GENERAL MOTORS CORPORATION
# MATERIAL SAFETY DATA SHEET

## SECTION I

| | |
|---|---|
| PRODUCT NAME OR NUMBER (as it appears on label)<br>ALL MODELS OF DELCO BATTERIES | GM COMMON CODE |
| MANUFACTURER'S NAME<br>Delco Remy Division, GMC | EMERGENCY TELEPHONE NO.<br>(317) 646-3080 |
| ADDRESS (Number, Street, City, State and Zip Code)<br>2401 Columbus Avenue, Anderson, IN 46018 | MANUFACTURER'S D-U-N-S NO. |
| HAZARDOUS MATERIAL DESCRIPTION, PROPER SHIPPING NAME, HAZARD ID NO. (49 CFR 172.101)<br>Battery, Wet, Filled with Acid, (Corrosive Material) Class 8 - UN2794 | |
| ADDITIONAL HAZARD CLASSES (as applicable) | |
| CHEMICAL FAMILY<br>Liquid Content - Sulfuric Acid | FORMULA<br>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 (@ 27 ° 25 °C) ☒ mm Hg ☐ psi | 2.730 | 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<br>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<br>While batteries are being charged, hydrogen gas is generated. Avoid open flames, spark or lighted matches. Acid, powerful oxidizers, can ignite combustible upon contact. | | | |

EFFECTS OF OVEREXPOSURE — Conditions to Avoid
Contact with sulfuric acid results in rapid destruction of body tissue (burns).

THRESHOLD LIMIT VALUE ☐ TLV=1 mg/m3
PERMISSIBLE EXPOSURE LIMIT ☐ Sulfuric Aci
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:

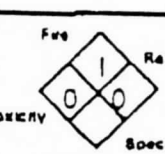
Name (print) Robert A. Chisman
Signature Robert A. Chisman
Title Senior Industrial Hygienist
Date May 8, 1991

# 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 (913) 782-5800
CHEM TREC 1-(800) 424-9300

3 CHEMICAL NAME OR FAMILY: Petroleum Hydrocarbon

4 FORMULA: NA

## SECTION II — CHEMICAL AND PHYSICAL PROPERTIES

### CHEMICAL

6 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 ( 1 )

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

# MATERIAL SAFETY DATA SHEET

PRODUCT SA 825 0012

## SECTION V — SPECIAL PROTECTION INFORMATION

| | |
|---|---|
| VENTILATION TYPE REQUIRED (LOCAL, MECHANICAL, SPECIAL) [36]: None Required | PROTECTIVE GLOVES [39]: 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

| | |
|---|---|
| [45] UNREGULATED BY D.O.T. [X] | U.S. D.O.T. PROPER SHIPPING NAME [47] |
| [46] 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 [44] | 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 Ray G Thomas TITLE Manager Technical Compliance

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

SUPERSEDES _____

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

# MATERIAL SAFETY DATA SHEET

PRODUCT SA 825 0012

## SECTION V — SPECIAL PROTECTION INFORMATION

| | |
|---|---|
| VENTILATION TYPE REQUIRED (LOCAL, MECHANICAL, SPECIAL) 36: None Required | PROTECTIVE GLOVES 38: Rubber or plastic oil resistant |
| RESPIRATORY PROTECTION (SPECIFY TYPE) 37: None Required | EYE PROTECTION 39: 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 Ray G Thomas TITLE Manager Technical Compliance

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

SUPERSEDES _____

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

# MATERIAL SAFETY DATA SHEET

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

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 ($H_2O$=1) | .951 |
| VAPOR PRESSURE (mm Hg) | N/A | PERCENT VOLATILE BY VOLUME (%) | N/A |
| VAPOR DENSITY (AIR=1) | N/A | EVAPORATION RATE (_____=1) | N/A |
| SOLUBILITY IN WATER | Complete | | |
| APPEARANCE AND ODOR | Blue-aromatic | | |

## SECTION IV FIRE AND EXPLOSION HAZARD DATA

| | | LEL | UEL |
|---|---|---|---|
| FLASH POINT (Method used): T.C.C. 112 F | FLAMMABLE LIMITS | | |
| 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 | | | CONDITIONS TO AVOID |
|---|---|---|---|
| | UNSTABLE | | Sparks, heat and flames. |
| | STABLE | X | |

