



Seismic Reflection Survey:  
Health and Safety Plan

Kansas Geological Survey  
Exploration Services Section

U.S. Army Corps of Engineers  
Clearwater Dam, Missouri  
March 2003



**KANSAS GEOLOGICAL SURVEY EXPLORATION SERVICES  
ACCIDENT PREVENTION PLAN**

**I. PROJECT DESCRIPTION**

Project Name: Seismic Investigation of a Sinkhole on Clearwater Dam

Location: Clearwater Dam, Missouri

Site Safety Officer: Richard D. Miller

Plan Prepared by: Richard D. Miller

Estimated Duration of Field Work: 2½ days

**II. STATEMENT OF WORK**

A sinkhole that formed catastrophically on Clearwater Dam during January of 2003 will be the target of a high-resolution seismic imaging program designed to determine the general geometry of the sinkhole's subsidence "root or chimney" and help ascertain if and to what extent bedrock and native alluvium is involved. When first discovered this sinkhole measured 10 ft wide and 10 ft deep, was approximately 120 ft from the dam crest, and on the upstream side (Figure 1). This sinkhole represents a not yet fully appraised risk to the overall integrity of the dam and is a symptom of a larger, yet undetermined subsurface leaching problem.

High-resolution seismic reflection and full-wavefield seismic studies will target key areas within and below this earthen dam. The high-resolution seismic reflection portion of the program will focus on bedrock and the rocks below as well as search for anomalies that may be present within the impervious core. Surface wave and first arrival analysis will attempt to image fill material composing the upstream cover of the impervious dam core above bedrock in sufficient detail to assist in the development of a 3-D model showing the disturbed engineered fill relative to intact or undisturbed dam materials. Ideally, these two geophysical tools in association with dam construction details and boring data will allow the generation of a detailed model of the sinkhole and subsidence-affected materials below what can be seen on the surface of the dam.

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 the U.S. Army Corps of Engineers (USACE). The testing phase will consist of walkaway tests undertaken near the planned survey lines but away from any possible subsurface expression of the sinkhole. Walkaway noise test data will be gathered according to common shot station and receiver offset and separated into distinct groups according to recording parameters (source, receiver, recording parameters, etc.). The quality and potential of the test data will dictate if the project proceeds to the next phase and the acquisition approach taken during the production portion of the project. Both KGS and USACE will jointly determine if the production phase will commence.

Seismic images and eventual material, structural, and/or geologic interpretations of those seismic images will be optimized for a dam volume from the base of the clay cap to several tens of feet into the bedrock beneath the sinkhole and for a significant distance away from the affected area. If the site is compatible with the seismic techniques intended to image the subsurface it should be possible to delineate the lateral as well as vertical extent of the void and associated collapse materials associated with the sinkhole. Both shear wave velocity profiles and seismic reflection sections will be coincidentally interpreted with the aid of construction reports and borings from this portion of the dam.

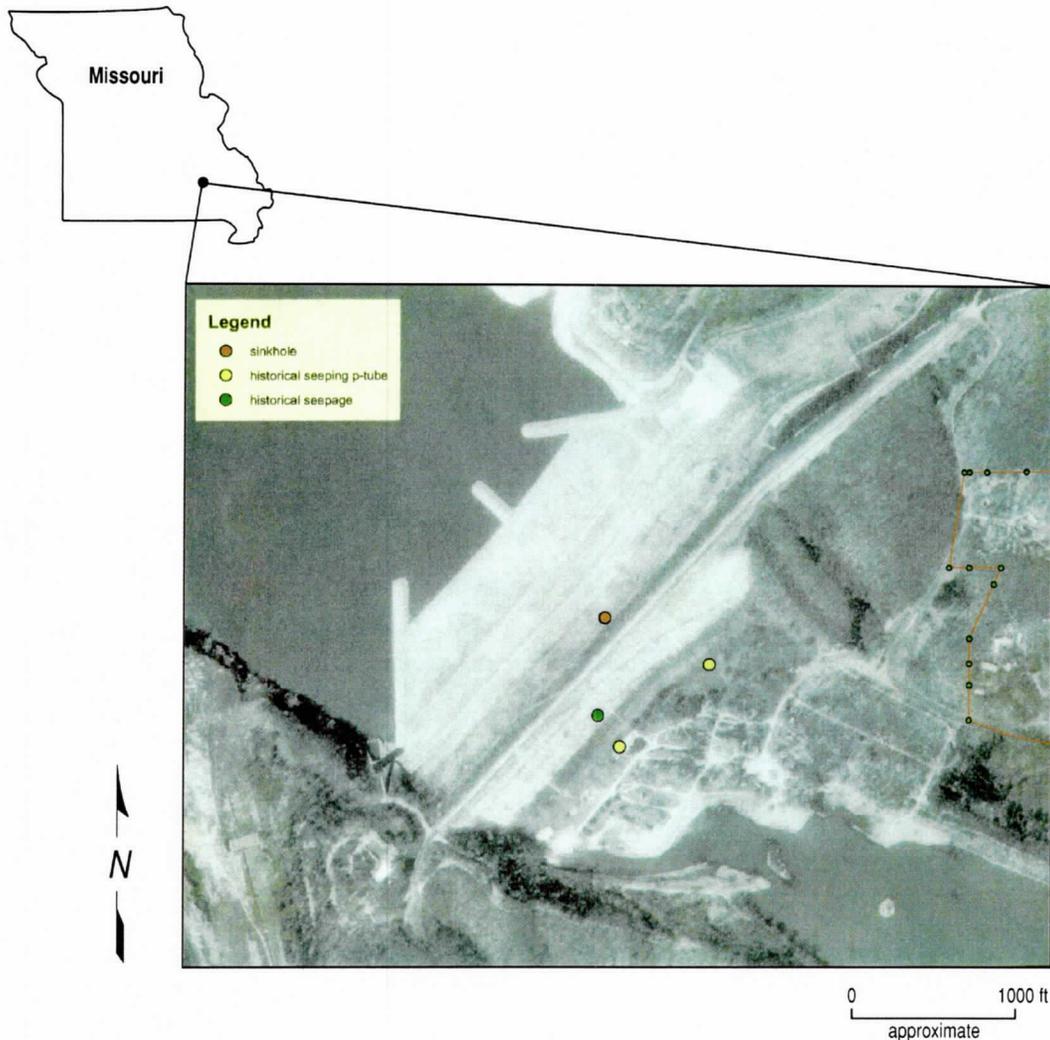


Figure 1. Aerial photo of Clearwater Dam. Sinkhole and seepage are indicated. Dikes extending into the lake were part of the 1989 retrofitting for seismic stability and seepage control.

These seismic data could play a critical role in understanding the processes and chronology of not only this particular sinkhole but the hundreds of potential sinkholes yet to have formed on other earthen dams in areas with karst potential. The bedrock and upper few tens of feet of rock as well as the design and construction of the Clearwater Dam are very similar to a large number of earthen dams throughout the midwest. Developing, applying, and evaluating various seismic imaging techniques for the purpose of improving our understanding of this particular subsidence feature has a broader significance to USACE dams in general and specifically throughout Kansas. Dam failure due to karst can occur without warning and can range from insignificant to catastrophic and from no threat to major risk to life and property. Studies like this will help enhance the repertoire of seismic tools and maintain the expertise necessary to rapidly respond to similar problems in Kansas. Maybe as importantly, development of geophysical tools that are well suited for dam and levee reconnaissance could provide the early warning necessary to save lives and avert structural failures in earthen retention systems.

This study will focus on: 1) optimal application of non-invasive, high-resolution seismic techniques on an earthen dam, 2) maximizing the resolution potential (both horizontal and vertical) of images of the disturbed materials, 3) optimizing source and acquisition geometries for physical site limitations, resolution, and survey economics, 4) correlating seismic data with dam construction and borehole data, 5) delineating intra-dam layers as thin as a few feet, 6) 3-D geometry of the “chimney”

feature likely responsible for the sinkhole, and 7) identifying bedrock analogies and possible chronologies of structures observed on seismic profiles.

The production data will require 2 to 3 days (depending on conditions) and will follow well established shallow high resolution data acquisition procedures (Hunter et al., 1984; Knapp and Steeples, 1986; Steeples and Miller, 1990; Park et al., 1999; Ivanov, 2002). The basic structure of both the acquisition and processing flow will be roughly designed around the findings of the preliminary testing. Step-by-step analysis during the acquisition and processing phases of the survey will be continuous with appropriate modifications made if deemed necessary to ensure the quality of the final product. The geophone spacing, seismic source, source spacing, optimum fold, geophone type, spread geometry, sampling interval, total samples, shots/point, and acquisition philosophy will be based on extensive pre-production tests

### **Introduction**

In support of the U.S. Army Corps of Engineer's strong commitment to dam safety, new and/or adaptations of existing technologies are being identified and evaluated at sites with both physical characteristics conducive to those technologies and failure potential. Proven correlation between acoustic properties and stiffness/rigidity is the basis for developing and implementing field efficient, laterally continuous, non-invasive methods to accurately measure the seismic wavefield. As well, routine non-invasive appraisal of dam/dike core integrity is feasible and could prove quite valuable in some settings. Ultimately, the goal is to identify localized anomalous material zones, indicative of either dissolution activity or non-uniform compaction/settling, prior to surface subsidence or the formation of vertically extensive chimney features. Seismic techniques hold vast potential for imaging and measuring materials in a fashion applicable to evaluations of dam integrity.

In many settings around the world carbonate rocks, such as limestone and dolomite, are susceptible to solution and the formation of voids. Movement of ground water in, around, and through, especially joints, fractures, and faults in soluble rocks can result in solution of those rocks and the development of cavities in the rock. A prerequisite for subsidence is the presence of voids in rocks or unconsolidated materials. Cavities formed naturally or manmade can represent a significant risk to surface activities and facilities.

Many areas in the mid-continent are underlain by carbonate rocks and can be characterized by the presence of subsurface cavities, sinkholes, and underground drainage. These anomalous rock features are called "karst terrains." Karst areas are most susceptible to sinkhole development and associated long-term subsidence. Most sinkholes form after a loss of roof rock support over voids followed by roof collapse and/or raveling. Ground water can provide buoyant support to the roofs of subsurface cavities. Lowering the water table removes this support and may result in the collapse of the roof of the sub-surface cavity. Collapse of an unsupported opening or void generally results when the opening is enlarged beyond the ability of the roof rock to support or bridge the materials above. Raveling or piping is the slow erosion of unconsolidated sediments into an underground opening.

A change in the local environment that affects the soil mass can initiate collapse and subsidence. Water and its conduit to the rock are generally the most important aspects effecting change that result in subsidence. Lowering water levels is one of the most significant triggering mechanisms for subsidence in a karst terrain. Other changes that can trigger subsidence include an increase in velocity of ground-water movement, an increase in the amplitude or frequency of water-table fluctuations, increased or induced recharge, and induced differences in hydrostatic head. Of lesser importance but still a factor is the increasing of roof rock load. The type and speed of change combined with the material characteristics and geologic setting control subsidence rates and volumes.

### **Dam and Sinkhole Chronology and Construction**

Clearwater Lake Dam was designed and constructed in the early 1940s as a control structure across the Black River. During the design and building of the cutoff trench two distinct and unique sets of enlarged joints were discovered in the limestone bedrock near stations 39+50 and 40+25 (Figure 2).

Additional drilling suggested the joints were extremely localized and inferred to only extend several tens of feet beyond the cutoff trench excavation. Based on the trench and drill findings the joints were filled with concrete consistent with the dam building practices of that time.

As part of a retrofit targeting seismic stability and seepage issues, clay berms were constructed in 1989 from the upstream toe of the dam out 500 ft into lake (Figure 3). Included with this retrofit was the addition of a clay blanket covering the rip-rap on the upstream slope. This clay facial formed an impervious lining on the upstream slope that extended from the upstream toe up to elevation 575.

Routine operations and pool levels were the rule through the 1990s and up till May of 2002. During May of 2002 a record pool of nearly 566 threatened to discharge through the uncontrolled spillway. During the summer of 2002 water levels were drawn down from 567 ft to 500 ft, thereby returning lake elevation to normal pool operating ranges.

On January 14, 2003, project personnel working at Clearwater Lake found a 10 ft diameter by 10 ft deep sink near elevation 573 and location 39+87 (Figure 4). A sinkhole of this nature and location represented a threat to dam integrity and prompted a response by the dam owner. On January 17, 2003, a backhoe excavated the sinkhole down to an elevation of 548 where the diameter of the subsidence feature

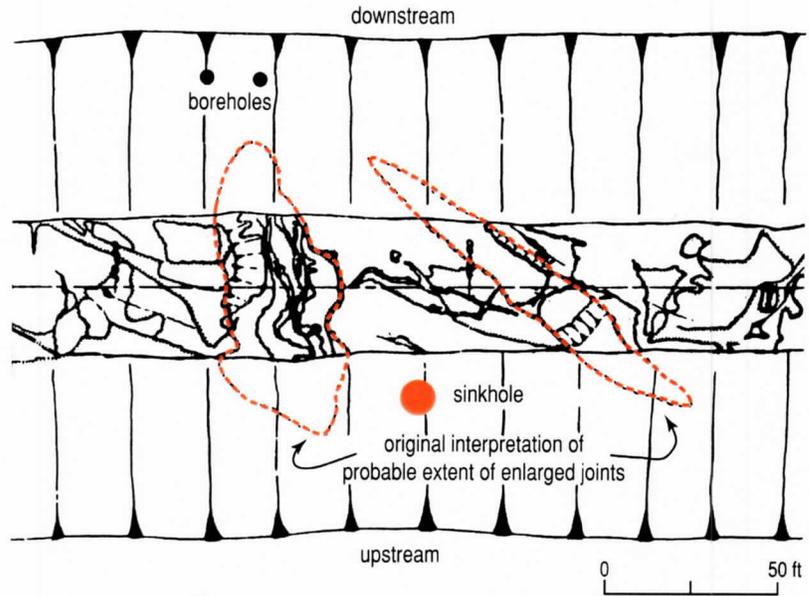


Figure 2. Joints mapped during construction of cutoff trench. Joints were filled with a custom cement mix prior to placement of engineered fill.

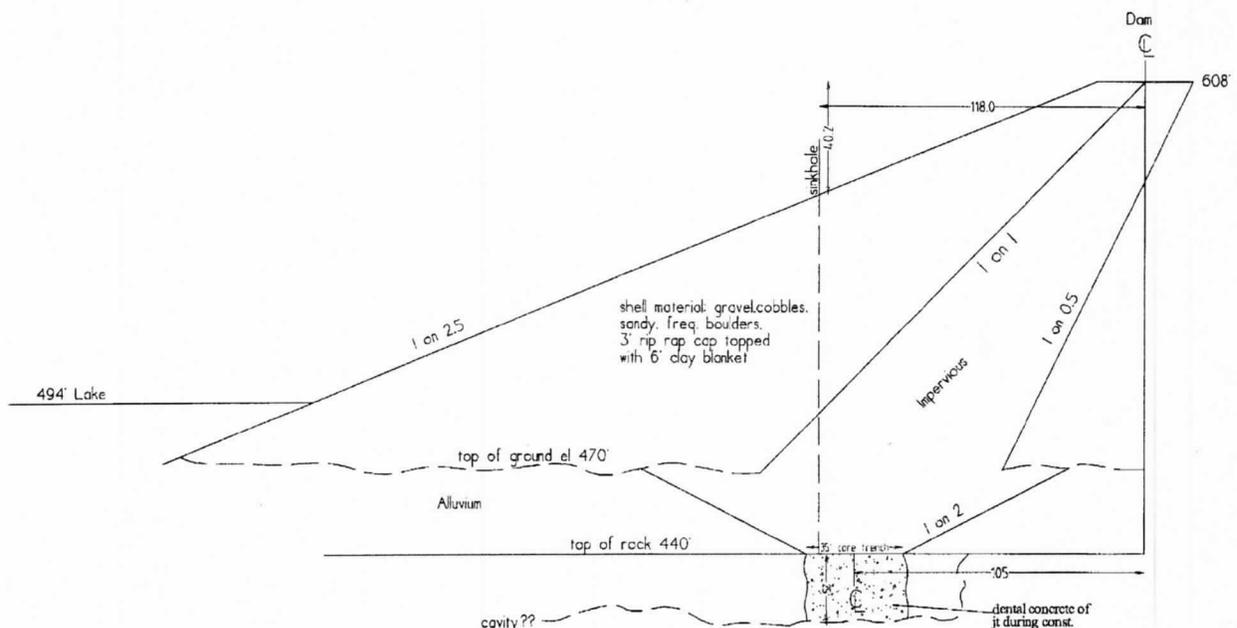


Figure 3. Cross-section of dam diagramming construction specifications and layer geometries (figure provided by Hartung, 2003, USACE).

narrowed to 3 ft (Figure 5). The 25 ft deep excavation was backfilled with a clay plug, returning the dam surface to original grade. On February 15, 2003, with the first sizeable rainfall (1.2 in) since the installation of the clay plug came subsidence of the clay plug (3 in around the perimeter and 6 in at the center). The backfilled sinkhole has been under constant surveillance since it formed with no evidence of downstream seepage, upstream slumps, cracks, or whirlpools. Soils engineers describe the 6-ft thick clay blanket covering the upstream slope as being very compacted, probably hiding the void that likely formed during the summer of 2002 and finally collapsed in January, forming the sinkhole.

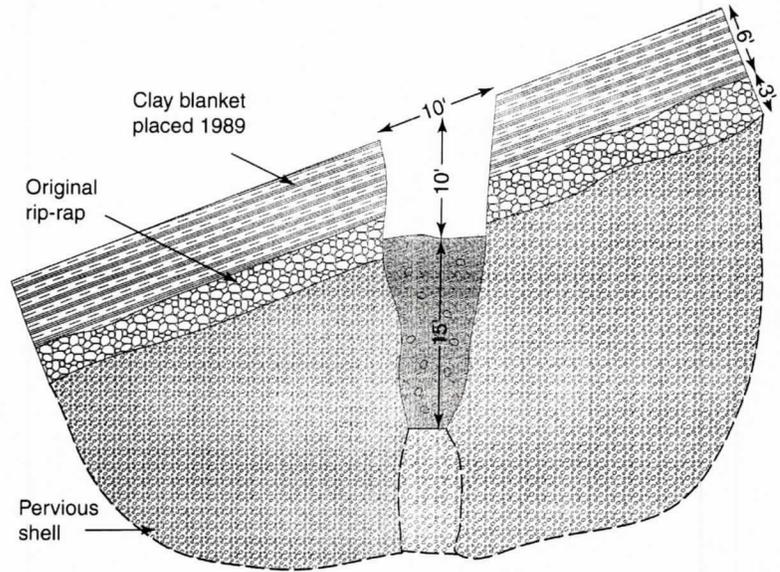


Figure 4. Material cross-section of sinkhole perpendicular to the axis of the dam. Dimensions and material classifications are based on findings of the excavation and backfill (figure from Hartung, 2003, USACE).

The current working theory suggests the clay blanket installed in 1989 has redirected the flow of lake rises and drops in/out of the pervious shell material. Instead of lateral flow out of the dam as it was

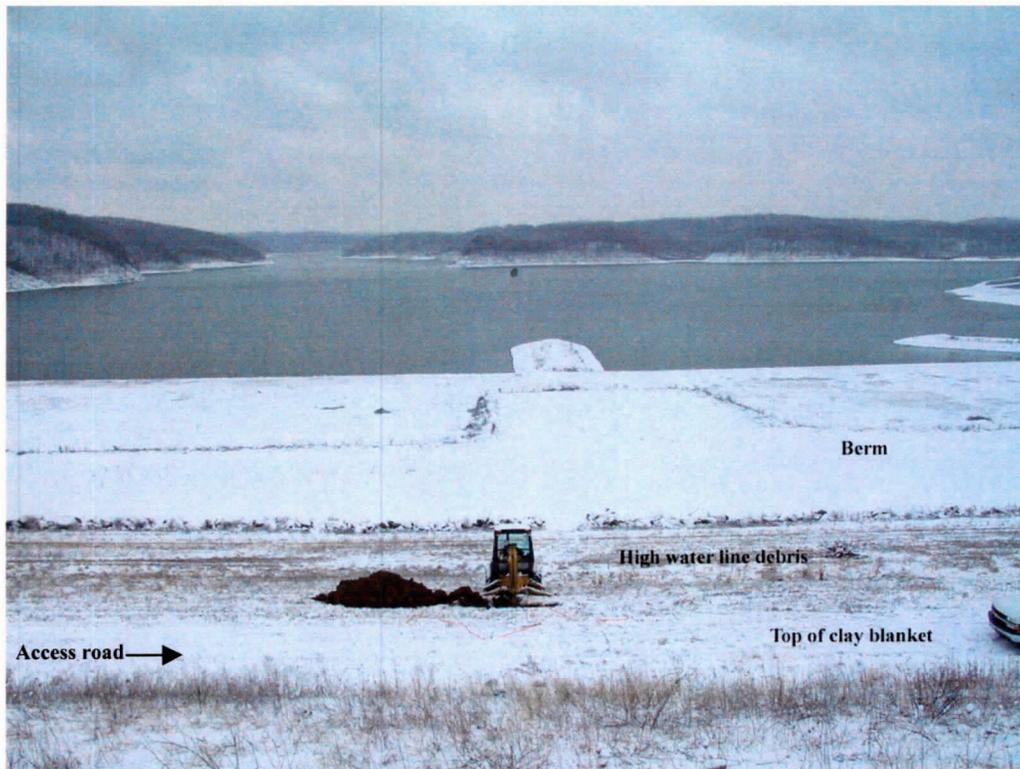


Figure 5. View looking northwest from crest of dam. Backhoe is process of excavating sinkhole during late January 2003.

prior to placement, the clay blanket and berm cause the movement through the underlying residual alluvium and possibility through the enlarged joints discovered and grouted shut during construction of the cutoff trench (Figure 2). It seems more than a coincidence the sinkhole formed directly between and within less than 50 ft of the only major bedrock enlarged joints mapped along the approximately 2400 ft expanse of this dam. The void responsible for the sinkhole likely formed during the massive lake draw down in the summer of 2002, but due to the strength of the clay blanket remained bridged until January of 2003.

### **Program Objectives**

Geophysics used during site characterization routinely involves relatively noisy measurements of earth properties, qualitatively incorporated into working subsurface models with ground truth provided by observational data sets (e.g., drilling, outcrop studies, etc.). Evaluation of dam and dike integrity and internal structures complicates and usually eliminates effective use of many geophysical tools due to layer geometries, conductive materials used during construction, utilities and operational workings, depth of investigations, and resolution requirements. Body wave seismic techniques have not been extensively used due to survey costs and resolution requirements. With equipment improvements and technique developments and the wealth of information contained in the entire seismic wavefield (body waves and surface waves), seismic measurement or imaging data are routinely underutilized (Steeple et al., 1995).

This applied research project will evaluate the applicability of several seismic techniques to identify, delineate, and estimate risk associated with physical characteristics or properties of materials within and beneath the Clearwater Dam. High-resolution seismic reflection will be studied to determine the feasibility of detecting subtle changes in the reflected wavelet—indicative of fractured bedrock—ultimately resulting in a series of closely spaced subsurface cells for use in detailed mapping of core and bedrock properties (Batzle et al., 1999; Berryman et al., 1999). Multichannel surface wave inversion techniques have proven capable of detecting anomalous shear wave velocity zones within and below fill materials (Miller et al., 1999). Surface tomography tests will rely on relatively straightforward travel time delay techniques that could provide a corroborative representation of the internal consistency in dam materials. Application of full wavefield techniques to the differential fill problems of this earthen dam will likely provide key insight into and an increased awareness of areas with failure potential.

### **Program Components**

#### ***Reflection***

A properly designed and executed high-resolution P-wave seismic reflection survey should be capable of mapping the bedrock and rock layers deeper and search for variations in seismic attributes that could be indicative of changes in the integrity of the impervious core or bedrock anomalies responsible for undesirable ground water movement. For this tool to be successful it will be essential that we concentrate on: 1) generating high resolution (>120 Hz P-wave) signals; 2) optimizing spread deployment and acquisition for 2-D imaging; 3) establishing the best equipment configurations and parameter settings to maximize signal-to-noise and resolution potential; 4) correlating P-wave reflections with S-wave imaged inverted from surface waves as well as with dam construction information and drill data; 5) insuring offset distributions appropriate for measuring the velocity from NMO curves and semblance analysis; 6) integrating well-established shallow high-resolution methodologies and conventional approaches; 7) tailoring processing flows to optimize the accuracy and spatial distribution of velocity analysis; 8) developing an extremely accurate velocity function correlated to depth models from dam construction records; and 9) mapping the 2½-D joint patterns identified during cut off trench construction. Proven high-resolution techniques will be used to design the data acquisition parameters and determine optimum equipment and methodologies (Steeple and Miller, 1990).

