Seismic Reflection Survey: Health and Safety Plan

Kansas Geological Survey
Exploration Services Section

USA-CRREL
Yuma Proving Grounds SWTR
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Kansas Geological Survey Exploration Services

Accident Prevention Plan

Project Name: Optimized Estimation of Earth Seismic Properties

Location: Yuma Proving Grounds SWTR

Plan prepared by _____ _____
Signature Date

Plan approved by _____ _____
KGS Safety Officer Date

Plan has been reviewed by the following crew members:

Name (printed)	Signature	Date

KANSAS GEOLOGICAL SURVEY EXPLORATION SERVICES
ACCIDENT PREVENTION PLAN

I. PROJECT DESCRIPTION

Project Name: Optimized Estimation of Earth Seismic Properties

Location: Yuma Proving Grounds SWTR

Site Safety Officer: Richard D. Miller

Plan Prepared By: Richard D. Miller

Estimated Duration of Field Work: 10 days

II. STATEMENT OF WORK

The Army is developing battlefield sensor networks intended to classify, track, and monitor the amount of ground vehicle traffic in rear operation areas. It is expected that these networks will rely heavily on seismic sensing capabilities and must function at a high degree of performance across a wide range of geologic settings. In support of these developing systems, we propose to conduct a carefully designed set of near-surface geophysical experiments using state-of-the-art high-resolution seismic exploration methods. We also propose to support system adaptation and performance prediction by collaborating in the development of methods to remotely sense geologic conditions. Our major objective is to define the 3-D near-surface soil and geologic variations over a well-defined region of a specified systems test range. We will be particularly concerned with mapping the geologic variations that have the largest impact on multi-mode seismic surface-wave propagation.

Measurement and analysis of earth properties by University of Kansas, Kansas Geological Survey (KU/KGS) personnel will be used to validate Army propagation models by providing needed geologic input data from a site selected by CRREL. It is expected that the input geologic data provided by KU/ KGS will be of sufficient detail and fidelity to allow CRREL, and other collaborating research groups, to make quantitative comparisons between simulated vehicle data and measured field data. Our measurements and analyses will include reflected, direct, and refracted P-waves and S-waves, plus dispersion analyses of surface waves. We will fuse these diverse data types by applying optimal sample point interpolation and spatial sampling based on geostatistics. This approach will yield quantitative statistical bounds on the resulting seismic parameters associated with the site's geologic structure.

Our broad experience in the application and development of near-surface body-wave exploration methods is well documented in the refereed literature over the past 15 years. More recently, our successful development and application of multi-channel surface-wave inversion techniques (MASW) have reached refereed journals and the less formal conference proceedings of both the SEG and EEGS. Geostatistical expertise within our research team has been globally recognized for more than 30 years. We can extend this expertise to support the development of

remote sensing estimations of geology and thus provide the total body of expertise that is required to address all aspects of the characterization problem.

GENERAL PROGRAM OBJECTIVES

In the first two years of our proposed work our objective is to provide CRREL with a 3-D geologic model over a limited volume of earth at a specific Army test area. This earth volume is expected to be no larger than 1 km by 1 km by 100 m in extent. Initial estimates of power spectra as a function of offset will be calculated for various seismic wave types. At that point the earth volume will be divided into a cellular grid, which will provide the optimum resolution based on frequencies in the recorded data. Within each grid cell we will specify key seismic propagation parameters including seismic body wave velocities (V_p, V_s) and measures of seismic energy loss in terms of Q_p, and Q_s. The earth model will preserve the local topographic variation, layer positioning, and thickness by correcting all data to actual ground surface, which will likely be accomplished through the use of multiple sloping datums. We will depend on CRREL to supply the needed surface topography at an appropriate resolution and scale. Estimates of these seismic properties will be bounded throughout the 3-D earth model via application of geostatistics. If additional data, such as density or borehole measurements, are provided by CRREL, we will incorporate these into the KU/KGS earth model. Formulation of models and appropriate interpretations that incorporate the seismic measurements and geostatistical analysis will represent a significant milestone. Significant insight into the overall problem could be gained by continuing this research through the collection and analysis of data from other geologic settings. Integration of the final product with other geological and remote sensing data will be a logical continuation of this research.

In the third and fourth years our major concentration will be assisting the Army in the development of methods for using remotely sensed data for estimating 3-D geologic structure and geophysical properties. In addition, geophysical investigations will be needed to verify the remotely sensed geologic interpretations. The ability to estimate geologic parameters in denied areas, using remote sensing, would greatly enhance the utility of battlefield seismic sensing. However, characterization of near-surface geologic structure via remotely sensed data is a new and rapidly developing field. As such, it presents substantive technical challenges and will require close collaboration among a number of specialists including geologists, geomorphologists, geophysicists, and remote sensing specialists. In our current conceptual framework this will consist of three stages. First, Army remote sensing specialists would gather and appropriately format remote sensing data and interpret it to provide information of the following types: high resolution topography, spectral determination of soil and rock type, soil moisture, vegetation, water bodies, and road construction and layout. Second, a collaborative team will estimate first-order 3-D geology using the provided remotely sensed data in conjunction with expert rules-of-thumb derived from standard geological principles of soil emplacement and structural geology. Accomplishment of this component of the research will require augmentation of the team with appropriate geoscientists. Finally, we will apply appropriate geophysical investigations (such as those described in later parts of the proposal) to ascertain the accuracy of the geologic predictions.