INCOMPATABILITY (Materials to avoid)
None

HAZARDOUS DECOMPOSITION PRODUCTS
Thermal decomposition may produce carbon dioxide and/or carbon monoxide.

| HAZARDOUS POLYMERIZATION | | | |
|---|---|---|---|
| | MAY OCCUR | | CONDITION TO AVOID |
| | WILL NOT OCCUR | X | |

## SECTION VII SPILL OR LEAK PROCEDURES

STEPS TO BE TAKEN IN CASE MATERIAL IS 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 | EYE PROTECTION |
|---|---|
| Neoprene or rubber gloves | Chemical safety goggles |

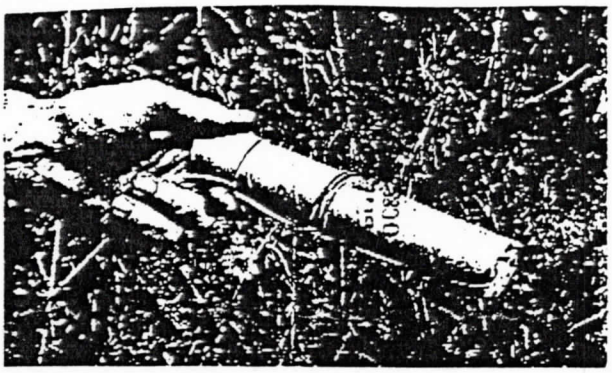
OTHER PROTECTIVE EQUIPMENT

## SECTION IX SPECIAL PRECAUTIONS

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

OTHER PRECAUTIONS

# seisPRIME/E® Emulsion Seismic Explosive



## EXCELLENT FOR "MINI-HOLES" AND VERTICAL STACKING

These non-nitroglycerin emulsion products are packaged in convenier one-pound, one-half, one-third, and one-quarter pound cartridges an formulated to provide a seismic pulse equal to dynamite for clear, shar seismic records.

Although classified as high explosive, seisPRIME/E emulsions are nor headache and have excellent resistance to accidental detonation by friction c 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 |

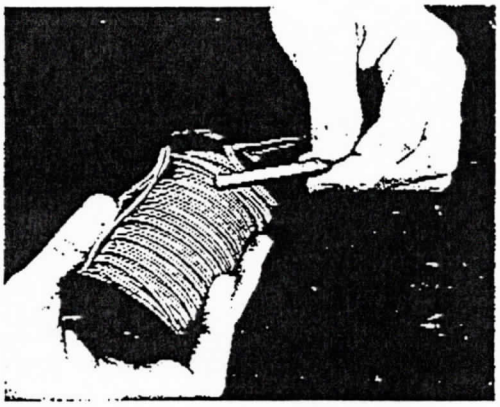
## PACKAGING

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 reliabl 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 consister 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 withstan 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 shootin

## 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 electri detonators meet all requirements for series firing.

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

## PACKAGING

STATICMASTER electric detonators come with spooled duplex copper lead wires (yellow color) in lengths of 40', 60', 80' 100', 120', 150', 160', 200', 250', 300', and 400'; and in shorte legwire lengths (folded duplex wires, yellow) measuring 12', 20' 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. | PAG |
|---|---|---|
| 11/18/91 | 40649 | 1 |

Van Amburgh/Alamo, Inc.
12900 Preston Road
1220 North Dallas Bank Tower
Dallas, TX 75230
(214) 233-9666

MSDS

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

SHIP TO: Fort Bend Co. Delivery

| SPCS # 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 |
| 50408000 | 80' SW STATICMASTER CHRS | | | | | |
| 12.000 | 12.000 | EACH | 816.50 | CU | | 97.98 |
| 0812533 | 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 |

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

NC docum

| | |
|---|---|
| SALES AMOUNT | 108.72 |
| MISC. CHARGES | .00 |
| FREIGHT | .00 |
| SALES TAX | ~~6.80~~ |
| TOTAL | ~~115.52~~ |
| PAYMENT REC'D | |
| BALANCE DUE | |