Maximizing the resolution potential, interpretability, and signal-to-noise ratio will be emphasized in the reflection surveys. Two CMP profiles (Mayne, 1962) will be acquired using two 120-channel fixed spreads designed to maintain the optimum recording window and image the subsurface

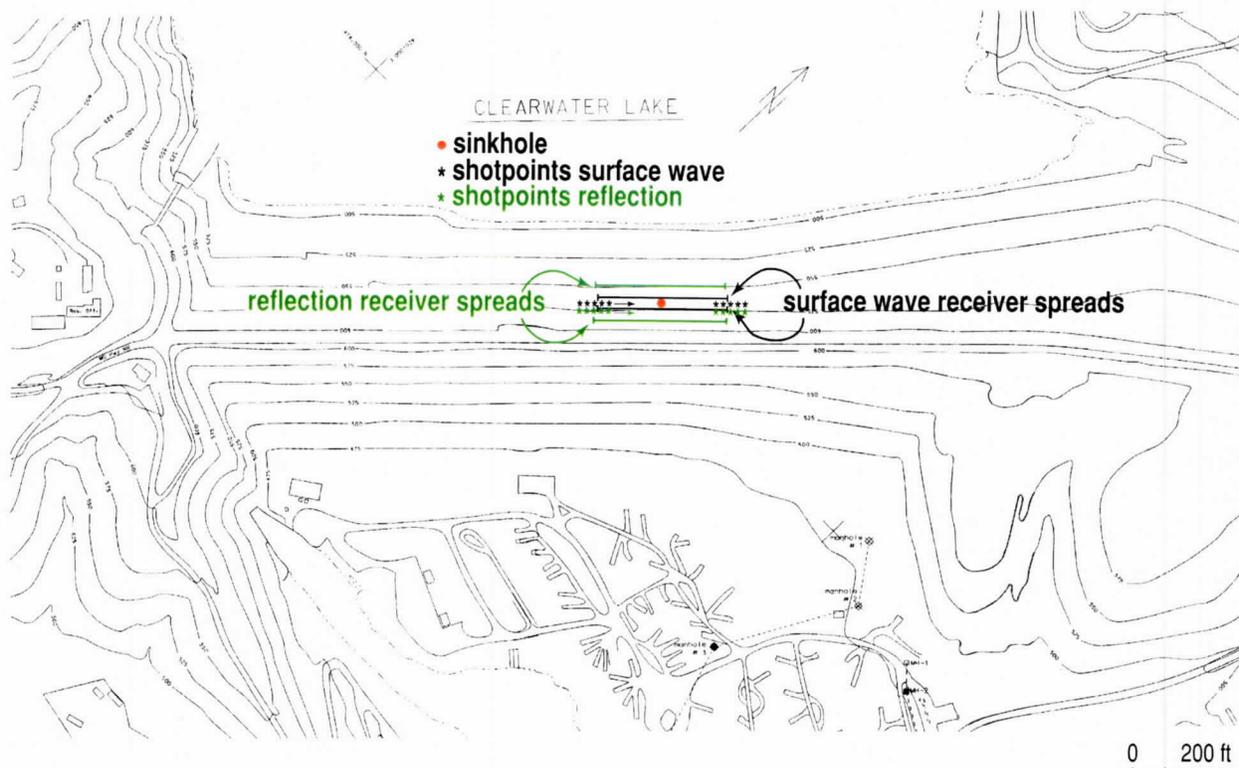


Figure 6. Site map with elevation contours, sinkhole, and planned locations of two seismic profiles (surface wave/tomography and high-resolution reflection).

parameters, spread geometry, shots/point, and acquisition philosophy used to acquire the CMP profile lines will be based on the results of walkaway noise tests. Data will be initially acquired and processed to delineate local irregularities in stratigraphy, structure, and material properties from bedrock down as deep as 250 ft using state-of-the-art high-resolution methodologies and equipment. Once all interpretable reflections are fully processed, they will be combined with surface wave, tomographic, and dam construction information to develop the most representative subsurface model possible.

Data acquisition and processing for the 2-D profile data will generally follow well-established shallow high-resolution data acquisition methodologies, emphasizing correlation with ground truth and optimized velocity control (Hunter et al., 1984; Knapp and Steeples, 1986; Steeples and Miller, 1990).

### ***Surface Wave Inversion***

Surface waves traditionally have been viewed as noise in multichannel seismic data collected to image targets for shallow engineering, environmental, and groundwater purposes (Steeples and Miller, 1990). Recent advances in the use of surface waves for near-surface imaging have combined spectral analysis techniques (SASW), developed for civil engineering applications (Nazarian et al., 1983), with multi-trace reflection technologies developed for near-surface (Schepers, 1975) and petroleum applications (Glover, 1959). The combination of these two uniquely different approaches to seismic imaging of the shallow subsurface permits non-invasive estimation of shear wave velocities and delineation of horizontal and vertical variations in near-surface material properties based on changes in these velocities (MASW) (Park et al., 1996; Xia et al., 1999; Park et al., 1999).

Extending this imaging technology to include lateral variations in lithology as well as void and fracture detection, bedrock mapping, and subsidence/karst delineation has required a unique approach that incorporates SASW, MASW, and CDP methods. By integrating these techniques, 2-D continuous shear wave velocity profiles of the subsurface can be generated (Figure 7). Estimating the dispersion curve from up to 60 closely spaced receiving channels calculated every 4 ft to 8 ft along the ground

surface enhances the signal and results in a unique, relatively continuous view of shallow subsurface shear wave velocities properties. This highly redundant surface wave method improves the accuracy of calculated shear wave velocities and minimizes the likelihood that irregularities resulting from erratic dispersion curves will corrupt the analysis.

Surface wave data will be acquired on two lines straddling the sinkhole as close as safely possible (Figure 6). Each profile will use the same spread geometry and permit correlation such that 2½-D volumetric representations of the shear wave velocity field can be produced.

With the unique requirements of surface wave measurements it will be necessary to use an accelerated weight drop source, low frequency receivers, and a fixed spread with end-on geometry. Shear wave velocity maps generated along each profile line will be optimized for resolution, using several unique approaches whose purpose is to minimize smearing resulting from variable wavelength averaging.

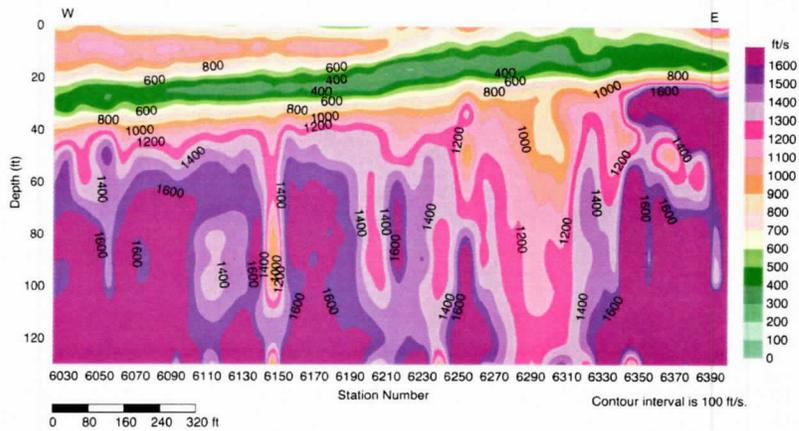


Figure 7. Shear-wave velocity contours at Alabama site.

**Refraction/Tomography**

Tomography has a variety of applications in the subsurface, including: waste repository characterization (Peterson et al., 1985), engineering studies (Cottin et al., 1986); void detection (Lytle and Dines, 1980); and in mining (Kilty and Lange, 1990). The simplicity of acquisition and computational intensity make it especially applicable for velocity estimation using data acquired for surface wave or refraction analysis. Using this approach in conjunction with multichannel surface wave inversion allows examination of anomalous features within the dam simultaneously with the mapping of compressional and shear wave velocity fields calculated from body and surface waves. Processing of data for tomographic analysis will use existing algorithms and standard methodologies such as algebraic reconstruction (Peterson et al., 1985), curved-ray (Chiu et al., 1986), and transformation (Lo et al., 1988).

Data acquired for use in multichannel surface wave analysis will also be suitable for turnray tomography analysis and the resulting designation of the compressional wave velocity field. Using the fixed spread deployment design along two parallel lines as suggested for surface wave analysis there should be offsets of sufficient length and spatial sampling for adequate sampling of the shallow subsurface. It is important that an appropriate number of rays pass through the sinkhole and surrounding undisturbed area to construct a subsurface model with sufficient redundancy to allow confident interpretations (Figure 8). To minimize the non-uniqueness of the inverted refraction arrival solutions coincident processing of surface waves and first arrivals will be the approach of choice (Ivanov, 2002). While the

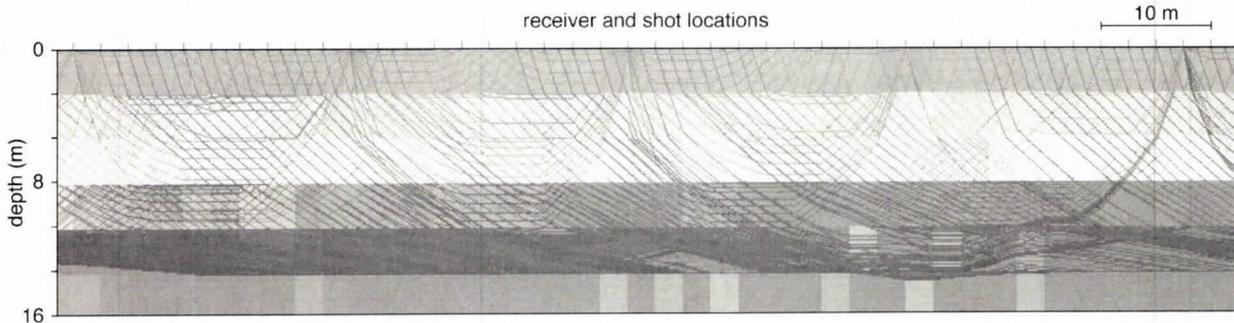


Figure 8. Ray tracings from a site in Arizona.

emphasis of this effort is on data collection and analysis, forward modeling will be necessary to insure a thorough understanding of the principal features of the seismograms.

### ***Uphole/VSP/Crosshole Tomography***

Surface-to-borehole and borehole-to-borehole data should be considered for developing a high-resolution 3-D image of the void geometry on future geophysical investigation. Once borings are placed into and around the subsidence feature, they can act to both confirm the surface seismic interpretations and provide the necessary access to the source area for remediation. Borehole seismic studies performed in these borings would be extremely useful in checking the accuracy of velocity field calculations and measurements obtained from the various seismic methods.

### **Previous Applications of Surface Wave Imaging**

Anomalous features at depths from 2 to 100 ft (tunnels, fractures, karst, pipes, subsidence) have been detected using surface wave analysis (Ivanov et al., 2000; Miller and Xia, 1998, 1999; Miller et al., 1999, 2000, 2002; Park et al., 1998; Xia et al., 2000).

- 1) Cross-border drug smuggling tunnels were detected by anomalous reflected and diffracted backscatter enhanced by processing at the tunnel locations (Figure 9).
- 2) Dissolution features (karst) beneath undisturbed alluvial overburden were detected on shear wave velocity profiles at a proposed power plant site in Alabama (Figure 7).
- 3) Subsidence features in western Florida were distinguished on 2-D shear-wave velocity data and confirmed by drilling, despite being obscured by houses and masked from other geophysical methods by power line noise, mechanical noise, and reinforced concrete (Figure 10).
- 4) A 6 ft deep steam tunnel was located and its general shape delineated using surface wave interference analysis (Figure 11).

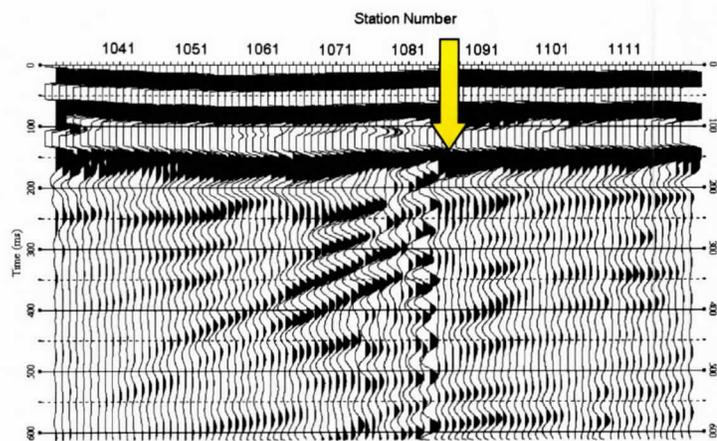


Figure 9. LMO stack with tunnel location indicated by arrow.

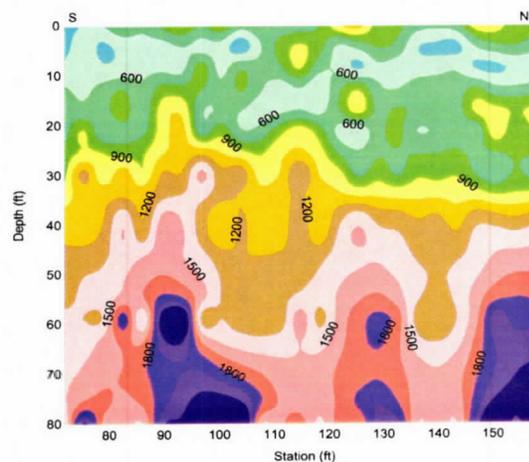


Figure 10. S-wave velocity contours at a site in Largo, Florida.

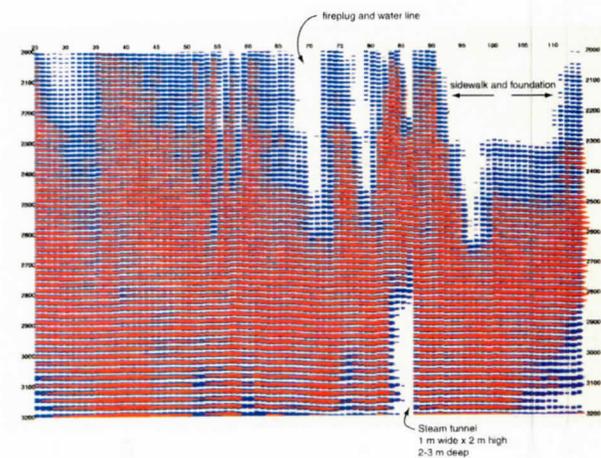


Figure 11. KGS tunnel test on the University of Kansas campus.

## Operations Plan

### *Experimental (Testing) Phase*

Experimentation will focus on a series of tests designed to evaluate a variety of acquisition methods and parameters. These experiments will mainly consist of walkaway noise tests, which involve recording data from a variety of sources into a fixed spread. These data will be recorded on a 24-bit, 240-channel Geometrics StrataView seismograph with a StrataVisor NZC controller and will likely take around half day to complete. The test spread needs to be located in an area with a uniform, relatively undisturbed subsurface, far enough away from the sinkhole to avoid disturbances in the recorded wavefield. Considering the estimated and confirmed locations of the joints and sinkhole, testing will best be accomplished right of the sinkhole (looking down stream) (Figure 6).

A walkaway spread will be deployed right of the sinkhole just down slope from the 575 end of the clay veneer. The testing will include data recorded from source-to-receiver offsets ranging from 8 ft to approximately 400 ft. The receiver interval for this testing will be 4 ft. The Rubberband Assisted Weight Drop (RAWD) and IVI Minivib high frequency vibrator will be tested to determine source characteristics for the near-surface conditions, target depth, resolution requirements, and environmental constraints (Figures 12a & 12b).

Data collected during the experimental phase of this survey will be reduced to the appropriate final display format on site. The final walkaway sections will be trace balanced and displayed in a variable-area wiggle trace format. Surface wave and tomography test data will be subject to overtone/dispersion analysis and inversion. Determination of source configuration and field parameters for the CMP production lines, inverted surface wave shear velocity profiles, and tomograms for each line will be based on analysis of all walkaway tests.



Figure 12a. Rubberband Assisted Weight Drop (RAWD).



Figure 12b. IVI minivib.

### *Production Acquisition*

Optimally, two sub-parallel profiles will be collected with both acquisition formats that straddle the sinkhole (Figure 6). This orientation will provide the optimum subsurface coverage for delineating the subsurface root or chimney of the sinkhole. Each technique will focus on a different portion of the subsurface. A pair of 120-channel lines separated by about 16 ft will be used to acquire the surface wave and tomography data and a pair of 120-channel lines separated by about 40 ft will make up the spread for the reflection survey. The two profiles will be approximately 400 ft long, each centered on the sinkhole and mapped joints. Based on previous experience, the IVI minivib will be the source of choice to acquire the reflection data and the RAWD will be best suited for the full wavefield (surface wave and tomographic) data acquisition.

Sources and receivers planned for this study are keenly suited for this environment and recording needs. The minivib, a non-invasive high frequency vibrator, will sub 3 psi ground pressure for minimum ground deformation and optimum mobility while providing over 4000 lbs of force at 200 Hz. The RAWD, on the other hand is a small, maneuverable, impulsive, non-invasive weight drop that delivers a

seismic pulse with a significant low frequency component to the wavefield. For the reflection survey a pair of 40 Hz geophones will be planted at each station and for the full wavefield data a single 4.5 Hz geophone will be planted at each receiver station. Receiver spacing will likely be 4 ft while source spacing best suited for the target will probably be 8 ft.

The production acquisition phase of this project will begin after the testing phase is completed and KGS and USACE are satisfied with the parameter design. The data should be acquired in four days or less. Acquisition equipment in general and source and receiver selection in particular will be a qualitative choice based on frequency, potential penetration depths, quantity of ground roll relative to body waves, and physical site and near-surface constraints.

### ***QA/QC***

The data acquired and processed on this survey will be managed to ensure the highest quality and most accurate acoustic representation of the geologic setting possible. Current state-of-the-art techniques will be used in a fashion that is appropriate and verified with step-by-step QA/QC. The most important (possibly even essential) information provided (besides the data images) will be samples of shot gathers after key intermediate processing steps. This information allows the geophysicist and geologist to make determinations as to the authenticity of processed seismic sections. Seismic processing software and techniques are very power tools that, if not used properly, can and most likely will result in unrealistic interpretations.

The equipment and recorded data will be continuously monitored during acquisition to ensure the highest quality sections. The response amplitude of receivers will be monitored using a modified tap test performed after the planting of each geophone or group of geophones. The continuity and leakage of each active station will be meter monitored prior to each shot. The system will be 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.

### **Production Processing Seismic Reflection**

High-resolution seismic reflection data, by its very nature, lends itself to over-processing, inappropriate processing, and minimal involvement processing. Interpretations of high-resolution shallow reflection data must take into consideration not only the geologic information available, but also each step of the processing flow and the presence of reflection events on raw unprocessed data. Processing for the reflection portion of this study will include only operations or processes that enhance signal-to-noise-ratio and/or resolution as determined by evaluation of high confidence reflections interpreted directly on shot gathers (Figure 13). For the most part, processing of high resolution shallow reflection data is a matter of scaling down conventional processing techniques and methods; however, without extreme attention to details, conventional processing approaches will produce undesirable artifacts. In-field processing of the reflection data will result in a brute stack used to insure the data acquired are of sufficient quality to provide meaningful interpretations and to permit the merging of the different modes when final processing is completed several months after leaving the field. In-field processing will be coincident with data acquisition and will not impact the full day field schedules.

The basic architecture and sequence of processing steps to be followed during the generation of the final stacked sections will be similar to conventional petroleum exploration flows (Yilmaz, 1987). The primary exceptions relate to the step-by-step QC necessary for the highest confidence interpretations of shallow features and realization of full resolution potential (Miller et al., 1989; Miller et al., 1990; Miller and Steeples, 1991) (Figure 13). Specific 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 one-quarter wavelength of the dominant reflection energy with large correlation windows, and coincident iterative velocity and statics analysis.

Each analysis step in the processing flow will be available for critique. Any additional information requested during the processing flow will be generated within a reasonable amount of time (amount of time determined jointly). All digital information will be delivered on the requested magnetic media (if readily available). All hardcopy displays of analysis steps as well as any specially requested data displays will be delivered on 300 dpi plots. Horizontal and vertical scale on hardcopy displays will be set to maximize the analysis potential of these and existing data.

### Production Processing Surface Wave

Processing of surface wave data will involve only the optimum 30 or so traces from each shot that provide the most accurate results after MASW processing. These 30-trace gathers will be analyzed with SurfSeis (a proprietary software package from the Kansas Geological Survey that facilitates use of MASW for continuous profiling). Each shot gather will generate one dispersion curve and will be assigned a surface location corresponding to the middle point of the spread being analyzed. Care will be taken to insure that the spectral properties of the t-x data (shot gathers) are consistent with the maximum and minimum  $f-v_c$  values ( $v_c$  is the phase velocity of surface waves) contained in the dispersion curve. Shear-wave velocity maps generated along each profile line will be optimized for resolution using several approaches whose purpose is to maximize resolution and accuracy. Wavefield maps will be generated based on optimized source offset for depths of interest.

To increase the signal-to-noise ratio and to improve convergence during inversion, a new technique called Filtering of Dispersive Seismic Event (FDSE) will be used to suppress higher modes on some shot records (Park et al., 2002). This method removes higher modes through filtering in the frequency domain and avoids the detrimental artifacts that are observed in dispersion analysis if higher modes are removed using time-domain muting. Because SurfSeis was designed to invert fundamental mode Rayleigh wave energy only, inclusion of higher mode or body wave energy can inhibit convergence.

Two-dimensional  $V_s$  cross-sections obtained from MASW analysis will be used to generate an initial inversion model for the tomographic inversion to  $V_p$  (Ivanov et al., 2000). The initial model will be iteratively optimized until the first arrivals predicted from modeling correlate with the actual shot records. Several inversion runs will be necessary using the initial model to converge on conditioning parameters appropriate for this data set.

Considering the resolution requirements and redundancy in rays penetrating each subsurface cell within the depth interval of interest, it will be essential that first arrivals be picked for all traces on every shot gather. Ray tracing clearly demonstrates the effect the proposed sampling distribution within the

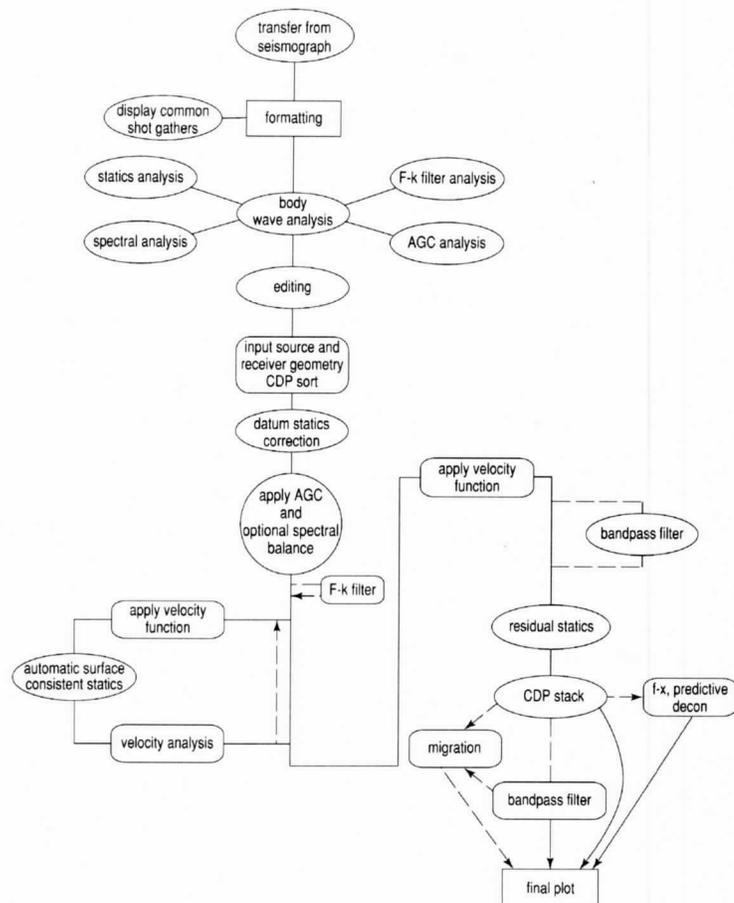


Figure 13. Processing flow.

volume will have on the final velocity profile (Figure 8). Frequency variable linear moveout and common receiver stacking will be evaluated to determine the method's sensitivity to scattered or reflected surface waves.

The final inversion results will be used as a quality control for first arrival picking by analyzing the correlations between the model and observed data. In some instances, secondary first arrival analysis will be necessary to converge on a "good" solution. Additional quality control will be achieved by verifying that the 2-D  $V_p/V_s$  data are reasonable.

### **Geologic Interpretation**

Geological interpretations will, for the most part, be consistent with well-established concepts and practices with particular emphasis being placed on velocity analysis, layer resolution, and reasonable geologic inferences. Based on the proposed acquisition and processing plan it should be possible to coincidentally interpret both seismic profiles, dam construction data, excavation logs, and corehole data in such a way as to produce a pseudo 2½-D section of the subsurface at this site. It is possible that the 3-D expression of the sinkhole within the dam as well as the presence and correlation of the sinkhole to the known enlarged joints on the bedrock surface maybe interpretable from the combined data set.

It will be the intent of this survey to provide a volumetric interpretation of the subsurface materials, loosely correlating major any disturbance in otherwise uniform materials as associated with the subsidence process. Extrapolation of current known sinkhole volume (via excavation) beyond the survey lines will depend on degree and apparent consistency of interpreted features on seismic profiles.

### **Overall Project Goal**

The goal of this study is to determine the feasibility of imaging and resolving material, structural, and stratigraphic characteristics of the subsidence feature at Clearwater Lake Dam. High-resolution seismic reflection and full-wavefield seismic studies will target key area within and below this earthen dam, focusing on bedrock and the rocks below as well as search for anomalies that may be present within the impervious core. Surface wave and first arrival analysis will attempt to image fill material composing the upstream cover of the impervious dam core above bedrock in sufficient detail to assist in the development of 3-D model showing the disturbed fill relative to intact or undisturbed dam materials. Ideally, these two geophysical tools in association with dam construction details and boring data will allow the construction of a detailed model of the sinkhole and associated effected materials below what can be seen on the surface of the dam.

### **Deliverables**

Products of this feasibility study will be delivered to USACE at various times throughout the operations schedule. These products include:

- Site safety plan
- Raw data in SEG2 format
- Field processed  $V_s$  profiles for surface wave lines
- Field processed  $V_p$  profiles for surface wave lines
- Field processed reflection sections for reflection lines
- Preliminary report assimilated after return to KGS facility in Lawrence, Kansas
  - Field layout and testing
  - Data acquisition procedures and data samples
  - Processing procedures and data samples
  - Interpretation of all processed data
  - Supporting data and discussions of results
  - Recommendations and conclusions

All deliverables will be consistent with the included schedule or a revised scheduled based on agreement by both KGS and USACE.

**Summary of Equipment, Specific Tests, and Timeline of Proposed Program**

1) Seismic system – Geometrics 240-channel R60 StrataView with StrataVisor controller

2) Equipment available for testing and parameters selections

- single 4.5 Hz GS-11 Geospace geophones
- double 40 Hz L-28E Mark Products geophones
- RAWD (Rubberband Assisted Weight Drop) P-Wave
- IVI Buggy mount high frequency vibrator (15 to 500 Hz, 6500 lb peak force)

Testing will include:

- establishing source characteristics
- various source configurations
- geophone response and sensitivity
- number of shots to obtain optimum vertical stacking
- optimum receiver station spacing
- source power and offset
- pseudo-continuous walkaway with source offsets from 8 ft to 400 ft
- digital filtering

3) Likely optimal design for surface seismic surveys:

- a) **Reflection—P-wave:** Vibrator (3 sweeps/station) 240 recording channels, 40 Hz geophones, 4 ft receiver spacing, 8 ft source spacing, and rolling fixed spread.
- b) **Surface Wave—S-wave & Tomography—P-wave :** RAWD (3 impacts/station), 240 recording channels, 4.5 Hz geophones, 4 ft receiver spacing, 8 ft source spacing, and an end-on rolling spread. At least two lines will be acquired centered on the

4) Planned Operations Schedule

	<u>Approx. Duration</u>
Mobilization/Demobilization	1 weeks
Travel, 1 roundtrip	2 days
Walkaway noise testing	½ day
2½-D optimized grid, data acquisition (surface waves)	1 day
2½-D optimized profiles, data acquisition (reflections)	1 day
Preliminary processing of 2½-D data and briefing	10 days
Preliminary report	1 month
Reporting and final processing	2 months

5) Deliverables Schedule:

- Site Safety Plan—first day on-site.
- Raw field data: SEG2 format—last day on-site.
- Test data analysis and basis for field design—1 week after return from field.
- Preliminary processed  $V_p$ ,  $V_s$ , and CMP profiles for individual 10 days after acquisition completed in field.
- Preliminary Report (including all data and analysis)—1 month after return from fieldwork.
- Final Report—after review and comment by USACE.

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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 USACE as well as those included in this document.

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

1. In the event of electrical storms in the vicinity, all surface operations will cease if lightning strikes are closer than three miles (determined by 15 second count between lightning and thunder).
2. If conditions become excessive (i.e., temperature  $> 100^{\circ} < 30^{\circ}$  F), continuous day operations will be modified to minimize chances for heat- or cold-related medical problems. Breaks of up to one hour every hour might be necessary in extreme situations. Maximum hydration of staff will be strived for at all times.
3. Appropriate field boots will be worn and due caution will be exercised with respect to snakes, ditches, swampy areas, and ground debris. Steel toes will be worn by all field crew members.
4. Safety glasses will be worn by crew members when operating vehicles or sources.
5. At least one gallon of fresh water will be on hand at the beginning of each day for each crew member. An ice chest for keeping food stuff cold and an ice chest for medical use in case of injury or overheating will be available on-site.
6. In the case of excessive cold weather, a sheltered area will be available with inside temperatures above  $32^{\circ}$  F.
7. The seismic crew will operate with an established protocol for initiating seismic sources. The safety plan will be approved by the USACE Representative prior to initiation of field operations.
8. Appropriate drivers licenses will be held by operators of vehicles at all times (KDOT regulations).
9. All explosive or flammable materials will be properly stored and labeled in accordance with KDOT regulations during transport.
10. High pressure systems will be identified and will be maintained to meet or exceed manufacturer's specifications.

**IV. SAFETY PERSONNEL**

**Safety Personnel and Emergency Contacts**

1. Rick Miller (KGS)—Site Safety Officer
2. David Laflen (KGS)—Operations
3. Steve Hartung (USACE)—Delegated Representatives and Site Supervisor









**V. EMERGENCY INFORMATION**

Missouri State Highway Patrol	<u>1-800-525-5555</u>
Wayne County Sheriff	<u>(573) 224-3090</u>
Emergency Medical–Ambulance	<u>(573) 223-4111</u>
Clearwater Fire Department:	<u>(573) 223-4222</u>
Lodging—Spring Valley Resort:	<u>(573) 223-4440</u>

**USACE Emergency Contacts**

Little Rock District, U.S. Army Corps of Engineers  
700 West Capitol  
Little Rock, Arkansas  
Ph. (501) 324-5055

Clearwater Office  
Ph. (573) 223-7777

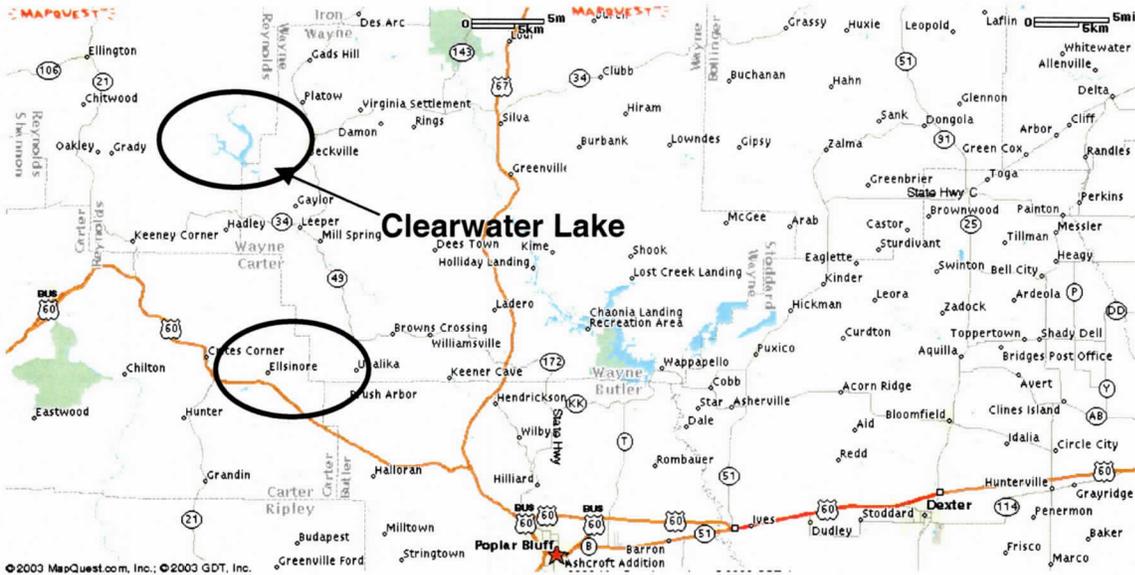
**KGS Emergency Contacts**

Safety Coordinator and Project Manager  
Rick Miller, Kansas Geological Survey  
Cellular (in the field): 785-766-8638

KGS Safety Officer  
Kathy Sheldon, Kansas Geological Survey  
Office: 785-864-2109

## Emergency Routes

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



Coming from the East on Hwy 60, approximately 8-10 miles from Elsinore (circled on upper map), look for right hand turn only onto Hwy 34, there will be signage for Clearwater Lake.

Approximately 6 miles later is a left turn only onto Hwy HH, then about a mile turn right at the intersection with Hwy HH?? This will take you across the dam and Spring Valley Resort is downstream about 2 miles on the left.

Spring Valley Resort (573-223-4440) is located on the right side of the highway going to dam from the local town of Piedmont.

**Procedures**

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

Several members of the KGS crew have certification in CPR/First Aid through 2/6/01. This certification was received through participation in the "Standard First Aid" and "CPR for the Professional Rescuer" programs presented by the Red Cross of Lawrence, Kansas. These classes are approved by the U.S. Department of Labor, Mine Safety, and Health Administration and meet or exceed OSHA requirements. OSHA certifications are provided by EPIC Training and meet or exceed 29 CFR 1910.120.

The following persons are certified as indicated (strikethrough denotes no certification):

Certified in:	First Aid	CPR	40hr OSHA	<u>Rick Miller</u>
Certified in:	First Aid	CPR	40hr OSHA	<u>David Laflen</u>
Certified in:	First Aid	CPR	40hr OSHA	<u>Joe Anderson</u>

Fire/Explosion: Upon notification of a fire or accidental explosion on site, the fire department or appropriate first responders shall be notified and all personnel shall leave the area. Since only Class "C" shotgun ammunition will be used as part of the program, local fire, police, and other governing authorities will not be contacted prior to the use of such devices on-site. On-site USACE demolitions personnel will manage and respond to any situation. If Class "A" explosives were used, prior consultation and contact would be made with the appropriate emergency response groups.

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

Permits: All necessary and appropriate permits, fees, and licenses will be obtained by USACE, with copies available on-site for inspection by local authorities.

## **VI. TASK SPECIFIC HAZARDS**

The purpose of the geophysical investigation is to acquire seismic data that can be used to extract key physical properties of the near surface.

### **Sledgehammer**

The sledgehammer is a well understood and available source of acoustic energy. The sledgehammer will be used with a hard-wire time break and will be operated by physically capable KGS staff members. An area twice the length of the hammer handle will be cleared prior to use. The hammer will be 1) raised above the operator's head using a two-hand grip, 2) accelerated with full arm extension toward the ground, 3) contact striker plate with hammer, and 4) lifted into split two-hand carry grip. Activities such as changing broken handles and attaching new hammer switches should only be done by experienced KGS staff. A minimum clear area directly in front of the operator of at least 25 ft must be maintained in case operator loses grip on hammer or hammer head breaks free from the handle. Gloves, safety glasses, steel toed boots, and hearing protection are required for operating this source.

### **Weight Drop**

The accelerated weight drop is a high energy, hydraulically operated source. All moving parts are shielded and designed to minimize risk of injury to operator and bystanders. By its very nature the weight drop represents a hearing danger. The source is powered by a standard commercial skid-steer loader. A single operator runs the device from inside a protective cage. Operation simply requires 1) the base plate to be placed on the ground and loader/weight drop weight applied for hold down, 2) idle at low rpm and initiate the hydraulic valve (foot control in operator cage), 3) weight is raised against resistive force (rubberband), 4) dropped once maximum pre-set height is reached, and 5) source is hydraulically lifted and carried to next shot point by tracked loader. The source is sufficiently shielded that only in a very unusual situation will pieces of the source come free from the source and represent a threat to safety. By maintaining a minimum 30 ft for hearing safety, the danger of fragments is all but eliminated.

### **IVI Minivib**

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

### **Control Measures**

- 1) This vehicle is center articulating and requires care when turning that no one is within 20 ft of the vehicle.
- 2) Safe operation of the vehicle is documented in the operator's manual provided by the manufacturer.
- 3) Hearing protection is required within 50 ft of the vehicle.
- 4) All shields are to remain in place while the vehicle is in operation

- 5) Hydraulic pressures of more than 1500 psi are routine during operation. No maintenance or service will take place while vehicle engine is running.
- 6) Quick inspection is necessary prior to lowering the pad.

**General**

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

The field investigations will involve project personnel performing geophysical surveys of the study area utilizing the aforementioned explosive, impacting, and vibratory seismic sources. The principal hazards associated with the use of sources mentioned here consist of handling or moving the equipment, improper use, fragments from high velocity impacts, and high sound levels.

## **VII. ALCOHOL AND DRUG POLICY**

The University of Kansas (of which the KGS is a part) is a drug and alcohol free workplace with stringent controls and penalties associated with the use and distribution of controlled substances and alcohol in the workplace regardless of whether it is at a remote field location or on campus. The University of Kansas and Kansas Geological Survey consider alcohol and drug use (non-doctor prescribed) while "on-duty" a health and safety risk. The following section details the University and Survey policy as it relates to drug and alcohol abuse and misuse, enforcement of policies, and penalties for violating those policies.

### **Policy on Prevention of Illegal Drug and Alcohol Use on Campus and in the Workplace**

The University of Kansas prohibits the unlawful possession, use, manufacture, or distribution of alcohol or drugs by students and employees on its property or as part of its activities. The University is committed to a program to prevent the illegal use of drugs and alcohol by students and employees. Any student or employee found to be using, possessing, manufacturing, or distributing controlled substances or alcohol in violation of the law on University property or at University events shall be subject to disciplinary action in accordance with applicable policies of the State of Kansas, the Board of Regents, and the University of Kansas. For employees, the University will take appropriate personnel action for such infractions, up to and including termination. Students who violate this policy will be subject to sanctions which include suspension and expulsion from the University.

As a condition of employment, all employees of the University of Kansas shall abide by the terms of this policy statement and will notify the University of any criminal drug statute conviction for a violation occurring in the workplace no later than five days after such conviction. The University will, in turn, notify as appropriate, the applicable federal agency of the conviction within ten days of receipt of notification of the conviction. The University will initiate personnel action, up to and including termination, within thirty days of receiving notice of such conviction. Employees may also be required to satisfactorily participate, at their own expense, in a drug abuse assistance or rehabilitation program before being allowed to return to work. For purposes of this policy, "conviction" means a finding of guilt (including a plea of nolo contendere) or imposition of sentence, or both, by any judicial body charged with the responsibility to determine violations of the federal or state criminal drug statutes.

### **Kansas Law**

Students and employees are reminded that illegal possession or use of drugs or alcohol may also subject individuals to criminal prosecution. The University will refer violations or proscribed conduct to appropriate authorities for prosecution. Kansas law provides that any person who violates the criminal statutes on controlled substances by possessing, offering for sale, distributing, or manufacturing opiates and narcotics, such as cocaine and heroin, shall be guilty of a drug severity Level 3 felony. For a conviction of such a felony, the court may sentence a person to a term of imprisonment in accordance with the Kansas Sentencing Guidelines Act and a fine of up to \$300,000. Unlawful possession of a depressant, stimulant or hallucinogenic drug is punishable as a Class A nonperson misdemeanor, with a penalty of imprisonment and a fine of \$2,500. Depressants include barbiturates, Valium, and barbital. Hallucinogens include LSD, marijuana, and psilocybin. State law classifies amphetamines and methamphetamines as stimulants. Kansas statutes also provide for criminal penalties for conviction of certain alcohol-related offenses. These penalties include imprisonment of up to six months and fines of up to \$1,000.

### **Federal Law**

The Federal Controlled Substances Act provides penalties of up to life imprisonment and fines up to \$4,000 for intentional unlawful distribution or possession with intent to distribute controlled substances. For unlawful possession of a controlled substance, a person is subject to up to twenty years of imprisonment and fines up to \$5,000. Any person who unlawfully distributes a controlled substance to a person under twenty-one years of age or who distributes a controlled substance on or within 1,000 feet of the University may be punished by up to twice the term of imprisonment and fine otherwise authorized by law.

### **Health Risks**

Accidents and injuries are more likely to occur if alcohol and drugs are used on University property or as part of University activities. Every year in the United States, over 200,000 people are treated in hospitals for drug-related accidents and mental and physical illness; another 25,000 die every year from drug-related accidents or health problems. Drug users can lose resistance to disease and destroy their health. Drug tolerance and psychological dependence can develop after sustained use of drugs. More specifically, physical dependency, heart problems, infections, malnutrition, and death may result from continued high doses of amphetamines. Chronic use of narcotics can cause lung damage, convulsions, respiratory paralysis and death. Depressants such as tranquilizers and alcohol can produce slowed reactions, a slowed heart rate, damage to liver and heart, respiratory arrest, convulsions, and accidental overdoses, because the abuser is unaware of how much the drug or alcohol has been taken. Use of hallucinogens may cause psychosis, convulsions, coma, and psychological dependency.

Alcoholism is the number one drug problem in the United States. Alcoholism takes a toll on personal lives by affecting finances, health, social relationships, and families. It can have significant legal consequences. Abuse of alcohol or use of drugs may cause an individual driving a motor vehicle to injure others and may subject the abuser to criminal prosecution. Drunk drivers are responsible for more than half of all traffic fatalities.

### **Counseling & Treatment Resources**

At the University of Kansas, alcohol and drug counseling and treatment are available to students at the University Counseling and Psychological Services, Watkins Health Center, and the Psychological Clinic. The Student Assistance Center and the University Information Center are excellent sources for information about University and community resources for counseling and treatment. The Health Education Department of Watkins Health Center can provide further information about health problems and treatment related to alcohol and drug problems.

University employees may contact the Counseling and Psychological Services and the Psychological Clinic for counseling and treatment. Faculty and staff members may also contact the State LIFeline, a 24-hour toll-free assistance line (1-800-284-7575) for a referral. If referred through the LIFeline program, the first counseling session is paid by the State. Please refer to page 63 for additional resources.

### **Definitions**

The term "controlled substance" as used in this policy means those substances included in Schedules I through V as defined by Section 812 of Title 21 of the United States Code and as further defined by the Code of Federal Regulations, 21 C.F.R. 1300.11 through 1300.15. The

term does not include the use of a controlled substance pursuant to a valid prescription or other uses authorized by law.

The term "alcohol" as used in this policy means any product of distillation or a fermented liquid which is intended for human consumption and which is more than 3.2% alcohol by weight as defined in Chapter 41 of the Kansas statutes.

### **Policy on Substance Abuse**

The University recognizes that problems related to the abuse of substances such as alcohol and drugs may be resolved through cooperation between the employer and the affected employee. The policy set forth here for handling substance-abuse problems is intended to enhance cooperation and to protect both the individual and the University.

The University has a right to expect that employees will perform their jobs appropriately and to insist that job-performance standards be met. The University may properly intervene only when impairment affects job performance.

- These problems are defined as those in which an employee's use of alcohol or drugs has become part of a pattern of deteriorating job performance.
- This policy does not supersede any regulations or standard administrative practices applicable to job performance requirements.
- It is the employee's right and responsibility to seek professional assistance for a substance-abuse problem.
- All employees, especially department chairpersons and supervisors, should work to engender an enlightened attitude toward and a realistic recognition of the nature of substance abuse and to encourage employees to take advantage of available treatments whenever needed.
- Responsibility for implementing this policy rests with all department chairpersons and supervisory personnel. Procedures must be followed to assure that no employee with a substance-abuse problem will have his or her job security or promotional opportunities jeopardized by a request for diagnosis and treatment.
- A chairperson or supervisor may wish to consult with a professional in the treatment of substance-abuse *WITHOUT IDENTIFYING THE CONCERNED EMPLOYEE* before attempting intervention with the employee.
- Before attempting intervention, a supervisor of classified staff should discuss with his or her own supervisor and the Department of Human Resources the rules and requirements protecting the rights of the person believed to be suffering from alcoholism or drug abuse.
- Departmental chairpersons and supervisors should not attempt diagnosis. When an employee's job performance is deteriorating and there is reason to suspect that the source may be the use of alcohol or drugs, the chairperson or supervisor will meet informally with the employee, make an appropriate referral to a professional agency and encourage him or her to seek help for the problem. At this meeting, a date will be set by which improvement in job performance will be assessed.
- The employee is responsible for complying with the referral for diagnosis and for cooperating in any prescribed treatment. He or she should be assured that the referral agency will treat all discussions with strict confidentiality. (Most agencies will, with the consent of their client, report to a supervisor that the client has followed up on a referral.)

- Between the time of the meeting and the date set for assessing improvement in job performance, the chairperson or supervisor will continue to monitor the performance but will in all other respects leave the initiative for further discussions to the employee.
- If, by the date set at the first meeting, the employee's job performance has improved to an acceptable level, no further official action is required.
- The University expects that employees with a possible problem of substance abuse, even in its early stages, will be encouraged to seek diagnosis and treatment. The employee should be assured that seeking help will not interfere with job status, promotional opportunities or other privileges.
- If the job performance remains below accepted standards and the employee has refused to accept diagnosis and treatment, or has failed to respond to treatment, the chairperson or supervisor should suggest that he or she use one of the options available to any employee with an illness that interferes with job performance:
  - a. Being placed on sick leave. This option is for those with accrued leave. It would allow the employee to enter an inpatient treatment center and adopt a treatment program. Under this option, a written plan should be developed between the staff member and the University and properly executed by the chairperson or supervisor in consultation with Human Resources. The plan will spell out specifically the terms of the employee's return to his or her duties at the end of treatment (e.g., how the University is to be informed of the progress made in treatment and the appropriateness of a return to duty and how job performance is to be assessed).
  - b. Being granted a leave of absence without pay for up to twelve months. This option is for classified employees, upon approval of the Department of Human Resources.
  - c. Taking early retirement. This option is for those otherwise eligible. It is, of course, a drastic solution for both the individual and the University.
  - d. Resigning. If a classified employee can make no progress, recommendations to demote or dismiss are to be submitted to the Department of Human Resources for review and action.

Information revealed by the employee while receiving professional services will remain confidential and separate from University employee records. All record-keeping and access procedures will meet the federal regulations governing the confidentiality of patient records and the state law protecting treatment records.

**VIII. ACTIVITY HAZARD ANALYSIS**

**A. Work Item: Traffic Control**

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

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

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

**B. Work Item: Accelerated Weight Drop**



The accelerated weight drop (AWD) generates acoustic energy by accelerating a 50 to 100 lb weight through a 2 ft stroke impacting an 18 in diameter steel plate held to the ground surface by the weight of a skid-steer style loader. The weight is accelerated within an enclosed steel guide. The drive mechanism consists of a hydraulic motor turning a set of sprockets that deliver power to a cycling lift arm that pulls the weight against the resisting force of an industrial rubber band. Simply

envisioned, this device is analogous to a sling-shot. All moving parts are shielded, with the contact area between the weight and plate sufficiently enclosed to avoid and possibility of debris becoming airborne and representing a risk to the operator or bystanders.

Control Measures

- 1) The operator wears hearing protection (30 dB down) while the loader is running.
- 2) No bystanders can be within 30 ft of the device while it is in operation and within 50 ft without hearing protection.
- 3) All shields are to remain in place while in operation. Routine maintenance, requiring removing shields, can take place only when the loader engine is off.
- 4) The operator can exit the vehicle only when the weight drop is in the full down position and solid contact is made with the ground surface.
- 5) Operation of the loader will be consistent with those published in the owner manual of the Case 1225 UniLoader.

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

ATVs that could be on site include the 4x6 John Deere Gator and three Polaris 4x6s. These ATVs all serve a very specific purpose and are critical to smooth and efficient operations. The ATVs never obtain speeds in excess of 15 mph and therefore do not



represent risk of injury due to excessive speeds. The tip-over potential is minimized by the 6-wheel design of the vehicles, but tip-over potential does exist. Care is always taken to properly load the vehicles and only traverse grades within the acceptable limits of the vehicle as defined by the manufacturer.

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

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

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

#### Safety Specifics:

Every ATV operator shall possess a valid state drivers license and shall have completed an ATV training course prior to operation of the vehicle.

The manufacturer’s recommended payload shall not be exceeded at any time.

Gloves and an approved motorcycle helmet with full face shield or goggles shall be worn at all times while operating an ATV.

ATVs are to be used off-road only (no paved road use).

ATVs shall be driven during daylight hours only.

Only ATVs with four or more wheels are permitted to be used.

Passengers are prohibited on ATVs.

All ATVs shall be equipped with a warning signal device (horn).

**D. Work Item: Slide Hammer and Sledgehammers**

Specific Hazards—Uncontrolled swing and fragmenting of hammer or plate.

Control Measures—Only experienced operators, power hammer into ground at a controllable level, no bystanders within the distance of two hammer handle lengths side-to-side and behind and 25 ft in front.



**IX. TRAINING**

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

**X. PERSONAL PROTECTIVE EQUIPMENT**

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

Based on the available information assessing the current condition of the sites, minimal skin protection is required for general access. The prescribed working uniform for all personnel engaged in activities related to the project is a modified EPA level D and shall consist of:

- Long-sleeved shirts and full-length pants
- Leather steel toed safety boots

Hard hat\* (only necessary for certain operations)  
Eye protection  
Hearing protection as required by OSHA for certain tasks (identified by work item)  
Orange vests along roadways (unlikely necessary for this project)

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

Added protection from the sun and insects might be necessary. All workers will be encouraged, but not required, to use sunscreen and insect repellent. These protective chemicals will be available for use on-site.

## **XI. SAFETY ANALYSIS**

The analysis list on the following two pages postulate hazards, consequences of those hazards, and the means of prevention or mitigation of each hazard associated with this survey activity.

## **XII. ENVIRONMENTAL IMPACT ANALYSIS**

The environmental impact of this activity has been evaluated and determined minimal ("small footprint") at more than six U.S. Government facilities (Y-12 ORNL, Oak Ridge, TN; WAG-10, ORNL, Oak Ridge, TN; Paducah Gaseous Diffusion Plant, Paducah, KY; Nevada Test Site, Las Vegas, NV; Fort Ord, CA; Berkeley Nat'l Lab, Berkeley, CA; INEL, Idaho Falls, ID) as well as multiple BLM and DOD sites.

## **XIII. 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*

\*When operating sledgehammer, slide hammer, 30.06 projectile, and auger gun.

SAFETY ANALYSIS

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

<u>Potential Hazard</u>	<u>Consequences</u>	<u>Mitigation/Prevention Mechanism</u>
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.
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.

**Kansas Geological Survey  
Incident Report Form**

Date of incident: \_\_\_\_\_

Location of incident: \_\_\_\_\_

Was anyone injured? Yes  No  If yes, name(s) of injured person(s):  
\_\_\_\_\_  
\_\_\_\_\_

Uninjured person(s) involved in incident: \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

Other witnesses (not involved): \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

Equipment involved in incident: \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

Narrative of what happened (continue on reverse of this page and draw a diagram if it helps explain what happened):  
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\_\_\_\_\_  
Site Safety Officer

**Kansas Geological Survey  
Incident Report Form**

Date of incident: \_\_\_\_\_

Location of incident: \_\_\_\_\_

Was anyone injured? Yes  No  If yes, name(s) of injured person(s):  
\_\_\_\_\_  
\_\_\_\_\_

Uninjured person(s) involved in incident: \_\_\_\_\_  
\_\_\_\_\_  
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Other witnesses (not involved): \_\_\_\_\_  
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Equipment involved in incident: \_\_\_\_\_  
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Narrative of what happened (continue on reverse of this page and draw a diagram if it helps explain what happened):  
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\_\_\_\_\_  
Site Safety Officer

**Kansas Geological Survey  
Incident Report Form**

Date of incident: \_\_\_\_\_

Location of incident: \_\_\_\_\_

Was anyone injured? Yes  No  If yes, name(s) of injured person(s):

\_\_\_\_\_  
\_\_\_\_\_

Uninjured person(s) involved in incident: \_\_\_\_\_

\_\_\_\_\_  
\_\_\_\_\_

Other witnesses (not involved): \_\_\_\_\_

\_\_\_\_\_  
\_\_\_\_\_

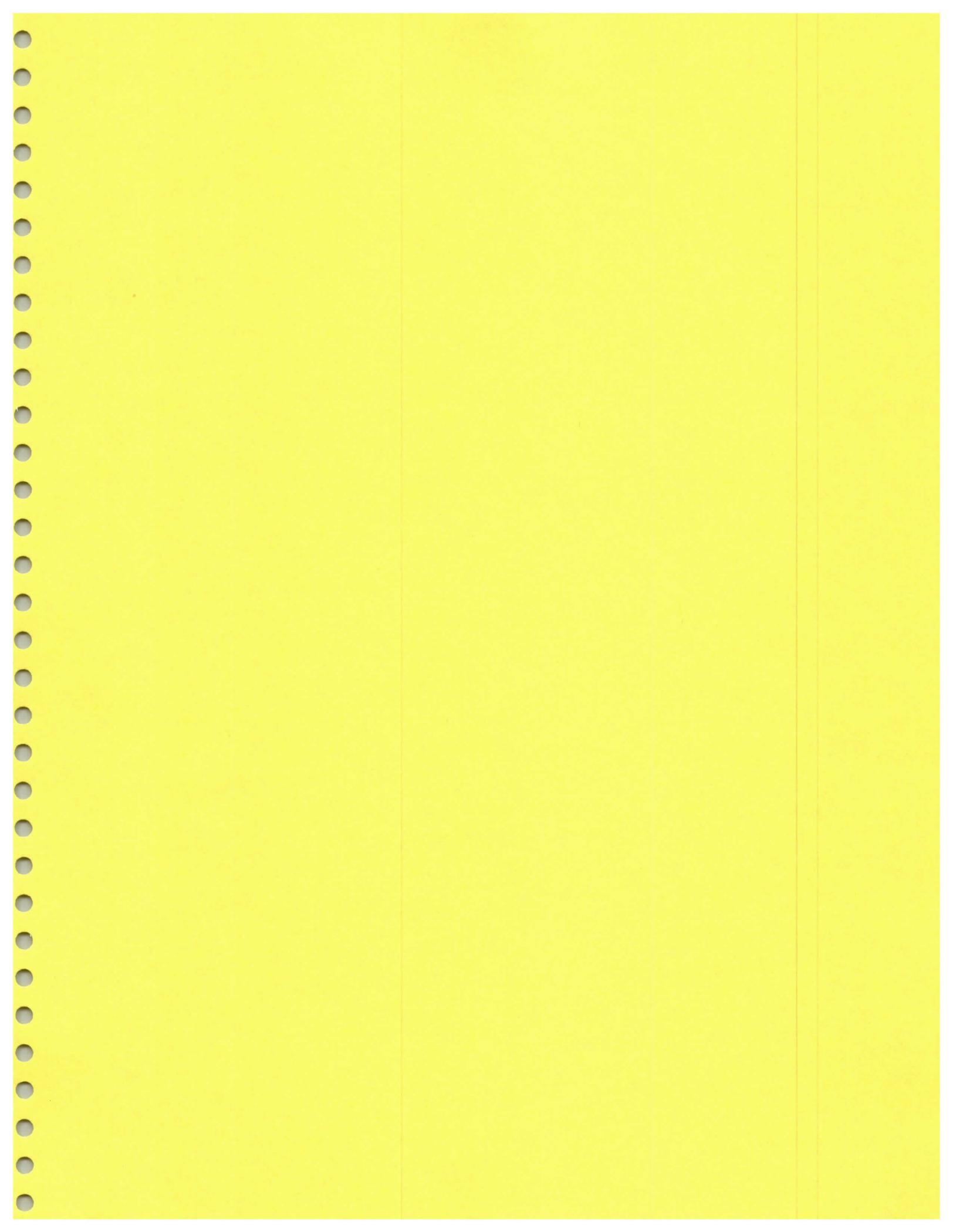
Equipment involved in incident: \_\_\_\_\_

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Narrative of what happened (continue on reverse of this page and draw a diagram if it helps explain what happened):

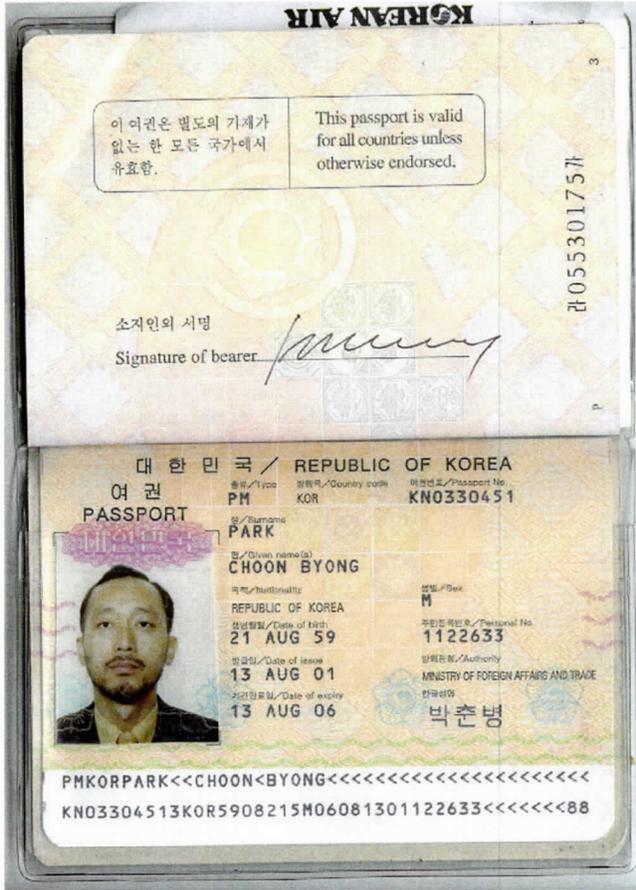
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\_\_\_\_\_  
Site Safety Officer



CHOON BYONG PARK

Passport



Visa



Back of I-94 card

**경고** 단순 방문자가 미국 내에서 불법으로 직업을 갖게 되면 추방당하게 됩니다.  
**중요사항** 이 허가서를 잘 소지하십시오. 미국을 떠날 때는 이것을 반환하셔야 합니다. 반환하지 않을 경우에는 앞으로 미국입국에 지장을 초래할 것입니다. 귀하의 미국 체류는 이 양식에 허가된 기간까지입니다. 이민 당국의 허가를 받지 않고 이 기간을 초과하여 체류하는 것은 법규를 위반하는 것입니다.  
**미국에서 나갈 때는 이 허가서를 반납하십시오.**

-신박 및 항공기 경우 각 회사에  
 -캐나다 국경 통과시에는 캐나다 관리어게  
 -멕시코 국경 통과시에는 미국 관리어게  
 이 허가서를 반납하기 전에, 학생은 본인의 학교에 재등록하기 위해 30일 이내에 미국 재입국을 계획할 때는 양식 I-20의 2페이지 "도착-출발"을 참조하십시오.

Record of Changes

Departure Record

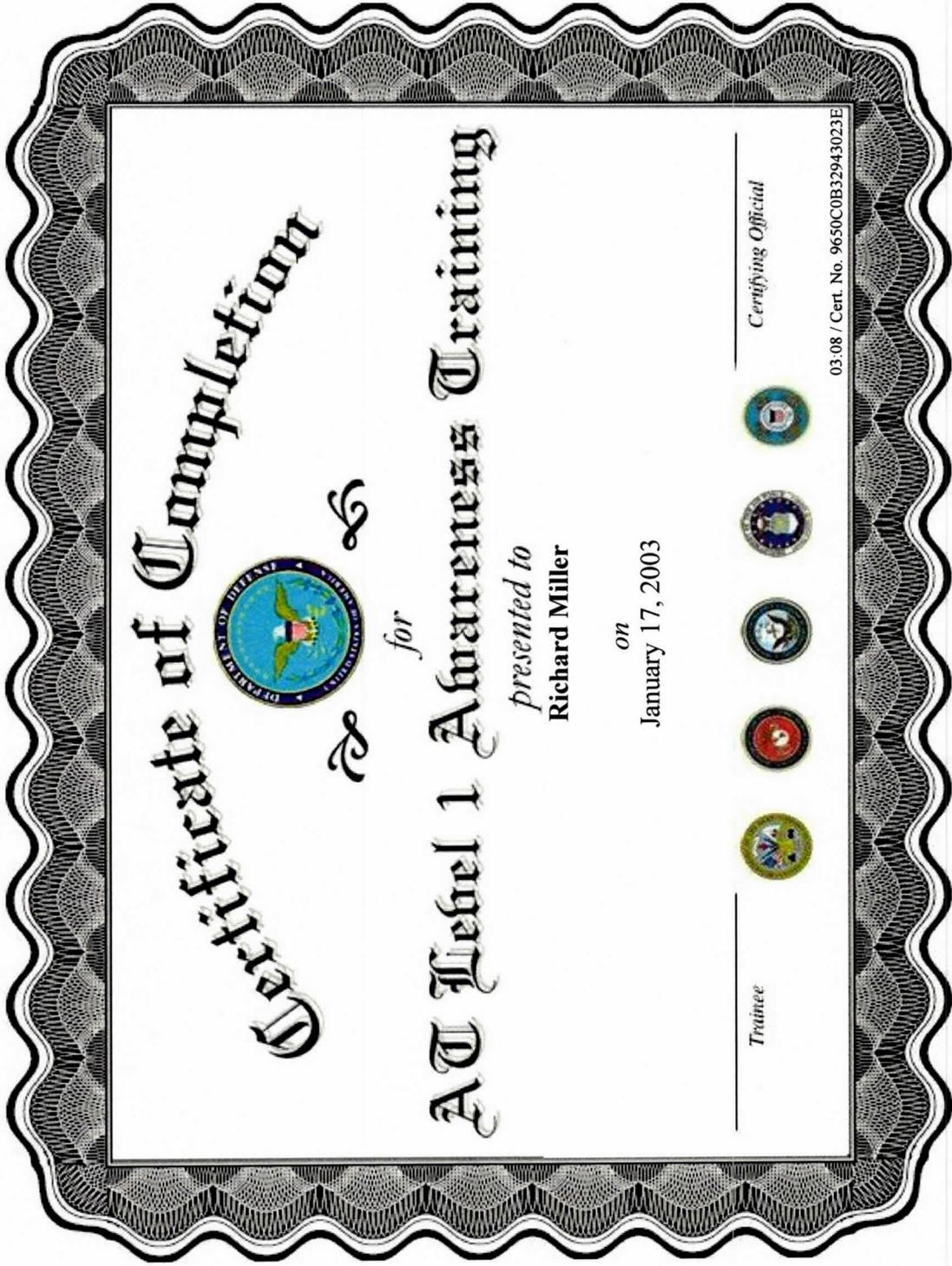
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Date:

Carrier:

Flight #/Ship Name: **KOREAN AIR**





*Certificate of Completion*  
  
*for*  
**AT Level 1 Awareness Training**  
*presented to*  
**Richard Miller**  
*on*  
**January 17, 2003**

Trainees



Certifying Official

03-08 / Cert. No. 9650C0B32943023E

**Certificate of Completion**



**for**

**A1 Level I Awareness Training**

*presented to*  
**David Laflen**

*on*  
 January 17, 2003

*Trainee*

*Certifying Official*



01-24 / Cert. No. 517AB75E7DE9CFDC

# Certificate of Completion



for  
**AT Level 1 Awareness Training**

presented to  
**Julian Ivanov**

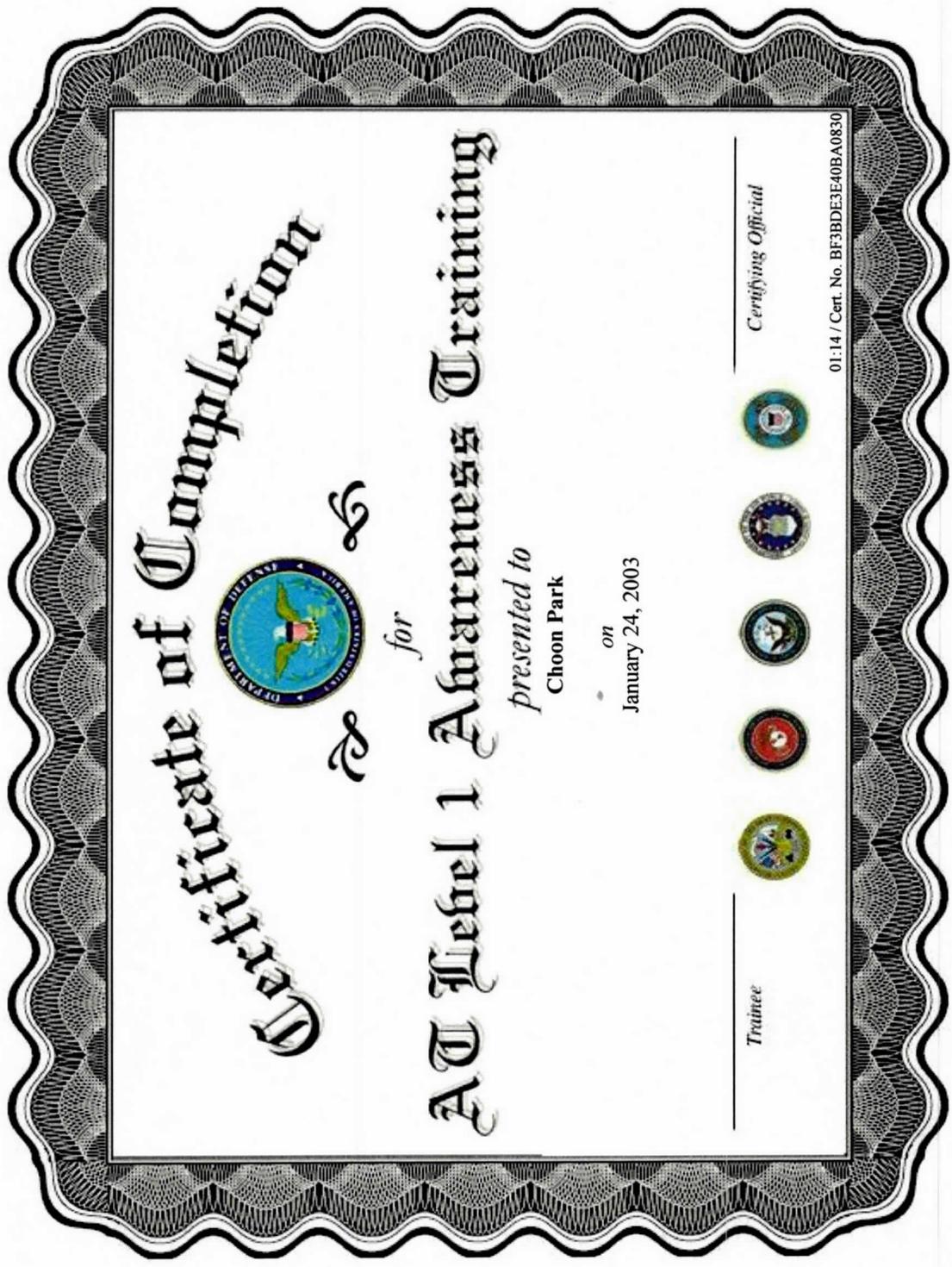
on  
January 19, 2003

Trainee



Certifying Official

04:03 / Cert. No. AC1F2021CADCBFAC



*Certificate of Completion*



*for*  
**AT Level 1 Awareness Training**

*presented to*  
**Choon Park**  
*on*  
**January 24, 2003**

*Trainee*

*Certifying Official*



01:14 / Cert. No. BF3BDE3E40BA0830

**Certificate of Completion**



*for*

**AI Level 1 Awareness Training**

*presented to*

**Chad Gratton**

*on*

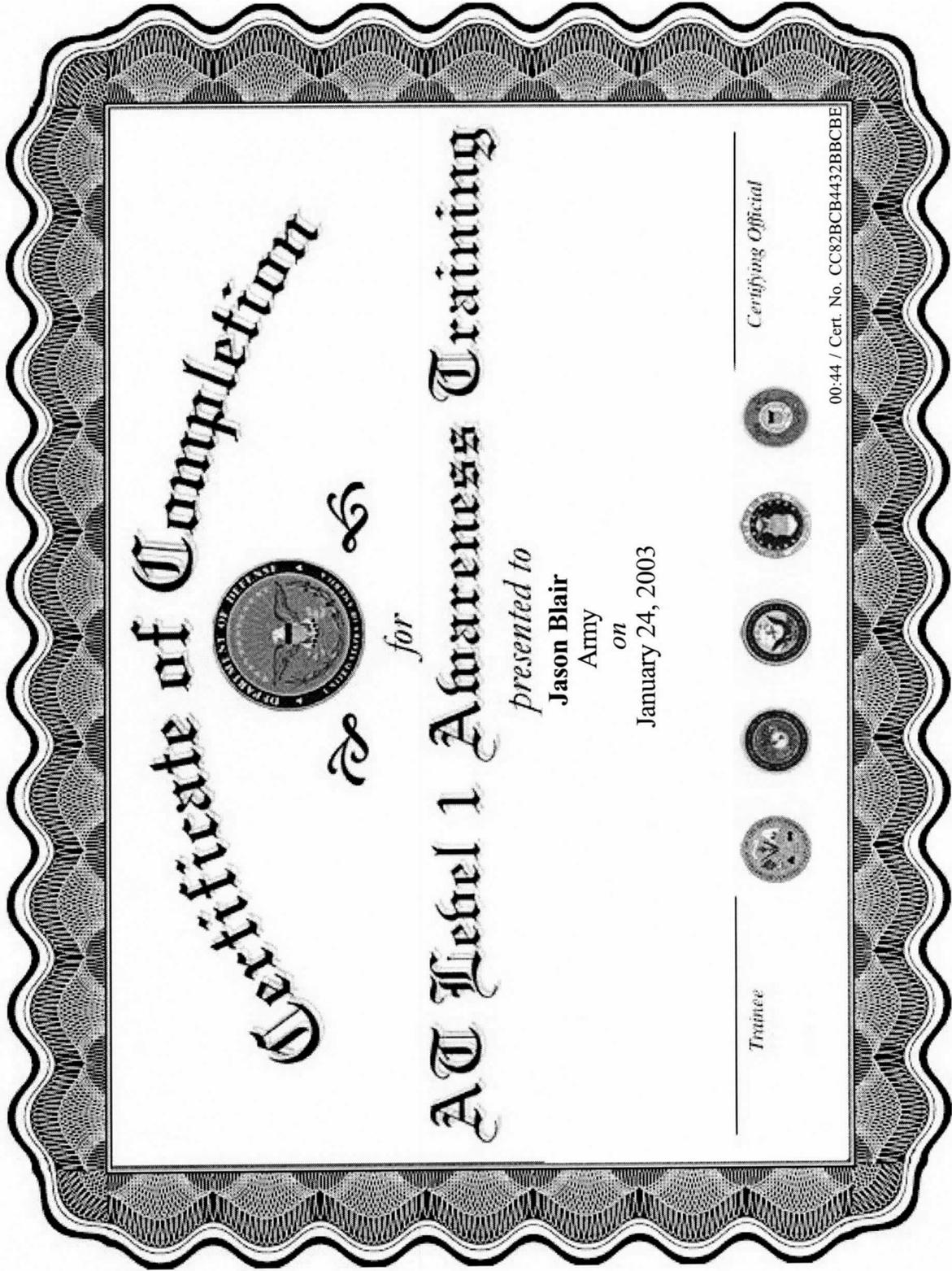
**January 17, 2003**

Trainee

Certifying Official



00:58 / Cert. No. EDAEDE505815212



*Certificate of Completion*



*for*

*AT Level 1 Awareness Training*

*presented to*

**Jason Blair**

**Army**

*on*

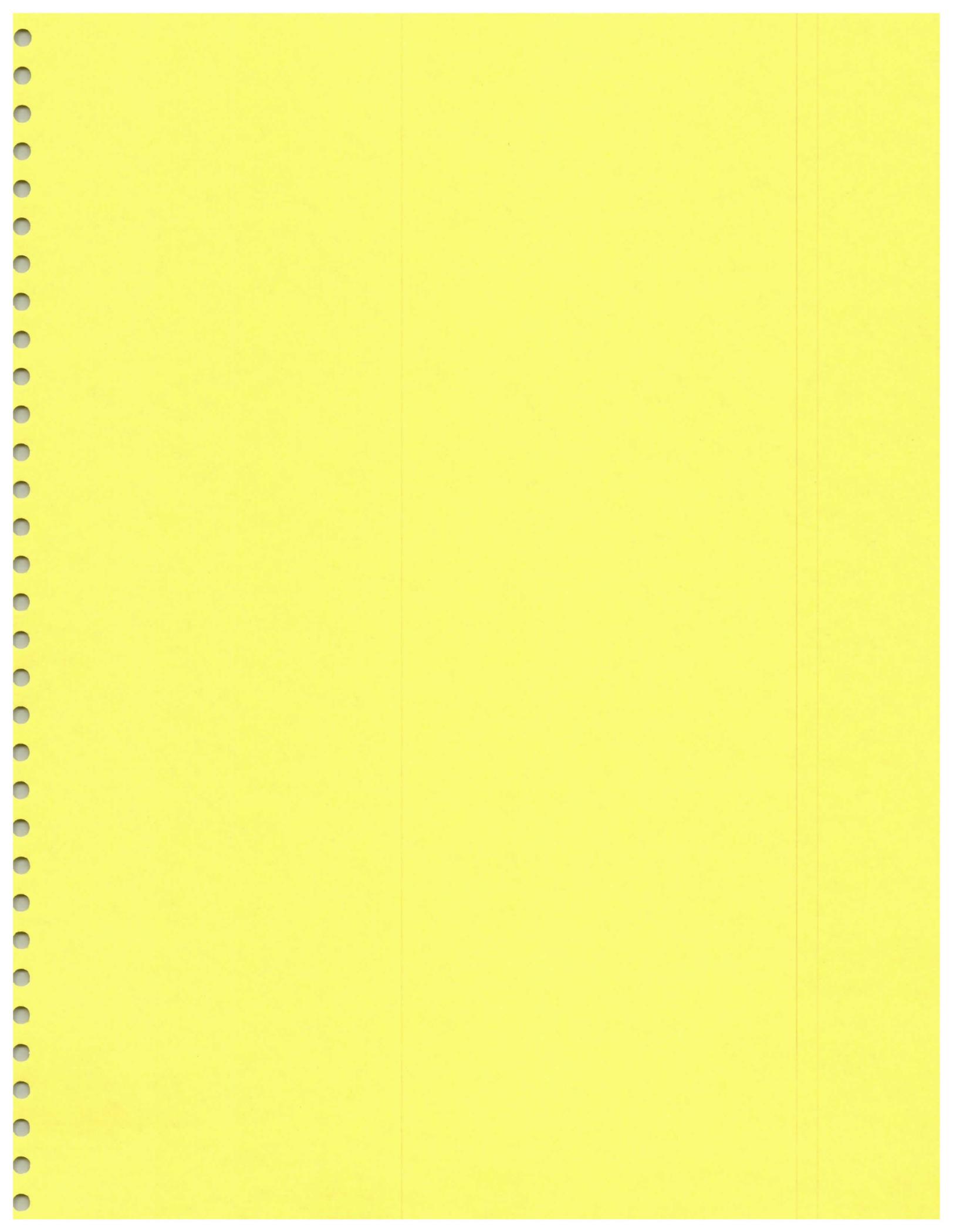
**January 24, 2003**

*Trainee*



*Certifying Official*

00:44 / Cert. No. CC82BCB4432BBCBE



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

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

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

1. In field:

- Always point down or away from populated areas
- Always avoid lodging foreign material in barrel
- Never strain to carry, get a second person
- Never assume anything

2. To and from site and storage:

- Must be storage in a metal locked container
- Must be stored with bolt and gun in separate locations
- Must be completely broke down and cleaned prior to storage
- Access to guns and ammo must be limited to trained personnel only
- Live rounds cannot be stored closer than 5 ft from guns

**B. *Cleaning***

1. Daily:

- Must be inspected for unusual wear, signs of metal fatigue, or structural weakness at the beginning and end of each days service
- Bolt and breech must be oiled and check for mechanical operation
- At the end of each 1/2 day service the barrel will be carefully inspected and checked for signs of fatigue.
- The bolts that secure the gun to the protective steel plate are checked at least 3 times a day.

2. Seasonal:

- R/R springs in extraction system and those associated with the firing rod
- R/R bolts and nuts that attach to protective steel plate.
- R/R mounting bracket as necessary

C. *Firing*

1. Assumptions

NONE

2. Never Do's

Move from downhole placement with shell in chamber

Gun loaded with no one standing on plate

With one person on plate

With knees locked

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

Without both operators aware of detonation

Drop a loaded round

Return a mis-fire to live round canisters

March 24, 1987

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

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

**Operational Safety Rules**

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

**Downhole Mode**

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

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

**Surface Mode**

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

5/10/92

## OPERATION/SAFETY RULES AND REGULATIONS FOR THE

### **AUGER GUN**

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

#### Operation and Safety Regulations

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

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

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

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

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

## Improved Shallow Seismic-Reflection Source: Building a Better Buffalo

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

### SUMMARY

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

### INTRODUCTION

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

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

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

### DESIGN AND TECHNIQUE

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

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

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

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

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

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

## RESULTS

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

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

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

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

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

## CONCLUSION

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

## ACKNOWLEDGMENTS

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

## REFERENCES

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

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

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

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

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

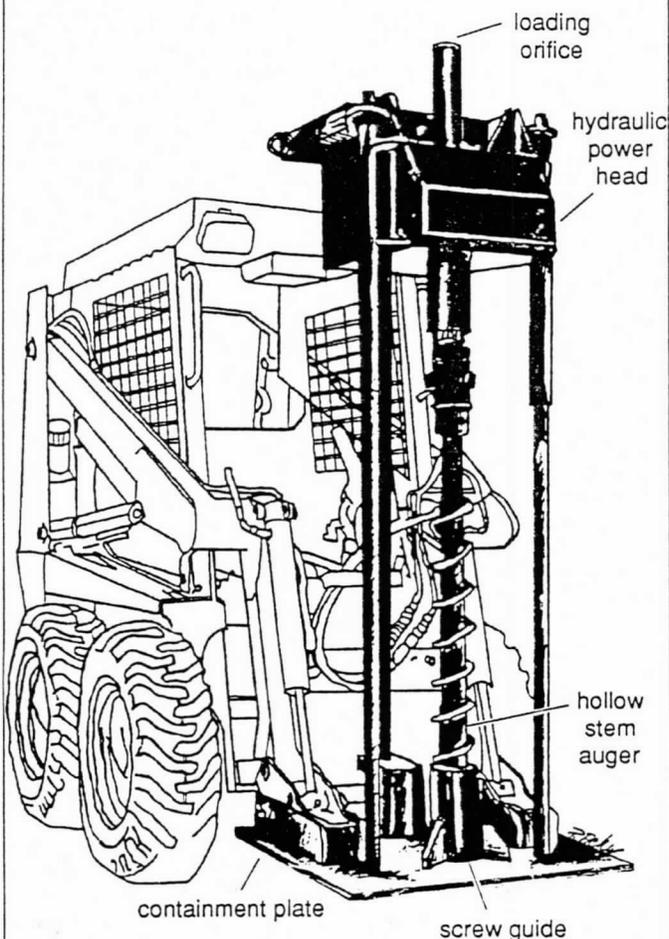


Fig. 1 Diagram represents the auger gun in above-ground position. Modified buffalo-gun portion of the auger gun is not shown, but is conceptually the same as previously documented (Pullan and MacAulay, 1987).

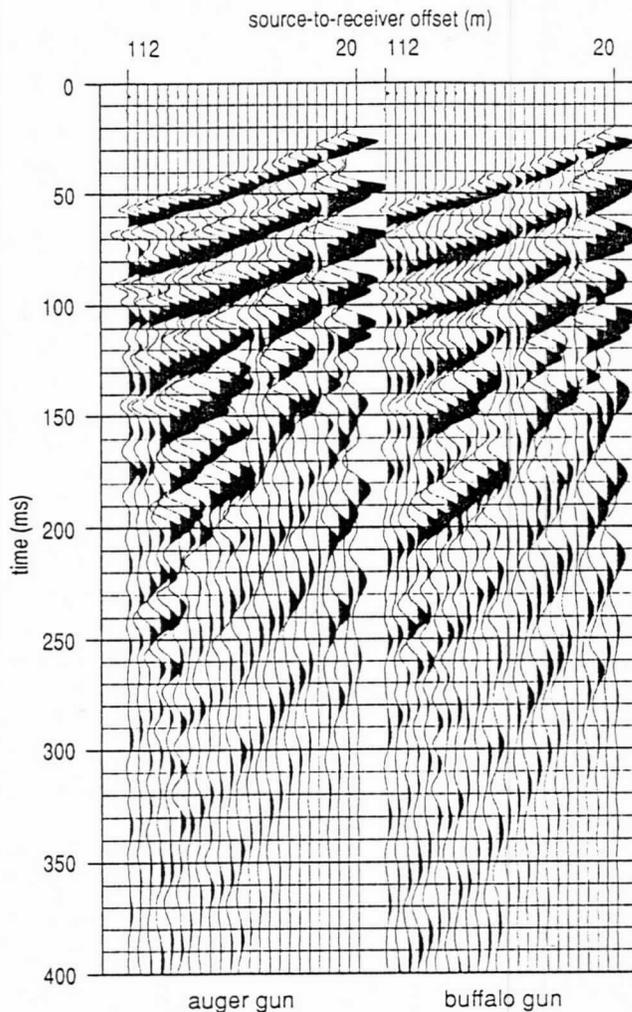


Fig. 2 Auger gun field file (left) compared to the buffalo gun (right).

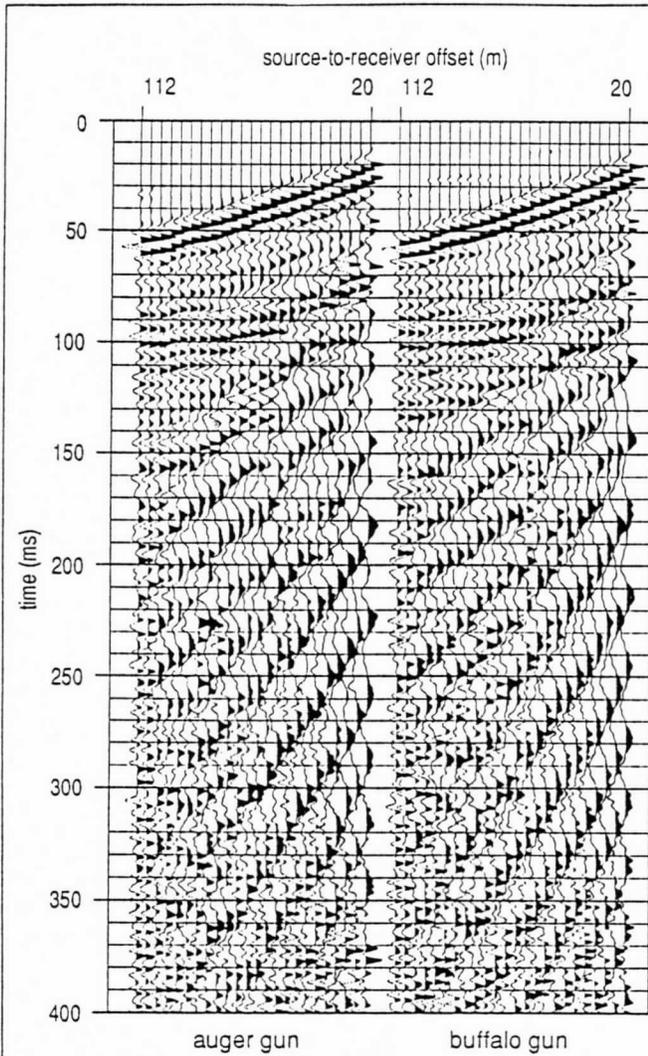


Fig. 3 A 150 Hz digital low-cut filter enhanced the 80 ms reflection event on both the auger (left) and buffalo (right) guns.

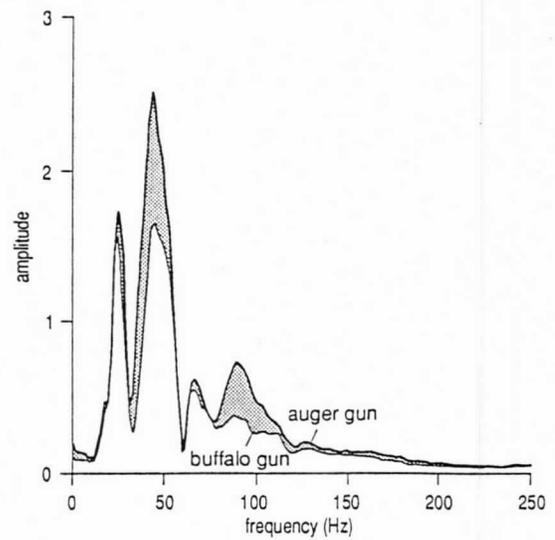


Fig. 4 The darkened area represents the difference between the lower curve (buffalo gun) and the upper curve (auger gun).

Downhole .50-caliber Rifle—An Advance In  
High-resolution Seismic Sources

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

SUMMARY

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

INTRODUCTION

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

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

DESIGN AND TECHNIQUE

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

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

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

FREQUENCY AND AMPLITUDE

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

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

SAFETY

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

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

#### CASE STUDY

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

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

##### Downhole .50-caliber Field Files and Spectrum

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

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

#### ACKNOWLEDGMENTS

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#### REFERENCES

- Miller, R.D., Pullan, S.E., Waldner, J.S., and Haeni, F.P., 1986, Field comparison of shallow seismic sources: *Geophysics*, v. 51, p. 2067-2092.
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- Steeple, D.W., and Knapp, R.W., 1982, Reflections from 25 feet or less: Paper presented at 1982 SEG Convention (Exp. Abs.), SEG program volume, p. 469-471.

Downhole 50-caliber Rifle  
Field File

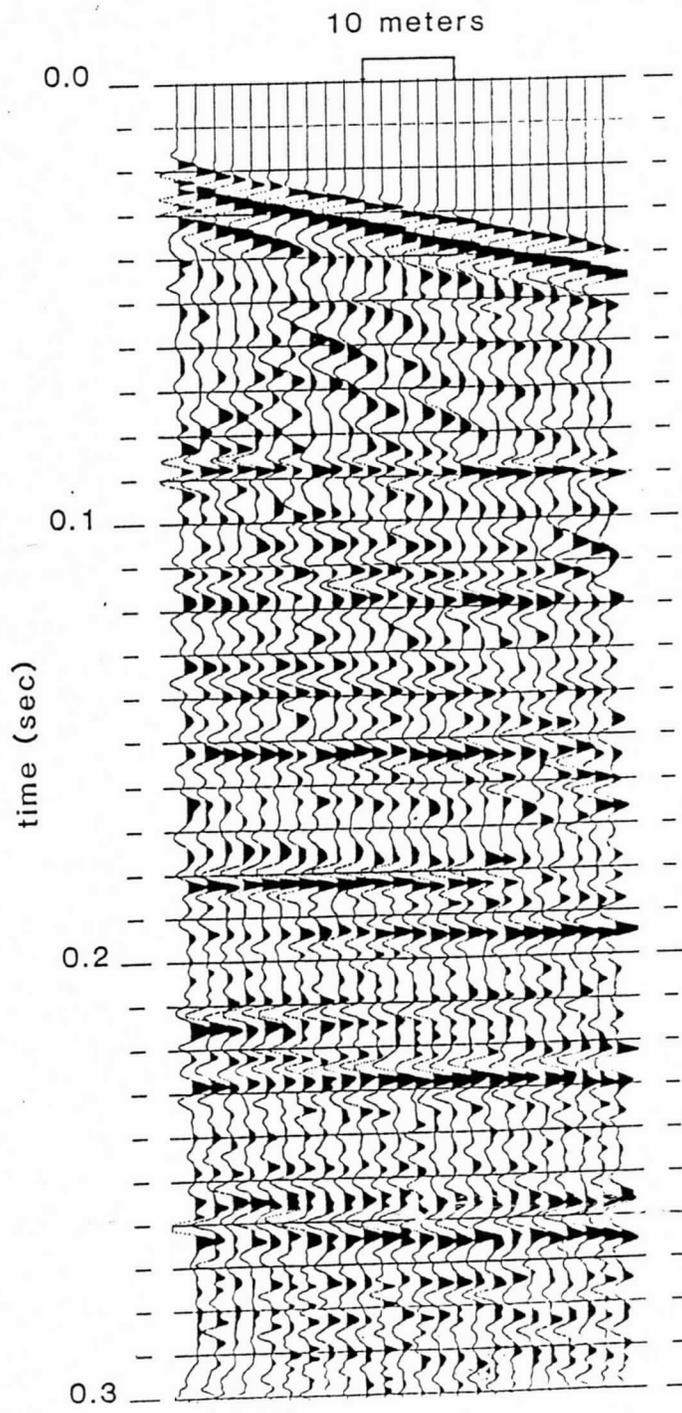


FIG. 2. -This single-shot field file with an AGC applied illustrates the high frequencies and therefore the resolution easily obtainable with a downhole .50-cal.

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

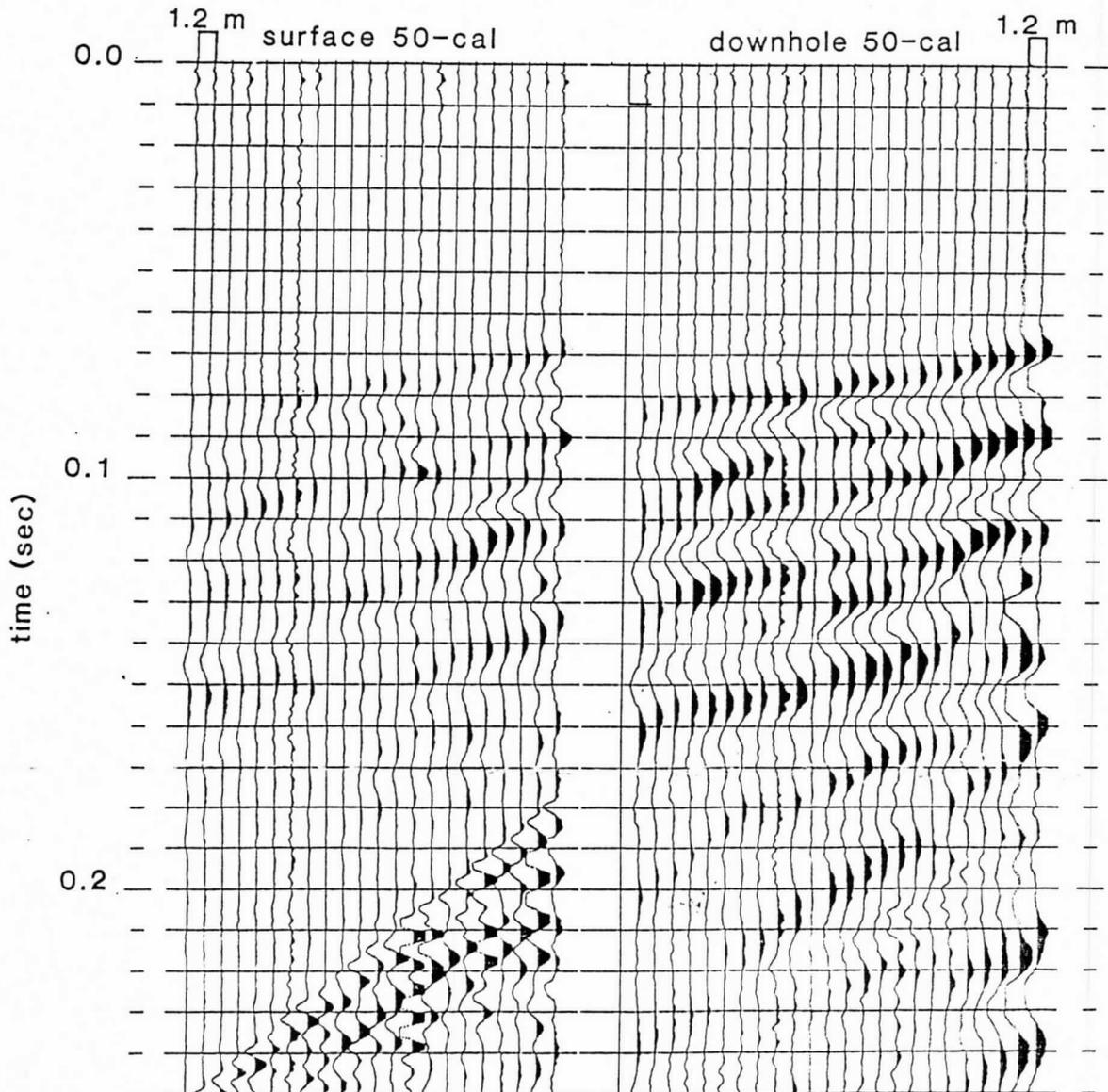
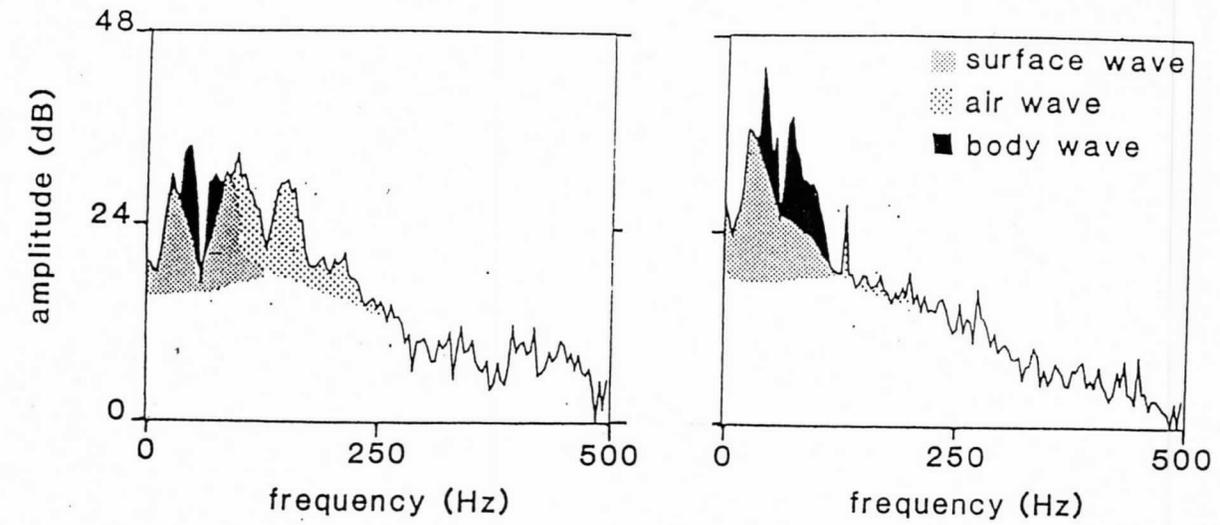


Figure Captions:

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

85 msec Reflector Wavelet  
Amplitude Spectrum

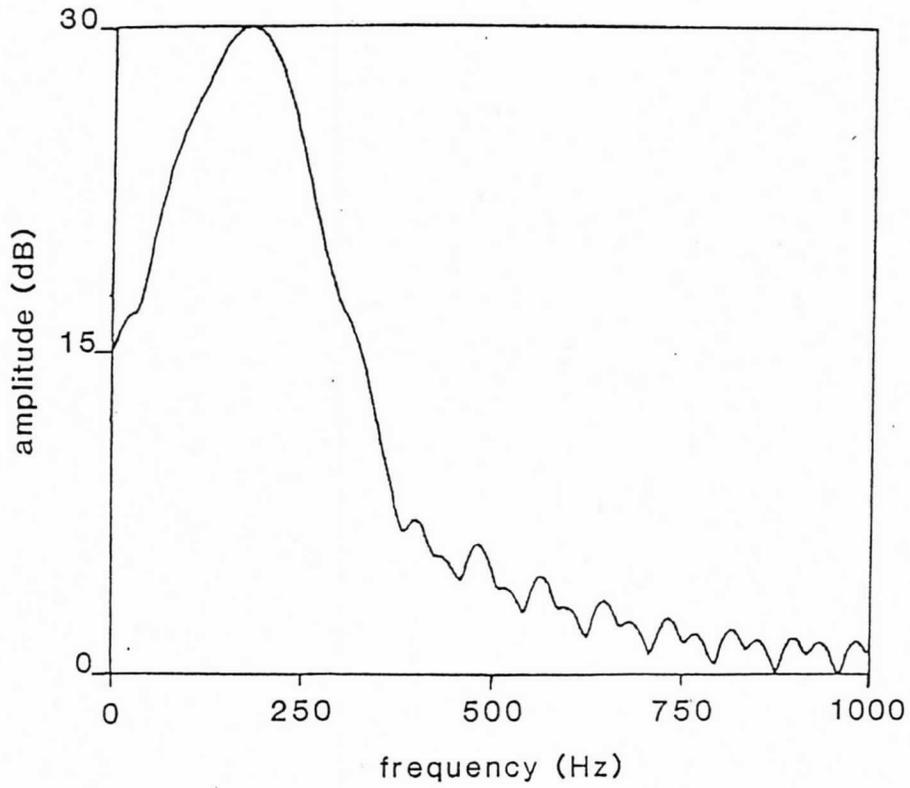


FIG. 3. -The amplitude spectrum of the reflection pulse at 85 msec is almost 3 octaves

Eight Shot Vertical Stack  
Downhole 50-caliber Rifle

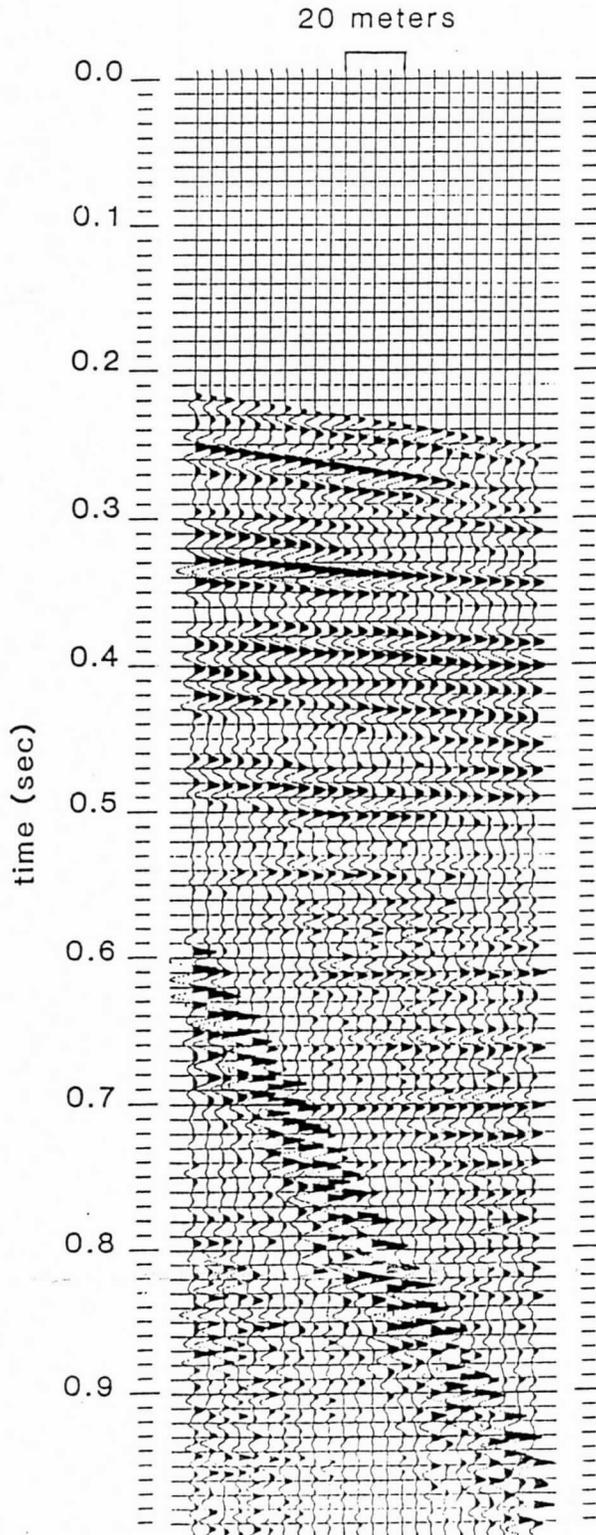
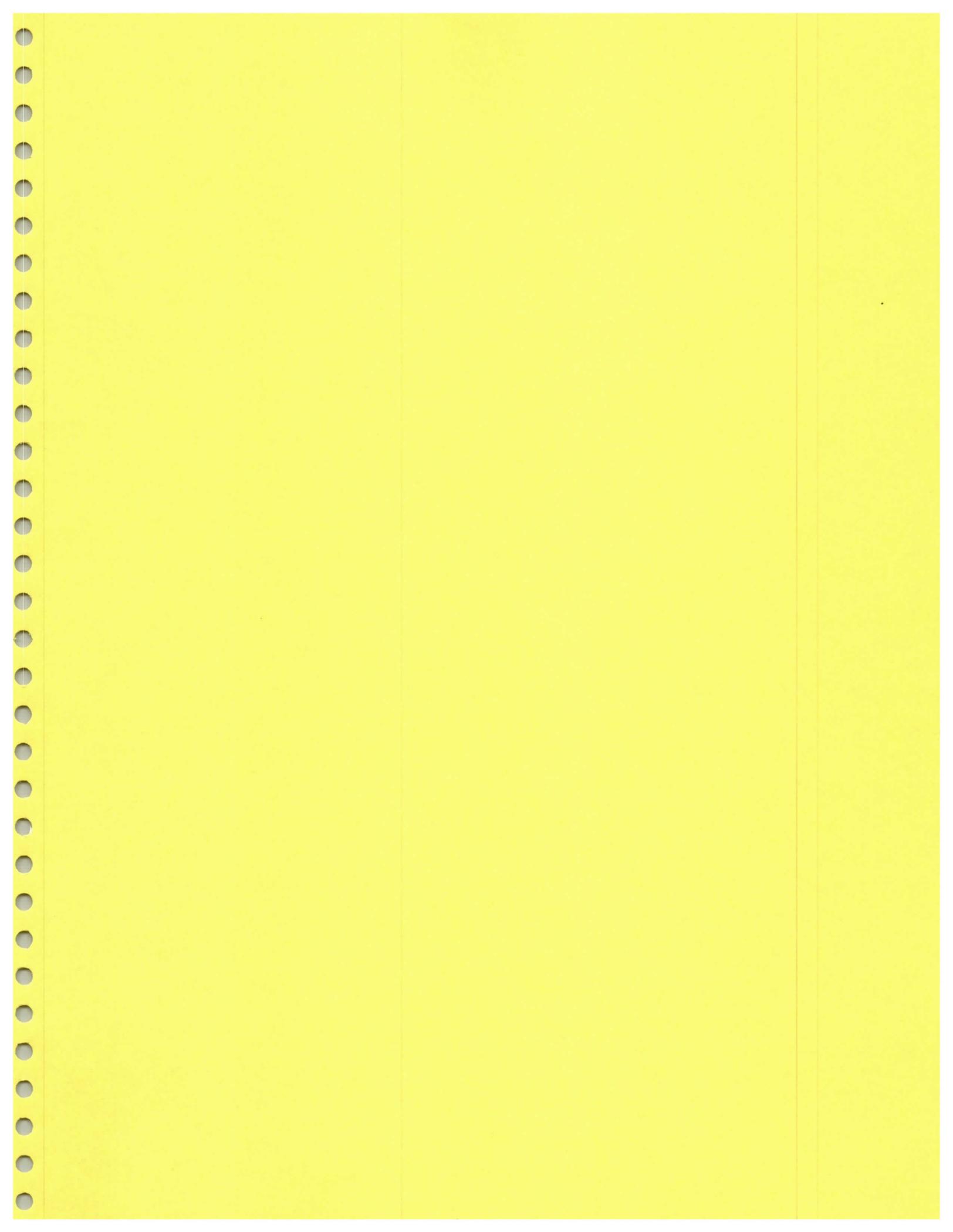


FIG. 4. -This stacked field file has 100 Hz reflection energy as deep as 1100 meters.





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EMERGENCY PHONE 1-800-OLIN-911

# MATERIAL SAFETY DATA

## SECTION I - IDENTIFICATION

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

## SECTION II - NORMAL HANDLING PROCEDURES

<b>PRECAUTIONS TO BE TAKEN IN HANDLING AND STORAGE</b> 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.	
<b>PROTECTIVE EQUIPMENT</b> Eyes Safety glasses or goggles Gloves None necessary Other Hearing protection recommended during discharge	<b>VENTILATION REQUIREMENTS</b> Local mechanical exhaust ventilation recommended during confined space discharge.

## SECTION III - HAZARDOUS INGREDIENTS

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

## SECTION IV - FIRE AND EXPLOSION HAZARD DATA

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

## SECTION V - HEALTH HAZARD DATA

THRESHOLD LIMIT VALUE None established. (Inorganic recm. std.-air: TWA 0.15 mg (Pb)m <sup>3</sup> (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



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

**U.S. Department of Labor**  
 Occupational Safety and Health Administration  
 (Non-Mandatory Form)  
 Form Approved  
 OMB No. 1218-0072



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

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

**Section I "Small Arms Ammunition"**

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

**Section II - Hazardous Ingredients/Identity Information**

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

DOT - "Small Arms Ammunition"  
 Class C Explosive

UPS      ORM-D

**Section III - Physical/Chemical Characteristics**

<b>Boiling Point</b> Not applicable	<b>Specific Gravity (H<sub>2</sub>O = 1)</b> Not applicable
<b>Vapor Pressure (mm Hg.)</b> Not applicable	<b>Melting Point</b> Not applicable
<b>Vapor Density (AIR = 1)</b> Not applicable	<b>Evaporation Rate</b> (Butyl Acetate = 1) <b>NOT APPLICABLE</b>
<b>Solubility in Water</b> Lead & Lead Styphnate - Insoluble; Lead Nitrate - 127 gm/100cc Water - 100°C	
<b>Appearance and Odor</b> Grayish, Gray, Silvery Material - No odor	

**Section IV - Fire and Explosion Hazard Data**

<b>Flash Point (Method Used)</b> Not applicable	<b>Flammable Limits</b> Not applicable	<b>LEL</b> NA	<b>UEL</b> NA
<b>Extinguishing Media</b> Material is self oxidizing; flood with water to fight fire and cool shells.			
<b>Special Fire Fighting Procedures</b> 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

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

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

Signs and Symptoms of Exposure Refer to health hazard above.

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

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

**Section VII — Precautions for Safe Handling and Use**

Steps to Be Taken in Case Material is Released or Spilled

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

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

Precautions to Be Taken in Handling and Storing

Refer to released or spilled data above.

Other Precautions

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

**Section VIII — Control Measures**

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

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

Protective Gloves Not applicable Eye Protection Safety glasses when shooting

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

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

**MATERIAL SAFETY DATA SHEET****SMALL ARMS AMMUNITION  
CENTERFIRE RIFLE & PISTOL AMMUNITION**

Federal Cartridge Company  
900 Ehlen Drive  
Anoka, Minnesota 55303

TELEPHONE: 612-323-2300  
PRODUCT SERVICE: 612-323-3706  
EMERGENCY PHONE NUMBER: 800-424-9300 (CHEMTREC)

Issue Date: January 4, 1999

=====

**SECTION #1 - PRODUCT IDENTIFICATION:**

<b>CENTERFIRE PRODUCT FAMILY</b>		
Centerfire Metallic Cartridge Including The Following:		
.222 Remington	.30-30 Winchester	.300 Savage
.22-250 Remington	.32 Automatic	.32 Winchester Special
.223 Remington	.32 S&W Long	.338 Winchester Magnum
6mm Remington	.32 H&R Magnum	.35 Remington
.243 Winchester	.380 Automatic	8mm Mauser
.257 Roberts +P	.38 Special	.45-70 Government
.25-06 Remington	.357 Magnum	.280 Remington
.270 Winchester	9mm Luger Auto	7-30 Waters
7mm Remington Magnum	9mm Ball (M-822)	7.62X39 Soviet
7mm Mauser	9mm Federal	.303 British
.300 Winchester Magnum	.41 Rem Magnum	.375 H&H Magnum
.308 Winchester	.44 S&W Special	.300 H&H Magnum
.30-06 Springfield	.44 Rem Magnum	.458 Winchester Magnum
.30 Caliber Carbine	.45 Automatic	.416 Rigby
.25 Automatic	.45 Colt	.470 Nitro Express
10mm Automatic	9mm Subsonic	.38 Special +P+
.40 S&W	6.5X55 Swedish	7X64 Brenneke
5.56 Limited Range	9mm Limited Range	.38 Special +P
356 TS&W	.270 Weatherby Magnum	.300 Weatherby Magnum
7mm Weatherby Magnum	.357 SIG	.38 Super

<b>CENTERFIRE PRODUCT FAMILY</b>		
Centerfire Metallic Cartridge Including The Following:		
9X18 Makarov	.257 Weatherby Magnum	.416 Remington Magnum
.220 Swift	.35 Whelen	.340 Weatherby Magnum
7mm STW	7mm-08 Remington	.260 Remington

**SECTION #2 - CHEMICAL COMPOUNDS:**

<b>CHEMICAL COMPOUNDS</b>			
	CAS NUMBER	TWA UNLESS OTHERWISE NOTED	
		OSHA PEL	ACGIH TLV
Bullet - Lead or Lead Core	7439-92-1	.05 mg/m <sup>3</sup>	.05 mg/m <sup>3</sup>
Copper Jacket	7440-50-8	1 mg/m <sup>3</sup> Fume: .1 mg/m <sup>3</sup>	1 mg/m <sup>3</sup> Fume: .2 mg/m <sup>3</sup>
Zinc (As Zinc Oxide)	7440-66-6 1314-13-2	10 mg/m <sup>3</sup> (5 mg/m <sup>3</sup> as respirable dust) Fume: 5 mg/m <sup>3</sup>	10 mg/m <sup>3</sup> Fume: 5 mg/m <sup>3</sup>
Tin	7440-315	.1 mg/m <sup>3</sup>	2 mg/m <sup>3</sup>
Nyclad Coating	Not Established	Not Established	Not Established
Cartridge Case - Brass, (As Zinc & Copper) (See Above)			
Nickel Plated Brass (As Nickel)	7440-02-0	1 mg/m <sup>3</sup>	1 mg/m <sup>3</sup>
Propellant - Nitrocellulose	9004-70-0	Not Established	Not Established
Nitroglycerine	55-63-0	2 mg/m <sup>3</sup> Ceiling	0.46 mg/m <sup>3</sup> (Skin)
Graphite	7782-42-5	15 mg/m <sup>3</sup> (5 mg/m <sup>3</sup> as respirable dust)	2 mg/m <sup>3</sup>
Primer - Lead Styphnate (As Lead)	12403-82-6	.05 mg/m <sup>3</sup>	.05 mg/m <sup>3</sup>
Barium Nitrate (As Barium)	7440-39-3	.5 mg/m <sup>3</sup>	.5 mg/m <sup>3</sup>
Antimony Sulfide (As Antimony)	7440-36-0	.5 mg/m <sup>3</sup>	.5 mg/m <sup>3</sup>
Aluminum	7429-90-5	15 mg/m <sup>3</sup> (5 mg/m <sup>3</sup> as respirable dust)	10 mg/m <sup>3</sup>

**DEFINITIONS OF ACRONYMS**

- OSHA PEL:** Occupational Safety and Health Administration's Permissible Exposure Limit.
- ACGIH TLV:** American Conference of Governmental Industrial Hygienists' Threshold Limit Values.
- TWA:** Time Weighted Average.
- STEL:** Short Term Exposure Limit, the 15 minute exposure which should not be exceeded at any time during a workday.
- CEILING:** The concentration which is not to be exceeded at any time during a workday.
- CAS:** Chemical Abstracts Service number.

**SECTION #3 - PHYSICAL DATA**

- Boiling Point:** Not Applicable
- Melting Point:** Not Applicable
- Vapor Pressure:** Not Applicable
- Density:** 3.1 - 8.0 grams/cc
- Solubility (Water):** None
- Evaporation Rate:** Not Applicable
- Percent Volatiles:** Not Applicable
- Vapor Density (Air = 1):** Not Applicable
- Appearance:** Brass or nickel plated brass case with plastic, lead, copper jacketed lead or nylon clad lead bullet.
- Odor:** None
- Odor Threshold:** None

**SECTION #4 - FIRE FIGHTING & EXPLOSION DATA:**

- Flash Point (F):** Not Applicable
- Auto Ignition Temperature (F):** Not Applicable
- Upper Explosive Limits (Percent):** Not Applicable
- Lower Explosive Limits (Percent):** Not Applicable
- Fire & Explosion Hazards:** May ignite if heated to 250 degrees F, independent of air. Unconfined ignited cartridges can produce low velocity metallic fragments which may cause eye injury or superficial skin wounds if unprotected by standard fire-fighter turnout gear.
- Extinguishing Media:** Water

**Special Fire Fighting Instructions:** Wear full fire-fighter protective gear including face shield or SCBA. Use wide fog pattern nozzle to stop any low velocity fragments. Use water to cool ordinary combustibles below ignition temperature.

## **SECTION #5A - EXPOSURE & EFFECTS -- INHALATION**

### **ROUTE OF EXPOSURE & EFFECTS - INHALATION**

**Acute:** Inhalation of gases and particulates produced while firing ammunition may result in mild throat, eye, upper respiratory and lung irritation. The irritant effects may lead to lung symptoms such as bronchitis. An over exposure to gases or particulates may also cause: anemia; nervous system symptoms which may include irritability, headache, restlessness, fatigue, muscle weakness, muscle tremor, convulsions, loss of memory, visual and hearing disturbances, loss of coordination; gastrointestinal effects such as vomiting, colic, diarrhea or constipation; circulatory symptoms such as a drop in blood pressure; reproductive effects including fertility problems, birth defects, miscarriages and possible kidney damage.

**Chronic:** Prolonged repeated over exposure to fired cartridge gases and particulates may result in elevated blood lead levels and elevated zinc protoporphyrin levels. Symptoms of chronic overexposure to lead may include: anemia; lead lines on the gums; nervous system symptoms which may include irritability, headache, restlessness, fatigue, muscle weakness (i.e. wrist drop), muscle tremor, convulsions, loss of memory, visual and hearing disturbances, loss of coordination; gastrointestinal effects such as weight loss, vomiting, colic, diarrhea, constipation; circulatory symptoms such as a drop in blood pressure; reproductive effects including fertility problems, birth defects, miscarriages and possible kidney damage.

If acute or chronic symptoms should appear, contact a physician. Blood lead and zinc protoporphyrin levels are recommended and should be monitored as per OSHA 1910.1025.

**First Aid:** Remove person to fresh air. Seek medical attention.

## **SECTION #5B - EXPOSURE & EFFECTS -- SKIN**

### **ROUTES OF EXPOSURE & EFFECTS - SKIN**

**Acute:** Elemental and inorganic lead compounds are not absorbed through the skin. Certain organic lead compounds, however, can be absorbed through the skin.

**Chronic:** Elemental and inorganic lead compounds are not absorbed through the skin. Certain organic lead compounds, however, can be absorbed through the skin.

**First Aid:** Wash exposed areas thoroughly with soap and water.

## **SECTION #5C - EXPOSURE & EFFECTS - EYES**

### **ROUTES OF EXPOSURE & EFFECTS - EYES**

- Acute: Contact with large volumes of smoke may cause minor eye irritation.
- Chronic: None reported
- First Aid: Remove person to fresh air. If foreign body is suspected, wash eyes in fresh water for 15 minutes, contact physician.

## **SECTION #5D - EXPOSURE & EFFECTS - INGESTION**

### **ROUTE OF EXPOSURE & EFFECTS - INGESTION**

- Acute: Acute ingestion of lead may occur from poor personal hygiene associated with the handling of lead bearing materials. The effects of lead ingestion would be similar to those listed under acute inhalation in addition to gastrointestinal irritation.
- Chronic: Chronic ingestion of lead may occur from poor personal hygiene associated with the handling of lead bearing materials. The effects of lead ingestion would be similar to those listed under chronic inhalation.
- Note: Wash hands thoroughly with soap and water before eating or smoking.

- First Aid: Ingestion is not a likely route of exposure. In case of ingestion, contact physician.

## **SECTION #5E - EXPOSURE & EFFECTS - CARCINOGENESIS DATA**

- N.T.P. No
- I.A.R.C.: Group 2B, possibly carcinogenic in humans.
- OSHA: No

## **SECTION #5F - EXPOSURE & EFFECTS - COMMENTS**

Lead and barium are toxic metals, which may be released during the firing of modern ammunition. Care should be taken in the cleaning of range facilities to minimize the exposure potential to lead and barium. Persons engaged in these activities should wear protective clothing with an appropriate respirator. Range operators should consult OSHA 1910.1025 for details pertaining to the handling of lead in the work environment.

Severe lead intoxication has been associated in the past with sterility, abortion, and stillbirth. Modern information confirming that lead poisoning affects birth rates or causes injury to the fetus in man is not conclusive.

## **SECTION #5G - AGGRAVATION OF PRE-EXISTING HEALTH CONDITIONS**

### **AGGRAVATION TO PRE-EXISTING HEALTH CONDITIONS**

Exposure to lead can aggravate pre-existing anemia, cardiovascular and respiratory diseases and conditions related to the gastrointestinal, reproductive, renal (kidney), and central nervous systems.

Reference: Industrial Toxicology, Safety and Health Applications in the Workplace;  
Williams/B.

## **SECTION #6 - REACTIVITY & POLYMERIZATION**

Stability: Stable under normal use conditions

Conditions to Avoid: Individual cartridges may ignite if the primer is struck or if the cartridge is exposed to excess heat

Incompatible Materials: Oils, acids, Alkalies, Ammonia, and other corrosive materials

Hazardous Decomposition Materials: Oxides of Barium, Lead, Antimony, Aluminum, Magnesium, Nitrogen, Carbon, and Sulfur. Lead and Antimony fume may also be produced.

Polymerization: Will not occur

## **SECTION #7 - SPILLS, LEAKS & DISPOSAL PROCEDURES**

### **STEPS TO BE TAKEN - SPILLS:**

Avoid conditions detailed in Section #6. If container should rupture, place all loose cartridges from broken shipping cases into a sturdy container. Secure container carefully.

Waste Disposal Methods: Contact Manufacturer - Product Service (612) 323-3706

**SECTION #8 - SPECIAL PROTECTIVE EQUIPMENT**

Ventilation: Use in a well-ventilated area. Consult the current addition of ACGIH Industrial Ventilation Manual and/or NRA ventilation recommendations.

**Protective Equipment:**

Eyes: Recommend protective eyewear conforming to ANSI Z-87

Gloves: Not generally required

Respirators: Use an approved respirator while cleaning range facilities. Consult OSHA 1910.1025 for exact requirements.

Hearing Protection: Hearing protection recommended while discharging cartridges

**SECTION #9 - SPECIAL PRECAUTIONS – STORAGE & HANDLING**

Store in a dry, cool area in the original container to assure performance. Keep out of the reach of children. Avoid striking the primer of unchambered cartridges. Remove ammunition from service if any of the following conditions have occurred:

1. Prolonged storage at or above 200 degrees F
2. Evidence of corrosion
3. Physical damage
4. Exposure to oil or spray type lubricants

Avoid prolonged storage in leather cartridge carriers. Cartridges can ignite if heated to 250 degrees F independent of air.

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Although reasonable care has been taken in the preparation of this document, Federal Cartridge Company extends no warranties and makes no representation as to the accuracy or completeness of the information contained herein and assumes no responsibility regarding the suitability of this information for the user's intended purpose or the consequences of its use. Each individual should make a determination as to the suitability of the information for their particular purpose.

Remington Arms

Material Safety Data Sheet

**Remington Arms****Material Safety Data Sheet**

This Material Safety Data Sheet has been prepared in compliance with Federal OSHA Hazard Communication Standard 29 CFR 1910.1200, ANSI Z400.1-1993 and the ISO Safety Data Sheet Standard. This product may be considered to be a hazardous chemical under 29 CFR 1910.1200. This information is required to be disclosed for safety in the workplace. *This MSDS is applicable only to the product identified herein and only when used properly.*

NOTE: Refer to Section XVII for *List of Acronyms*.

**I. PRODUCT IDENTIFICATION**

<b>Product:</b>	Cartridges, Small Arms	
<b>Trade Name:</b>	<b>CENTERFIRE RIFLE, PISTOL &amp; REVOLVER LOADED ROUND</b>	
<b>CAS Registry No.:</b>	N/A	
<b>CAS Name:</b>	N/A	
<b>Formula:</b>	N/A	<b>HMIS Rating</b>
<b>Molecular Weight:</b>	N/A	<b>Health: 2</b>
<b>Grade:</b>	N/A	<b>Flammability: 0</b>
		<b>Reactivity: 1</b>

**IN EVENT OF EMERGENCY**  
(Spill, Leak, Fire, Exposure, Accident)  
**CALL CHEMTREC DAY OR NIGHT**  
(800) 424-9300  
In Washington, D.C. 483-7616  
Outside Continental U.S.A. (202) 483-7616

**II. HAZARDOUS COMPONENT INFORMATION**

## NOTE

This list includes, but is not limited to, those hazardous materials which comprise greater than 1% (0.1% if carcinogenic) of the total component weight per 29 CFR 1910.1200.

A Centerfire Rifle, Pistol and Revolver Loaded Round is comprised of the following four (4) components. The hazardous chemicals contained in each are listed.

- |                           |                                                                 |
|---------------------------|-----------------------------------------------------------------|
| 1. <b>Projectile</b>      | Lead, Copper, Zinc, Antimony                                    |
| 2. <b>Brass Shellcase</b> | Copper, Zinc, Nickel                                            |
| 3. <b>Propellant</b>      | Nitrocellulose, Nitroglycerin, Dibutyl Phthalate, Graphite      |
| 4. <b>Primer</b>          | Copper, Zinc, Lead, Antimony, Barium, Lead Styphnate, Tetrazene |





**Remington Arms****Material Safety Data Sheet****IV. FIRST AID MEASURES**

- Skin Contact:** Wash affected area thoroughly with soap and water. Remove contaminated clothing. Wash clothing thoroughly prior to reuse. Discard any contaminated leather items (i.e. shoes, etc.).
- Eye Contact:** If wearing contacts, immediately remove contact lenses. Hold eyelids apart and flush eyes thoroughly with water for at least 15 minutes. Obtain medical attention immediately.
- Inhalation:** Immediately remove to fresh air. Administer artificial respiration, if necessary. If breathing is difficult, administer oxygen. Obtain medical attention immediately.
- Ingestion/Absorption:** If conscious, drink large amounts of water. Induce vomiting. Immediately contact a physician or Poison Control Center. *Never* induce vomiting or give anything by mouth to an unconscious person.

**V. FIRE HAZARDS**

- Flammable Properties:** Refer to *HVMS Rating*. May ignite if heated to 250°F. Will ignite when exposed to flame and high temperatures. Be cautious of shrapnel.
- Extinguishing Media:** Flood fire with water to fight fire and cool shells. If no water is available, use carbon dioxide, dry chemical or earth.
- Fire-Fighting Instructions:** Evacuate area immediately. Deluge area with water. Wear full fire-fighting protective gear including face shield or SCBA to protect from shrapnel.

**VI. ACCIDENTAL RELEASE MEASURES**

- Safeguards:** Remove from all sources of ignition.
- Spill Cleanup:** Use non-sparking equipment to clean up spill. If disposal is necessary, refer to *XIII. DISPOSAL CONSIDERATIONS*.
- Accidental Release:** See above.

**VII. HANDLING AND STORAGE**

- Personnel Handling:** Handle with care. Do not strike or crush the rounds.
- Storage:** Store in original containers in a cool, dry, well-ventilated area away from all sources of ignition. Do not subject to mechanical shock. Keep out of reach of children. This product *must not be stored* with acids, strong oxidizers or caustics.

Remington Arms

Material Safety Data Sheet

**VIII. PERSONAL PROTECTION/EXPOSURE CONTROLS**

- Engineering Controls:** N/A
- Personal Protective Equipment:**
- Safety glasses recommended when handling or firing rounds.
  - Hearing protection recommended when firing rounds.
  - Use of NIOSH/MSHA-approved respirator required when exposed to fumes and/or dust in an enclosed or poorly-ventilated area.
- Exposure Guidelines:**
- Keep product away from sources of accidental ignition.
- Exposure Limits:**
- Exposure limits listed with each hazardous chemical.

**IX. PHYSICAL AND CHEMICAL PROPERTIES****PHYSICAL DATA**

**Appearance:** Projectile: cylindrical; grayish, silvery color  
Case: cylindrical; bronze color

<b>Form:</b>	Solid	<b>Evaporation Rate:</b>	N/A
<b>Color:</b>	Variable	<b>Melting Point:</b>	N/A
<b>Odor:</b>	None	<b>Solubility in Water:</b>	N/A
<b>Boiling Point:</b>	N/A	<b>pH:</b>	N/A
<b>Specific Gravity:</b>	N/A		
<b>Vapor Density:</b>	N/A		

**X. STABILITY AND REACTIVITY**

- Chemical Stability:** Stable under normal use conditions. Will not react with water.
- Other Hazards:**
- Incompatibility:** Incompatible with acids, strong oxidizers and caustics.
- Polymerization:** Will not occur.
- Conditions to Avoid:** Flames, sparks, percussion, shock, static, high temperatures (266°F or 130°C)

**XI. TOXICOLOGICAL INFORMATION**

- Oral LD 50:** No available data.
- Dermal LD 50:** No available data.
- Inhalation LC 50:** No available data.
- Irritation:** Not a skin or eye irritant.

**XII. ECOLOGICAL INFORMATION**

- Aquatic Toxicity:**
- Lead (LC 50) to Bluegill: 2-5 mg/l
- Barium to Stickleback: 400 mg/l
- Barium Nitrate to Stickleback: 760 mg/l
- Environmental Impact:**

When used and disposed of properly, there is no known environmental impact.

**Remington Arms****Material Safety Data Sheet****XIII. DISPOSAL CONSIDERATIONS**

This product is considered a characteristic hazardous waste per 40 CFR 261.24 for disposal purposes only. Dispose of as required by local, state and federal laws and regulations.

EPA Hazardous Waste Code: D008 (lead)

**XIV. TRANSPORTATION INFORMATION****SHIPPING INFORMATION**

<b>Proper Shipping Name:</b>	Cartridges, Small Arms
<b>Hazard Class:</b>	ORM-D
<b>UN/NA No:</b>	N/A
<b>Packing Group:</b>	N/A
<b>Shipping Label:</b>	None required.
<b>Special Information:</b>	May be reclassified internationally as:
	Hazard Class: 1.4S
	UN/NA No.: UN0012
	Packing Group: II
	Shipping Label: 1.4S label

**XV. REGULATORY INFORMATION****U.S. FEDERAL REGULATIONS**

TSCA Inventory Status: Included on list.

**HAZARD CLASSIFICATION**

<b>Chronic Health:</b>	Headache, nausea, weakness
<b>Acute Health:</b>	Anemia, embryotoxin.
<b>Fire Hazard:</b>	0 (per HMIS Rating)
<b>Pressure Hazard:</b>	Sudden release of pressure.
<b>Reactivity Hazard:</b>	1 (per HMIS Rating)

**XVI. OTHER INFORMATION**

NFPA Rating: Not established.

**NPCA-HMIS Ratings:**

<b>Health:</b>	2
<b>Flammability:</b>	0
<b>Reactivity:</b>	1

**References:**

*Code of Federal Regulations, Monthly Summary*, CFR 1910.1200(g) and Appendix E (B.), Regulations Management Corporation, Bloomington, Indiana, July 1, 1994.

*Hazardous Chemical Desk Reference: Third Edition*, Richard J. Lewis, Sr., Van Nostrand Reinhold, Copyright 1993.

*American National Standards Institute*, Z400.1-1993

*International Standards Organization Safety Data Sheet Standard*.

*Remington Arms**Material Safety Data Sheet***XVII. LIST OF ACRONYMS**

<b>ACGIH</b>	American Conference of Governmental Industrial Hygienists
<b>AIHA WEEL</b>	American Industrial Hygienists Association-Workplace Environmental Exposure Level
<b>ANSI</b>	American National Standard Institute
<b>BEI</b>	Biological Exposure Indexes
<b>CAS</b>	Chemical Abstract Service
<b>CFR</b>	Code of Federal Regulations
<b>CL</b>	Ceiling Limits (not to be exceeded)
<b>DSL</b>	Domestic Substances List
<b>EPA</b>	Environmental Protection Agency
<b>HMIS</b>	Hazardous Materials Identification System
<b>IARC</b>	International Agency for Research on Cancer
<b>IATA</b>	International Air Transport Association
<b>ICAO</b>	International Civil Aviation Organization
<b>ISO</b>	International Standards Organization
<b>MITI</b>	Ministry of International Trade and Industry (Japan)
<b>MSHA</b>	Mine Safety and Health Appliance
<b>NFPA</b>	National Fire Protection Association
<b>NIOSH</b>	National Institute for Occupational Safety and Health
<b>NTA</b>	National Transportation Agency (Canada)
<b>NTP</b>	National Toxicology Program
<b>OSHA</b>	Occupational Safety and Health Administration
<b>ORM</b>	Other Regulated Materials
<b>PEL</b>	Permissible Exposure Limit (OSHA)
<b>SCBA</b>	Self-contained Breathing Apparatus
<b>STEL</b>	Short-Term Exposure Limit
<b>TLV</b>	Threshold Limit Values (ACGIH)
<b>TSCA</b>	Toxic Substances Control Act
<b>TWA</b>	Time Weighted Average
<b>UN/NA</b>	United Nations/North American (Identification number)

For additional information, please contact:

**Remington Arms Company, Inc.**  
**Consumer Information**  
**Wilmington, DE 19805**

(800) 243-9700

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The information contained in this *Material Safety Data Sheet* is provided to all individuals who are or will be exposed to this product through use, handling, storage or transport. Remington believes, yet makes no warranty, that all information contained in this document is current as of the date of publication.

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# GENERAL MOTORS CORPORATION MATERIAL SAFETY DATA SHEET

## SECTION I

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

## SECTION II — INGREDIENTS (list all ingredients)

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

## SECTION III — PHYSICAL DATA

BOILING POINT 233 °F °C	SPECIFIC GRAVITY (H <sub>2</sub> O = 1) Varies with battery size	Average 1.280 ± .01
VAPOR PRESSURE (at 77 °F 25 °C) 2.730 mm Hg <input type="checkbox"/> psi	PERCENT VOLATILE BY VOLUME (%)	PERCENT SOLID BY WEIGHT (%)
VAPOR DENSITY (AIR = 1)	EVAPORATION RATE ( = 1)	NA
SOLUBILITY IN WATER Miscible	pH =	< 1.0
APPEARANCE AND ODOR Water - white liquid (acid content)	IS MATERIAL: <u>LIQUID</u> <u>SOLID</u> GAS PASTE POWDER	

## SECTION IV — FIRE AND EXPLOSION HAZARD DATA

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

## SECTION V-HEALTH HAZARD DATA

EFFECTS OF OVEREXPOSURE — Conditions to Avoid Contact with sulfuric acid results in rapid destruction of body tissue (burns).	THRESHOLD LIMIT VALUE <input checked="" type="checkbox"/> TLV=1 mg/m3 PERMISSIBLE EXPOSURE LIMIT <input type="checkbox"/> Sulfuric Acid OTHER LIMIT <input type="checkbox"/>
PRIMARY ROUTES OF ENTRY Inhalation <input checked="" type="checkbox"/> Skin Contact <input type="checkbox"/> Other (specify) Ingestion	
EMERGENCY AND FIRST AID PROCEDURES Do not exceed 1 mg/m3 TWA. Remove to fresh air. Get medical attention. EYE OR SKIN CONTACT: Flush with large volumes of water. Get medical attention. INGESTION: DO NOT induce vomiting. Give milk mixed with egg white if conscious.	

## SECTION VI-REACTIVITY DATA

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

## SECTION VII-SPILL OR LEAK PROCEDURES

STEPS TO BE TAKEN IN CASE MATERIAL IS RELEASED OR SPILLED Lime or soda may be used to neutralize and/or flush with large volumes of water. Contain spill.	
WASTE DISPOSAL METHOD According to local, state, and federal regulations for acid or lead scrap.	
RCRA (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	
<input checked="" type="checkbox"/> Theoretical 4 lb/gal	<input type="checkbox"/> 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 MECHANICAL (General) (Specify Rate)	SPECIAL NA OTHER NA
PROTECTIVE GLOVES (specify type) Rubber		EYE PROTECTION (specify type) Splash-proof safety g.
OTHER PROTECTIVE EQUIPMENT Use rubber boots and acid-proof clothing for major spills.		

## SECTION IX-SPECIAL PRECAUTIONS

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

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

PLEASE COMPLETE QUESTIONNAIRE AND RETURN TO:	Name (print) Robert A. Chisman Signature <i>Robert A. Chisman</i> Title Senior Industrial Hygienist Date May 8, 1991
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**ANSUL**®ANSUL FIRE PROTECTION  
MARINETTE, WI 54143-2542**MATERIAL SAFETY DATA SHEET****FORAY**

QUICK IDENTIFIER (In Plant Common Name)

Manufacturer's Name:	ANSUL FIRE PROTECTION	Emergency Telephone No.:	CHEMTREC (800) 424-9300
Address:	One Stanton Street, Marinette, WI 54143-2542	Other Information Calls:	(715) 735-7411
Prepared By:	Safety and Health Department	Date Prepared:	April 22, 1994

**SECTION 1 — IDENTITY**

Common Name: (used on label) (Trade Name and Synonyms)	FORAY Dry Chemical Extinguishing Agent	CAS No.:	N/A
Chemical Name:	N/A This is a Mixture	Chemical Family:	Mixture
Formula:	N/A		

**SECTION 2 — INGREDIENTS**

PART A — HAZARDOUS INGREDIENTS				
Principal Hazardous Component(s) (chemical and common name(s)):	Wt. %	CAS No.	ACGIH TLV	Acute Toxicity Data
Magnesium Aluminum Silicate (Attapulgite Clay)	5-7	8031-18-3	10 mg/M <sup>3</sup>	NDA
PART B — OTHER INGREDIENTS				
Other Component(s) (chemical and common name(s)):	Wt. %	CAS No.		Acute Toxicity Data
Proprietary Mixtures of: Monoammonium Phosphate	65-82	7722-76-1		Oral (Rat) LD <sub>50</sub> 5750 mg/kg
Ammonium Sulfate	12-22	7783-20-2		Oral (Rat) LD <sub>50</sub> 3000 mg/kg
Calcium Carbonate	<2	1317-65-3	10 mg/M <sup>3</sup>	NDA
Methyl Hydrogen Polysiloxane	<1	63148-57-2		NDA
Yellow Pigment	<.05	5468-75-7		NDA

**SECTION 3 — PHYSICAL AND CHEMICAL CHARACTERISTICS (Fire and Explosion Data)**

Boiling Point:	N/A	Specific Gravity (H <sub>2</sub> O = 1):	N/A	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:	Slight	Reactivity in Water:	Unreactive		
Appearance and Odor:	Yellow colored powder, no characteristic odor				
Flash Point:	None	Flammable Limits in Air % by Volume:	N/A	Extinguisher Media:	N/A
Auto-Ignition Temperature:	N/A				
Special Fire Fighting Procedures:	NONE — THIS IS AN EXTINGUISHING AGENT				
Unusual Fire and Explosion Hazards:	None				

**SECTION 4 — PHYSICAL HAZARDS**

Stability:	Unstable <input type="checkbox"/> Stable <input checked="" type="checkbox"/>	Conditions to Avoid:	N/A
Incompatibility (Materials to Avoid):	Strong alkalis, Mg, oxidizers that can release chlorine per NFPA 43A		
Hazardous Decomposition Products:	NH <sub>3</sub> and/or PO <sub>x</sub> may be evolved		
Hazardous Polymerization:	May Occur <input type="checkbox"/> Will Not Occur <input checked="" type="checkbox"/>	Conditions to Avoid:	N/A

## FORAY (Continued)

## SECTION 5 — HEALTH HAZARDS

Threshold Limit Value:	OSHA nuisance dust limit of 15 mg/M <sup>3</sup> or ACGIH nuisance dust value of 10 mg/M <sup>3</sup> for the eight hour time-weighted average.		
Routes of Entry: Eye Contact:	Mildly irritating for a short period of time.		
Skin Contact:	May be mildly irritating.		
Inhalation:	Treat as a mineral dust. Irritant to the respiratory tract.		
Ingestion:	Not an expected route of entry.		
Signs and Symptoms:	Acute Overexposure: Transient cough, shortness of breath. Chronic Overexposure: Chronic fibrosis of the lung, pneumoconiosis.		
Medical Conditions Generally Aggravated by Exposure:	Reactive airway		
Chemical Listed as Carcinogen or Potential:	National Toxicology Program: Yes <input type="checkbox"/> No <input checked="" type="checkbox"/>	I.A.R.C. Monographs: Yes <input type="checkbox"/> No <input checked="" type="checkbox"/>	OSHA: Yes <input type="checkbox"/> No <input checked="" type="checkbox"/>

## SECTION 6 — EMERGENCY AND FIRST AID PROCEDURES

Eye Contact:	Flush with large amounts of water; if irritation persists, seek Medical attention.
Skin Contact:	Wash with soap and water; if irritation persists, seek Medical attention.
Inhalation:	Remove victim to fresh air. Seek Medical attention if discomfort continues.
Ingestion:	If patient is conscious, give large amounts of water and induce vomiting. Seek Medical help.

## SECTION 7 — SPECIAL PROTECTION INFORMATION

Respiratory Protection (Specify Type):	Dust mask where dustiness is prevalent, or TLV exceeded. Mechanical filter respirator if exposure is prolonged.		
Ventilation:	Local Exhaust: Discretionary	Mechanical (General):	Recommended
Protective Gloves:	N/A	Eye Protection:	Recommended as mechanical barrier for prolonged exposure.
Other Protective Clothing or Equipment:	If irritation occurs, long sleeves and impervious gloves should be worn.		

## SECTION 8 — SPECIAL PRECAUTIONS AND SPILL/LEAK PROCEDURES

Precautions to be Taken in Handling and Storage:	Should be stored in original container or Ansol fire extinguisher.
Other Precautions:	Do not mix agents.
Steps to be Taken in Case Material is Released or Spilled:	Sweep up.
Waste Disposal Methods:	Dispose of in compliance with local, state, and federal regulations.

## HAZARDOUS MATERIAL IDENTIFICATION SYSTEM RATINGS

HAZARD INDEX:	
4 Severe Hazard	<u>1</u> HEALTH
3 Serious Hazard	<u>0</u> FLAMMABILITY
2 Moderate Hazard	<u>0</u> REACTIVITY
1 Slight Hazard	
0 Minimal Hazard	

N/A = Not Applicable      NDA = No Data Available

ANSUL and FORAY are registered trademarks.



**DEERE & COMPANY**  
 John Deere Road, Moline, IL 61265  
 1-800-822-8262

**Material Safety Data Sheet**

JOHN DEERE PRODUCT NAME: **Hy-Gard Transmission and Hydraulic Oil**

DATA SHEET NO: 8503-40,100  
 LATEST REVISION DATE: 15 Feb. 1989  
 DEERE CODE: Y3, Y38, XN, Y4  
 JDM PART NO: TY6237, TY6238, TY6278,  
 TY6354, AR69444, AR69445,  
 TY22028, TY22062, TY22077,  
 TY22078, TY22079, TY22080,  
 TY22092

----- **SECTION I - PRODUCT IDENTIFICATION** -----

CHEMICAL NAME AND SYNONYMS: Lubricating Oil; Hydraulic Fluid; J20C  
 CHEMICAL FAMILY: Hydrocarbon FORMULA: Complex

----- **SECTION II - HAZARDOUS INGREDIENTS** -----

<u>INGREDIENT</u>	<u>PERCENT</u>	<u>TLV/PEL</u>	<u>V.P.</u>	<u>CAS.#</u>
Solvent refined, hydrotreated, heavy paraffinic distillate	50-60	5 mg/m <sup>3</sup> *	-	64742547
Solvent refined, hydrotreated, middle distillate	0-25	5 mg/m <sup>3</sup> *	-	64742467
Severely hydrotreated light naphthenic distillate	0-25	5 mg/m <sup>3</sup> *	-	64742536
Polymeric additive in oil (poly-methacrylate)	10-15	None	-	None
Additive containing zinc dialkyl dithiophosphate	5- 6	None	-	Mixture

\*for oil mists

----- **SECTION III - PHYSICAL DATA** -----

BOILING POINT: N.A. SP. GRAVITY (WATER=1): 0.89  
 % VOLATILE VOLUME: N.A. EVAPORATION RATE: N.A.  
 VAPOR DENSITY: N.A. SOLUBILITY IN WATER: Insoluble  
 APPEARANCE/ODOR: dark amber/slight odor N.A. - not available

----- **SECTION IV - FIRE & EXPLOSION HAZARD DATA** -----

FLASH POINT: 390° F C.O.C. FLAMMABLE LIMIT - LEL: N.A.  
 EXTINGUISHING MEDIA: Water fog, foam, dry chemical, carbon dioxide, or halogenated  
 agents.  
 SPECIAL FIRE FIGHTING PROCEDURES: Do not use a direct stream of water. Product will  
 float and can be reignited on surface of water. Cool fire exposed containers with  
 water. Use NIOSH approved self-contained breathing apparatus.  
 UNUSUAL FIRE & EXPLOSION HAZARDS: None



## ----- SECTION V - HEALTH HAZARD DATA -----

EXPOSURE LIMIT: See Section II - Hazardous Ingredients

EFFECTS OF OVEREXPOSURE: Exposure to vapors or mists of this product may cause mild upper respiratory tract irritation. Prolonged or repeated contact may cause various skin disorders such as dermatitis, oil acne, or folliculitis. Eye contact is minimally irritating. Effects of ingestion are expected to be relatively non-toxic. Exposure to product may aggravate preexisting skin and respiratory conditions.

EMERGENCY & FIRST AID: Eyes - flush with water 15 minutes. Skin - remove contaminated clothing; wash skin with soap and water; if material is injected under the skin, do not wait for symptoms to develop - get medical attention promptly to prevent serious damage. Inhalation - remove victim to fresh air and provide oxygen if breathing is difficult. Ingestion - do NOT induce vomiting. In all cases seek medical attention.

## ----- SECTION VI - REACTIVITY DATA -----

STABILITY: Stable

INCOMPATIBILITY: Avoid open flame, and oxidizing materials

HAZARDOUS POLYMERIZATION: Will not occur

DECOMPOSITION PRODUCTS: Dependent on combustion conditions. A complex mixture of airborne solid, liquid, and gas will evolve when this material undergoes pyrolysis or combustion. Oxides of carbon, sulfur, phosphorous, and other unidentified organic compounds may be formed.

## ----- SECTION VII - SPILL OR LEAK PROCEDURE -----

STEPS TO BE TAKEN IN CASE MATERIAL IS RELEASED OR SPILLED: Dike and contain. Use vacuum or an absorbent such as clay or sand to pick up. Flush area with water to remove trace residue. NOTE: This product is classified as an oil under the Clean Water Act.

Spills, entering surface waters or any watercourse or sewer leading to surface waters, must be reported to the National Response Center 800-424-9802.

WASTE DISPOSAL METHOD: In accord with federal, state, and local regulations

## ----- SECTION VIII - PROTECTIVE EQUIPMENT INFORMATION -----

VENTILATION: Local exhaust to keep TLV/PEL below acceptable levels

RESPIRATOR: NIOSH approved as needed EYE WEAR: Recommended

GLOVES: Recommended to minimize skin contact OTHER:

## ----- SECTION IX - SPECIAL PRECAUTIONS -----

Minimize skin contact. Wash with soap and water before eating, smoking, or using toilet facilities. Launder contaminated clothing before reuse. Properly dispose of contaminated articles including shoes that cannot be cleaned. Store in a cool, dry place with adequate ventilation. Keep away from open flames. Keep away from children.

## ----- SECTION X - DATA PREPARATION -----

NAME: T. M. Snyder, CIH

TITLE: Industrial Hygienist

SIGNATURE:

DATE: January 29, 1998

-----  
The information contained herein is believed to be accurate. However, no warranty is expressed or implied regarding the accuracy of these data or the results to be obtained from the use thereof. Vendor assumes no responsibility for injury to vendee or third persons proximately caused by the material if reasonable safety procedures are not adhered to as stipulated in the data sheet. Furthermore, vendee assumes the risk in use of the material.



CITGO Petroleum Corporation  
P. O. Box 3758  
Tulsa, Oklahoma 74102

### Material Safety Data Sheet

Trade Name: CITGO No. 2 Fuel Oils, All Grades Date: September 26, 1997  
CAS No.: 68476-30-2 Commodity Code: AG2FO  
Synonyms: Fuel Oil, No. 2 Technical Contact: (918) 495-5933  
Medical Emergency: (918) 495-4700  
CITGO Index No.: 5388 CHEMTREC Emergency: (800) 424-9300

#### MATERIAL HAZARD EVALUATION

(Per OSHA Hazard Communication Standard [29 CFR 1910.1200])

**Health Precautions:** DANGER: Harmful or fatal if swallowed; can enter the lungs and cause damage. Contains Petroleum Distillates. If swallowed, do not induce vomiting. Call a physician immediately. Keep out of reach of children.

**Safety Precautions:** Combustible Liquid. Keep away from heat, flame and other potential ignition sources.

HMIS Rating<sup>1</sup>: Health: 1\* Flammability: 2 Reactivity: 0

### 1.0 GENERIC COMPOSITION / COMPONENTS

Components	CAS No.	%	Hazard Data
Petroleum Distillates (A complex mixture of hydrocarbons, having a viscosity range of 32.6 SUS to 37.9 SUS at 37.7° C (100°F).)	68476-30-2	100	Oral LD <sub>50</sub> (rat): 9.0 ml/kg Dermal LD (rabbit): > 5 gm/kg Dermal Sensitization: Nonsensitizing Skin (rabbit): Irritant Eye (rabbit): Mild irritant Teratogenesis (rat): Negative

### 2.0 PHYSICAL DATA

PHYSICAL HAZARD CLASSIFICATION (Per 29 CFR 1910.1200)

Combustible	Yes	Flammable	No	Pyrophoric	No
Compressed Gas	No	Organic Peroxide	No	Reactivity	No
Explosive	No	Oxidizer	No	Stable	Yes

<sup>1</sup>Hazard Rating: least-0; slight-1; moderate-2; high-3; extreme-4.

CITGO assigned these values based on an evaluation conducted pursuant to NPCA guidelines. Use of an asterisk (\*) indicates that the material may present chronic health effects.

NA-Not Applicable

ND-No Data

NE-Not Established

CITGO No. 2 Fuel Oils, All Grades (AG2FO, September 26, 1997, CIN: 5388)

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**2.0 PHYSICAL DATA (continued)**

Boiling Point, 760 mm Hg, °C (°F):	160 - 360 (320 - 680)
Specific Gravity (0 °F) (H <sub>2</sub> O = 1):	0.84
Vapor Density (Air = 1):	> 1
% Volatiles by Volume:	ND
Melting Point, °C (°F):	-29 (-20)
Vapor Pressure, mm Hg (25 °C):	2 - 26
Solubility in Water:	Negligible
Evaporation Rate:(n-butyl acetate = 1):	< 1
pH of Undiluted Product:	NA
Appearance and Odor:	
Dyed:	Red liquid, petroleum odor.
Undyed:	Water white to yellow tinted liquid, petroleum odor.

**3.0 FIRE AND EXPLOSION DATA**

Flash Point, OC, °C (°F):	ND
Flash Point, CC, °C (°F):	52 - 85 (125 - 185)
Autoignition Temperature, °C (°F):	254 - 285 (489 - 545)
NFPA Rating <sup>2</sup> :	Health: <u>0</u> Flammability: <u>2</u> Reactivity: <u>0</u>
Flammable Limits (% by volume in air):	Lower: <u>0.6</u> Upper: <u>7.0</u>
Extinguishing Media:	CO <sub>2</sub> , dry chemical, foam, water fog
Special Fire Fighting Procedure:	Wear self-contained breathing apparatus when in a confined area. Structural firefighter's protective equipment will only provide limited protection.
Unusual Fire or Explosion Hazard:	Fires involving the products represented by this MSDS may release irritating fumes.

**4.0 REACTIVITY DATA**

Stability:	Stable.
Conditions Contributing to Instability:	Heat, flame.
Incompatibility:	Oxidizing agents.
Hazardous Decomposition Products: (thermal, unless otherwise specified)	Carbon dioxide (CO <sub>2</sub> ), smoke, fumes, hydrocarbons, carbon monoxide (CO) and oxides of nitrogen.
Hazardous Polymerization:	Hazardous polymerization is not expected to occur.

**5.0 SPILL, LEAK AND DISPOSAL PROCEDURES****Procedure if Material is Spilled:**

- Remove sources of heat or ignition; provide ventilation; contain leak.
- **Small Spills:** Absorb released material with non-combustible absorbent. Place into containers for later disposal. (See Waste Disposal section below.)

<sup>2</sup>Hazard Rating: least-0; slight-1; moderate-2; high-3; extreme-4.

CITGO assigned these values based on an evaluation conducted pursuant to NFPA guidelines.

NA-Not Applicable

ND-No Data

NE-Not Established

## 5.0 SPILL, LEAK AND DISPOSAL PROCEDURES (continued)

- **Large Spills:** Evacuate area in the event of significant spills. Adequately ventilate area and determine potential exposure conditions. Exposure potential may require the use respiratory protection. Use protective clothing. Contain spill in temporary dikes to avoid product migration and to assist in recovery. Do not allow material to escape into sewers, ground water, drainage ditches or surface waters.
- Control ignition sources around spill area. Use of a fire fighting foam blanket on spilled material will reduce vapor release and fire potential.
- Administer first aid, as needed.
- OSHA regulations may require establishing a regulated area with site control.
- Report spills as required to appropriate federal, state and local authorities.

### Waste Disposal:

- It is the responsibility of the user to determine if the material is a hazardous waste at the time of disposal.
- Transportation, treatment, storage and disposal of waste material must be conducted in accordance with RCRA regulations (see 40 CFR 260 through 40 CFR 271).
- State and/or local regulations may be more restrictive.
- Contact the RCRA/Superfund Hotline at (800) 424-9346 or your regional US EPA office for guidance concerning case specific disposal issues.

### Protective Measures During Repair and Maintenance of Contaminated Equipment:

- Refer to Section 7.0 - Special Protection Information.
- Keep unnecessary persons from hazard area.
- Drain and purge equipment, as necessary, to remove material residues
- Use gloves constructed of impervious materials such as heavy nitrile and protective clothing if direct contact is anticipated.
- Provide ventilation to maintain exposure potential below applicable exposure levels.
- Eliminate heat and ignition sources.
- Remove contaminated clothing.
- Wash exposed skin thoroughly with soap and water.

## 6.0 HEALTH HAZARD DATA

### Health Hazard Classification (Per 29 CFR 1910.1200):

Highly Toxic	No	Sensitizer	No
Toxic	No	Reproductive Effects	No
Corrosive	No	Mutagen	No
Irritant	Yes	Target Organ (skin)	Yes

### Carcinogen:

Product/Component	CAS No.	Conc. (%)	NTP	IARC	OSHA	Other
No. 2 Fuel Oil	68476-30-2	100	No	Group 3	No	ND

### Toxicity Summary:

If swallowed, this material can enter the lungs and cause severe damage.  
This material can cause skin irritation.

NA-Not Applicable

ND-No Data

NE-Not Established

CITGO No. 2 Fuel Oils, All Grades (AG2FO, September 26, 1997, CIN: 5388)

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## 6.0 HEALTH HAZARD DATA (continued)

**Major Route(s) of Entry:** Inhalation of mists or vapors. Skin contact.

### Acute Exposure Symptoms:

- Inhalation:** Inhalation of mists or vapors above applicable workplace exposure levels can cause transient euphoria, respiratory tract irritation, gastrointestinal irritation, headache, dizziness, or central nervous system depression. Studies with laboratory animals suggest that bronchoconstriction and respiratory impairment are associated with inhalation of high concentrations of fuel oil mists.
- Dermal:** This material can cause skin irritation.
- Eye:** This material can cause transient eye irritation including stinging, tearing and swelling.
- Ingestion:** Symptoms of fuel oil ingestion can include burning of mouth and upper gastrointestinal tract, stomach cramps, coughing, drowsiness, restlessness, irritability, vomiting, diarrhea and unconsciousness. In addition, breathing difficulty may develop. Coughing, pneumonia and painful breathing can suggest that the product has entered the lungs. Ingestion of large concentrations of product can cause convulsions, coma and death.
- Injection:** Injection under the skin, in muscle or into the blood stream can cause irritation, inflammation, swelling, fever, and systemic effects, including pulmonary edema, pneumonia and mild central nervous system depression. Injection of pressurized hydrocarbons can severe, permanent tissue damage.

### Chronic Exposure Symptoms:

The products represented by this MSDS contain a mixture of petroleum hydrocarbons commonly referred to as "middle distillates." Laboratory data have associated some middle distillates with skin cancer when the material is applied repeatedly over the lifetime of the test animal.

Middle distillates similar to the products represented by this MSDS have been associated with liver and kidney damage in subchronic (90 day) inhalation studies of male rats. The relevance of these findings to human health is unclear.

Prolonged or frequent contact can cause the skin to dry or crack. Also, long term dermal exposure can cause an inflammation of the skin marked by redness, pain or itching (dermatitis).

### Other Special Effects:

None.

### Medical Conditions Aggravated by Exposure:

Individuals with chronic respiratory disorders, liver dysfunction or kidney disease can have these conditions aggravated by elevated exposure to vapors, mists or aerosols of this material.

### First Aid and Emergency Procedures for Acute Effects:

- Inhalation:** Move victim to fresh air. If victim is not breathing, immediately begin cardiopulmonary resuscitation (CPR). If breathing is difficult, 100 percent humidified oxygen should be administered by a qualified individual. Seek medical attention immediately.
- Dermal:** Remove contaminated clothing. Wash exposed skin with soap and water. Launder clothing before use. Seek medical attention if tissue appears damaged or if irritation persists.
- Eyes:** Flush eyes with cool water while occasionally lifting and lowering eyelids. Remove contact lenses if worn. Seek medical attention if excessive tearing, irritation or pain persists.

## 6.0 HEALTH HAZARD DATA (continued)

**Ingestion:** Do not induce vomiting. If spontaneous vomiting is about to occur, place victim's head below knees. Never give anything by mouth to a person who is not fully conscious. Seek medical attention immediately.

**Injection:** Injection under the skin, in muscle or into the blood stream is a medical emergency. Seek medical attention immediately.

### Notes to Physician:

**Inhalation:** If cough or difficulty in breathing develops, evaluate for respiratory tract irritation, bronchitis, or pneumonitis. Administer 100 percent humidified supplemental oxygen with assisted ventilation as required. In symptomatic patients (coughing, choking, tachypnea, etc.), monitor blood gases to assure adequate ventilation. If vital signs become abnormal or symptoms develop, obtain a chest x-ray.

**Ingestion:** The viscosity at of this material is approximately 32 SUS at 100° F. Accordingly, upon ingestion, there is a high risk of pulmonary aspiration. Aspiration can result in chemical pneumonitis or lipid pneumonia. Removal by careful gastric lavage with tight fitting, cuffed endotracheal tube may be considered.

Pulmonary edema can be managed with PEEP and supplemental oxygen. Antibiotics are indicated only if bacterial superinfection of the lungs occurs. Steroids have not been shown to be of benefit for hydrocarbon pneumonitis.

## 7.0 SPECIAL PROTECTION INFORMATION

### Ventilation Requirements:

Use in well ventilated area. In confined spaces or when hot, mechanical ventilation may be required to maintain airborne concentrations below applicable work place exposure levels as evaluated by designated and properly trained individuals.

### Applicable Workplace Exposure Levels:

Chemical Component	ACGIH TLV TWA ppm (mg/M <sup>3</sup> )	ACGIH TLV STEL/ Ceiling (C) ppm (mg/M <sup>3</sup> )	ACGIH TLV Skin notation?	OSHA PEL TWA ppm (mg/M <sup>3</sup> )	OSHA PEL STEL/ Ceiling (C) ppm (mg/M <sup>3</sup> )	OSHA PEL Skin notation?
Petroleum Distillates	NE	NE	NE	NE	NE	NE

### Specific Personal Protective Equipment:

Personal protective equipment should be selected based upon the conditions under which this material is used. A hazard assessment of the work area for PPE requirements should be conducted by a qualified professional pursuant to OSHA regulations.

**Respiratory:** Only NIOSH or MSHA approved equipment should be used. Use of an organic vapor and dust/mist filter dual cartridge respirator is required when vapor and mist concentrations exceed the applicable workplace exposure levels. Respiratory protection should be selected on the basis of the maximum expected air concentration.

**Eyes:** Use safety goggles or chemical splash goggles if splashing is anticipated.

**Dermal:** Use gloves constructed of impervious materials such as heavy nitrile rubber if frequent or prolonged contact is expected.

**Clothing or Equipment:** Wear body-covering work clothes to avoid prolonged or repeated exposure. Remove contaminated clothing and launder before reuse.

## 8.0 TRANSPORTATION AND SPECIAL PRECAUTIONS

**Storage:** Do not use or store this product near heat, flame or other potential ignition sources. Do not store with oxidizers. Do not store this product in unlabeled containers. Keep container closed.

**Danger:** **Flammable or Combustible Liquid.** Vapors are heavier than air and may travel to an ignition source and flash back. Use only in a well ventilated area. Never siphon by mouth. Empty containers may contain product residues which can ignite with explosive force. Consult appropriate federal, state and local authorities before reusing, reconditioning, reclaiming, recycling or disposing of empty containers and/or waste residues of this product.

**DOT Information:**

Proper Shipping Name:	Fuel Oil, No.2
Hazard Class:	3
Hazard Identification No.:	UN 1202
Placard:	Flammable liquid

## 9.0 ENVIRONMENTAL DATA

### Title III of the Superfund Amendments and Reauthorization Act of 1986 (SARA)

#### Section 313 - Toxic Chemicals:

This product is not known contain any components in concentrations above *de minimis* levels that are listed as toxic chemicals in 40 CFR Part 372 pursuant to the requirements of Section 313 of SARA.

#### Section 311/312 - Hazard Categories:

This product may meet one or more of the criteria for the hazard categories defined in 40 CFR Part 370 as established by Sections 311 and 312 of SARA as indicated below:

Immediate (Acute) Health Hazard:	<u>Yes</u>	Sudden Release of Pressure Hazard:	<u>No</u>
Delayed (Chronic) Health Hazard:	<u>Yes</u>	Reactive Hazard:	<u>No</u>
Fire Hazard:	<u>Yes</u>		

#### Section 302 - Extremely Hazardous Substances:

This product is not known to contain any components in concentrations greater than one percent that are listed as Extremely Hazardous Substances in 40 CFR Part 355 pursuant to the requirements of Section 302(a) of SARA.

#### Clean Water Act (CWA):

Under the CWA, discharges of crude oil and petroleum products to surface water without proper Federal and State permits must be reported immediately to the National Response Center at (800) 424-8802.

#### Comprehensive Environmental Response, Compensation & Liability Act (CERCLA) Section 102 Hazardous Substances:

As defined by CERCLA, the term "hazardous substance" does not include petroleum, including crude oil or any fraction thereof which is not otherwise specifically listed or designated as a hazardous substance.

**9.0 ENVIRONMENTAL DATA (continued)****California Proposition 65 (The Safe Drinking Water and Toxics Enforcement Act):**

**Warning:** This material contains the following chemicals which are known to the State of California to cause cancer, birth defects or other reproductive harm, and are subject to the requirements of California Proposition 65 (CA Health & Safety Code Section 25249.5):

<u>Component:</u>	<u>Effect:</u>
Diesel Engine Exhaust	Cancer

**New Jersey Worker and Community Right-to-Know Act:**

Fuel Oil (68476-30-2)

**Toxic Substances Control Act (TSCA):**

<u>Reported in TSCA Inventory as:</u>	<u>Product</u>	<u>Components</u>
No. 2 Fuel Oils	X	

**10.0 LABELING****DANGER:**

**HARMFUL IF SWALLOWED - CAN ENTER LUNGS AND CAUSE DAMAGE  
CONTAINS PETROLEUM DISTILLATES  
COMBUSTIBLE LIQUID  
CAUSES SKIN IRRITATION  
MAY CAUSE CANCER BASED ON ANIMAL DATA  
TARGET ORGAN(S): Skin**

**HANDLING:**

**Keep away from heat, sparks and flames. Keep container closed.  
Avoid breathing vapor or mists.  
Avoid direct dermal contact.**

**FIRST AID:**

**If swallowed, do not induce vomiting.  
Call a physician immediately.  
In case of contact, remove contaminated clothing immediately and wash thoroughly with soap and water.**

**ALL STATEMENTS, INFORMATION, AND DATA PROVIDED IN THIS MATERIAL SAFETY DATA SHEET ARE BELIEVED TO BE ACCURATE AND RELIABLE, BUT ARE PRESENTED WITHOUT GUARANTEE, REPRESENTATION, WARRANTY, OR RESPONSIBILITY OF ANY KIND, EXPRESSED OR IMPLIED. ANY AND ALL REPRESENTATIONS AND/OR WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE ARE SPECIFICALLY DISCLAIMED. USERS SHOULD MAKE THEIR OWN INVESTIGATIONS TO DETERMINE THE SUITABILITY OF THE INFORMATION OR PRODUCTS FOR THEIR PARTICULAR PURPOSE. NOTHING CONTAINED HERE IN IS INTENDED AS PERMISSION, INDUCEMENT OR RECOMMENDATION TO VIOLATE ANY LAWS OR TO PRACTICE ANY INVENTION COVERED BY EXISTING PATENTS, COPYRIGHTS OR INVENTIONS.**

NA-Not Applicable

ND-No Data

NE-Not Established

CITGO No. 2 Fuel Oils, All Grades (AG2FO, September 26, 1997, CIN: 5388)

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# MATERIAL SAFETY DATA SHEET

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

H A Z A R D R A T I N G	4 - EXTREME	
	3 - HIGH	
	2 - MODERATE	
	1 - SLIGHT	
	0 - INSIGNIFICANT	

**SECTION I**

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

**SECTION II - CHEMICAL AND PHYSICAL PROPERTIES**

HAZARDOUS DECOMPOSITION PRODUCTS	FORM
6   Carbon monoxide, carbon dioxide	8   Semi-solid
INCOMPATIBILITY (KEEP AWAY FROM)	ODOR
6   Strong oxidizing agents such as: hydrogen peroxide, chromic acid, bromine	9   Mineral Oil
LIST ALL TOXIC AND HAZARDOUS INGREDIENTS	APPEARANCE
7   None	10   Grease
	COLOR
	11   Amber
	SPECIFIC GRAVITY
	12   (WATER = 1) RT 0.924

**SECTION III - FIRE AND EXPLOSION DATA**

SPECIAL FIRE FIGHTING PROCEDURES	FLASH POINT (METHOD USED)	BOILING PT.
24   Fire fighters should wear an approved self contained breathing apparatus.	Above C.O.C.	13   NDA °C
	26   190 °C 374 °F	°F
	FLAMMABLE LIMITS %	MELTING PT.
	27   LOWER NDA UPPER	14   NA °C
UNUSUAL FIRE AND EXPLOSION HAZARDS	EXTINGUISHING AGENTS	°F
25   Dense smoke	<input checked="" type="checkbox"/> DRYCHEMICAL <input checked="" type="checkbox"/> CO, <input type="checkbox"/> WATERSPRAY <input checked="" type="checkbox"/> FOAM <input checked="" type="checkbox"/> WATERFOG <input checked="" type="checkbox"/> SAND/EARTH 28   <input type="checkbox"/> OTHER	SOLUBILITY IN WATER
		15   AT 25 °C Negligible
		% VOLATILE (BY WT %)
		18   NA
		EVAP. RATE
		17   ( = 1) NA
		VAPOR PRESSURE (mm Hg at 20 °C)
		18   NA
		VAPOR DENSITY (AIR = 1)
		19   NA
		pH AS IS
		20   NA
		STRONG ACID
		STRONG BASE
		STABLE
		21   UNSTABLE
		VISCOSITY SUS AT 100 °F
		22   < 100 100 OR >XX
		23   NA

**SECTION IV - HEALTH HAZARD DATA**

PERMISSIBLE CONCENTRATIONS (AIR)	VAPOR DENSITY (AIR = 1)
29   NDA	20   NA
EFFECTS OF OVEREXPOSURE	
30   May cause skin & eye irritation with prolonged contact.	
TOXICOLOGICAL PROPERTIES	
31   NDA	
EMERGENCY FIRST AID PROCEDURES	
32   EYES Flush with large amounts of water for at least 15 min. Call a physician immediately.	
33   SKIN CONTACT Wash thoroughly with soap and water.	
34   INHALATION NDA	
35   IF SWALLOWED Call a physician immediately.	

NA = NOT APPLICABLE

NDA = NO DATA AVAILABLE

<= LESS THAN

>= MORE THAN

# MATERIAL SAFETY DATA SHEET

PRODUCT SA 825 0012

## SECTION V - SPECIAL PROTECTION INFORMATION

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

## SECTION VI - HANDLING OF SPILLS OR LEAKS

PROCEDURES FOR CLEAN-UP  
 Transfer bulk of material into another container. Absorb remaining residue with proper absorbents such as sand, earth, vermiculite. Sweep up and dispose as solid waste in accordance to local, state and federal regulations.  
 41

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

## SECTION VII - SPECIAL PRECAUTIONS

PRECAUTIONS TO BE TAKEN IN HANDLING AND STORAGE  
 Keep containers closed.  
 43

## SECTION VIII - TRANSPORTATION DATA

UNREGULATED BY D.O.T. <input checked="" type="checkbox"/>	U.S. D.O.T. PROPER SHIPPING NAME 47	
REGULATED BY D.O.T. <input type="checkbox"/>	U.S. D.O.T. HAZARD CLASS 48	I.D. NUMBER 49
TRANSPORTATION EMERGENCY INFORMATION  CHEM TREC 1-(800) 424-9300 54	RQ LABEL(S) REQUIRED 60 51 FREIGHT CLASSIFICATION Petroleum Lubricating Grease 52 SPECIAL TRANSPORTATION NOTES 53	

## SECTION IX - COMMENTS

KEEP OUT OF REACH OF CHILDREN!!  
 54

SIGNATURE Ray G. Leonard TITLE Manager Technical Compliance

REVISION DATE \_\_\_\_\_ SENT TO ATTN: \_\_\_\_\_ DATE 3/05/84

SUPERSEDES \_\_\_\_\_

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



# MATERIAL SAFETY DATA SHEET

Tox no. : 042840

Page 1

Print Date : 04/02/90  
Last Reviewed : 05/03/89

Part Type and Number

Part name

Ford - U.S. BATTERY - ALL  
Motorcraft - U.S. BATTERY - ALL

BATTERY ELECTROLYTE  
BATTERY ELECTROLYTE

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

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

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

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

Exposure Limit Abbreviations

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

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

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

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

**DANGER -- CORROSIVE**

----- HAZARDS -----

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

M S D S  
(CONTINUED)

Tox no. : 042840

Page 2  
Print Date : 04/02/90

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

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

Lungs  
Teeth  
Skin, Eyes, and Respiratory System

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

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

7664-93-9 SULFURIC ACID  
Inhalation, adult rat, LC50 = 510 mg/m<sup>3</sup> (2 Hours)  
Oral, adult rat, LD50 = 2140 mg/kg

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

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

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

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



Tox no. : 042840

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Print Date : 04/02/90

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

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

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

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

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

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

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

This is an acidic material.

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

Shipping name: BATTERY FLUID, ACID UN: 2790  
 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

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Print Date : 04/02/90

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

Health and safety information has been evaluated by:

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

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

This is the last page of this MSDS.



MATERIAL SAFETY  
DATA SHEET

AMOCO REGULAR LEAD-FREE GASOLINE

MSDS NO: 02003992

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

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

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

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

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

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

#### HEALTH HAZARD INFORMATION

##### EYE

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

##### SKIN

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

##### INHALATION

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

PAGE 02 OF 05

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HEALTH HAZARD INFORMATION - CONTINUED

---

INGESTION

EFFECT: Low viscosity product. Harmful or fatal if aspirated into lungs.  
FIRST AID: If swallowed, do NOT induce vomiting. Get immediate medical attention.

---

FIRE AND EXPLOSION INFORMATION

---

FLASHPOINT: -45°F  
FLAMMABLE LIMITS: UPPER: 7.6% LOWER: 1.3%  
AUTOIGNITION TEMPERATURE: 495°F  
EXTINGUISHING MEDIA: Agents approved for Class B hazards (e.g., dry chemical, carbon dioxide, halogenated agents, foam, steam) or water fog.  
UNUSUAL FIRE AND EXPLOSION HAZARDS: Extremely flammable vapor/air mixtures form. Extinguishment of fire before source of vapor is shut off can create an explosive mixture in air.  
PRECAUTIONS: Keep away from ignition sources (e.g., heat, sparks and open flames). Keep container closed. Use with adequate ventilation.

---

REACTIVITY INFORMATION

---

DANGEROUS REACTIONS: Avoid chlorine, fluorine and other strong oxidizers.  
HAZARDOUS DECOMPOSITION: Burning can produce carbon monoxide and/or carbon dioxide and other harmful products.  
STABILITY: Burning can be started easily.

---

CHEMICAL AND PHYSICAL PROPERTIES

---

BOILING POINT: 80°F TO 430°F, Range  
SOLUBILITY IN WATER: Negligible, below 0.1%.  
SPECIFIC GRAVITY (WATER = 1): 0.75  
VAPOR PRESSURE: 7-15 lb RVP (ASTM D-323)  
VAPOR DENSITY (AIR = 1): 3 TO 4

PAGE 03 OF 05

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STORAGE AND ENVIRONMENTAL PROTECTION

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**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

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**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.

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SUPPLEMENTAL INFORMATION - CONTINUED

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

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

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

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

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

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

ISSUE INFORMATION

BY:



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

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

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

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

# MATERIAL SAFETY DATA SHEET

## SECTION I

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

## 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 <sub>2</sub> O=1)	.951
VAPOR PRESSURE (mm Hg)	N/A	PERCENT VOLATILE BY VOLUME (%)	N/A
VAPOR DENSITY (AIR=1)	N/A	EVAPORATION RATE	N/A
SOLUBILITY IN WATER	Complete		
APPEARANCE AND ODOR	Blue-aromatic		

## SECTION IV FIRE AND EXPLOSION HAZARD DATA

FLASH POINT (Method used)	T.C.C. 112 F	FLAMMABLE LIMITS	Let	Uel
EXTINGUISHING MEDIA	Dry chemical, CO <sub>2</sub> 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.			

## SECTION V HEALTH HAZARD DATA

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

## SECTION VI REACTIVITY DATA

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

## SECTION VII SPILL OR LEAK PROCEDURES

STEPS TO BE TAKEN IF CASE MATERIAL IS HELD (SPILL OR SPILLED) Place leaking container in well ventilated areas, eliminate ignition sources. Avoid run-off into storm sewers and ditches which lead to natural waterways
WASTE DISPOSAL METHOD Incineration, biological treatment of dilute solution.

## SECTION VIII SPECIAL PROTECTION INFORMATION

RESPIRATORY PROTECTION (Specify type)			
VENTILATION	LOCAL EXHAUST When appropriate to control employee exposure.	SPECIAL	
	MECHANICAL (General)	OTHER	
PROTECTIVE GLOVES Neoprene or rubber gloves	EYE PROTECTION Chemical safety goggles		
OTHER PROTECTIVE EQUIPMENT			

## SECTION IX SPECIAL PRECAUTIONS

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

# seisPRIME/E<sup>®</sup> Emulsion Seismic Explosive



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

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

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

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

## PROPERTIES AND SPECIFICATIONS

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

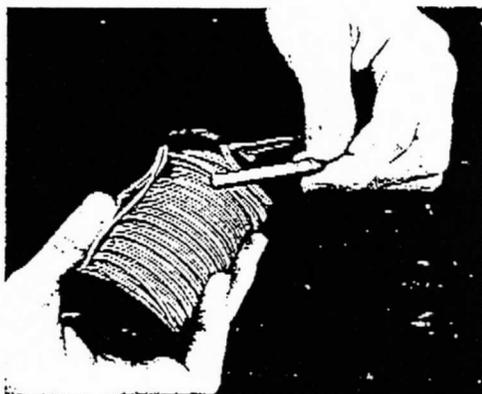
## PACKAGING

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

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

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

## STATICMASTER<sup>®</sup> Electric Detonators for Seismic Exploration



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

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

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

## PROPERTIES AND SPECIFICATIONS

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

## REDUCED SENSITIVITY TO EXTRANEIOUS 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 electric detonators meet all requirements for series firing.

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

## PACKAGING

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

HAZARDOUS CHEMICAL MATERIAL SAFETY DATA SHEET

(Conforms to the Requirements of 29 CFR 1910.1200)

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

1. NAME AND ADDRESS OF MANUFACTURER:

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

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

3. MEDICAL EMERGENCY TELEPHONE NUMBERS:

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

4. THE MATERIALS DESCRIBED IN THIS DATA SHEET ARE:

HAZARDOUS CHEMICAL INGREDIENTS

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

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

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

Note: See MSDS for Ammonium Nitrate Plus Fuel Oil

6. PHYSICAL AND CHEMICAL CHARACTERISTICS:

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

nd = No Data      d = Dissociates      na = Not Applicable

7. PHYSICAL HAZARDS:

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

8. HEALTH HAZARDS:

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

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

10. PERMISSIBLE EXPOSURE LIMITS: No Data

11. LISTINGS:

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

12. GENERALLY APPLICABLE PRECAUTIONS FOR SAFE HANDLING AND USE:

HYGIENIC PRACTICES:

Avoid Skin and Eye Contact. Avoid Breathing Blasting Fumes.

PROTECTIVE MEASURES DURING REPAIR AND MAINTENANCE OF CONTAMINATED EQUIPMENT:

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

PROCEDURES FOR CLEANUP OF SPILLS AND LEAKS:

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

13. CONTROL MEASURES:

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

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

PERSONAL PROTECTIVE EQUIPMENT:

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

14. EMERGENCY AND FIRST AID PROCEDURES:

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

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