SITE CHARACTERIZATION OBJECTIVES (FY 01 and FY 02)

When geophysics is used for site characterization, it routinely involves measurement and incorporation of data from as many as three or four different geophysical tools and techniques, each of which responds to different earth properties. If shallow seismic is one of the tools,

interpretations typically have focused on qualitative assessment of subsurface layer topography rather than on quantitative measurements (Clement et al., 1997; Pullan and Hunter, 1990; Lankston, 1990). The resulting acoustically derived subsurface structure and velocity maps are incorporated into geologic and hydrologic models constructed from borehole data. These simplistic models are used for groundwater monitoring purposes in an intuitive, experience-based manner (Steeples and Miller, 1990; Miller and Xia, 1999).

Seismic measurement or imaging data has been underutilized for site characterization, considering the wealth of information contained in the seismic wavefield (Steeples et al., 1995). Surface seismic techniques have been limited almost exclusively to routine mapping and delineation of subsurface structures, layer topography, anomalies, and stratigraphic changes (Jongerius and Helbig, 1988; Miller et al., 1989; Goforth and Hayward, 1992; Miller et al., 1995; Shtivelman et al., 1998; Guo and Liu, 1999; Stokoe et al., 1994; Michaels, 1999). In most instances, different earth properties (V_p, V_s, Q_p, Q_s, layer orientation, and thickness) can be estimated from each seismic wave type, providing the potential for redundant measurement if several techniques are applied coincidently. Phase velocity is probably the parameter most consistently measured or estimated by all the seismic methods.

This applied research project will evaluate as many seismic imaging and sampling techniques as necessary to redundantly estimate V_p and V_s independently within subsurface cells. If seismic data are acquired repeatedly using parameters and equipment optimized for specific parts of the wavefield, it should be possible to estimate V_p and V_s from as many as three different measurements. It will be necessary to first determine which methods are applicable to a specific test area and then to define acquisition and processing parameters and equipment necessary to optimize the resulting velocity information. Designing the distribution of subsurface cells, interpolating between sample points, and constructing confidence levels on values in the 3-D volume will require geostatistical procedures. Estimation of Q will be based on amplitude difference comparisons observed in consistent surface waves and direct, refracted, and reflected body waves between adjacent traces. This method of determining attenuation will provide a close approximation of Q for both S- and P-type waves.

Other geophysical measurements may be necessary to provide confirmation of physical properties or to determine additional physical properties. These methods may include cone penetrometer, cross-hole seismic, GPR, or soil density mapping. The role of density in seismic wave propagation models can only be determined with certainty with appropriate simulations. CRREL or CRREL contractors will be relied upon for determining the significance of density on the future models and for any physical measurements of density. Enhancement of the seismic model studies may be possible using direct one-way velocity or blow count measurements such as those possible with the cone penetrometer. Extending the 2-D measurements into the 3-D volume may require borehole seismic measurements such as cross-hole tomography. Other information about the upper one or two meters provides valuable insight into a variety of problems in high-resolution seismic studies. Near-surface GPR surveys may provide key insight into changes in thickness of the ultra-low velocity layer that are undetectable on shallow seismic surveys, but which exert a strong influence on trace-to-trace consistency in arrival time and waveform. If these data are necessary to further constrain the KU/KGS geologic model, it will be the responsibility of CRREL or its contractors to provide these surveys. If such data are provided, they will be incorporated into the statistical KU/KGS earth model.

This research group has extensive experience in high-resolution shallow seismic reflection, surface wave inversion, and geostatistical methods. Feasibility of P-wave and S-wave reflection, refraction, and turning ray tomography, as well as S-wave velocity inverted from

surface waves, coincident P-wave refraction and surface wave inversion, three-component VSP, and three-component reflection will be studied using data acquired during an extensive series of tests at a site where good subsurface control can be obtained. Based on initial wavefield tests, several 2½-D acquisition designs will be evaluated using geostatistical methods. Once the best seismic methods have been selected and acquisition designs have been optimized, a geophysical survey of a volume approximately 200 m × 100 m × 200 m deep will be made and physical properties estimated and assigned to cells within the survey area. If the data are of sufficient resolution and accuracy to satisfy the Army's requirements, a 1 km × 1 km × 0.2 km volume can be acquired in a later phase of the project, based on results of the feasibility test.

SITE CHARACTERIZATION PROGRAM COMPONENTS

Reflection

A properly designed and executed high resolution P-wave or S-wave seismic reflection survey should be capable of mapping all high-amplitude reflectors separated by 10 m or more in the upper 200 m at most sites. We will concentrate on: 1) generating high resolution (>100 Hz P-wave and 60 Hz S-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 reflections as well as with other seismic data, 5) ensuring offset distributions appropriate for measuring the velocity from NMO curves and semblance analysis, 6) integrating well-established shallow high-resolution methods and conventional approaches to 2½-D, 7) tailoring processing flows to optimize the accuracy and spatial distribution of velocity analysis, 8) developing an accurate velocity function correlated to borehole guided depth models, and 9) correlating compressional and shear wave velocities to specific reflectors. Proven high-resolution techniques will be used to design the data acquisition parameters and determine optimum equipment and methodologies (Steeples and Miller, 1990). This will likely include the use of multiple sloping datums to insure the topographic effects on the processed data will be minimized. Sloping datums reduce the assumptions associated with static corrections of near-surface topography and subsurface velocity variations. Topographic corrections such as this will be necessary for all the seismic methods.

Maximizing the resolution potential, interpretability, and signal-to-noise ratio will be emphasized in the reflection surveys. Continuous CMP profile lines (Mayne, 1962) will be acquired using a 240-channel fixed spread, rolled to maintain the optimum recording window for each recorded shot (Hunter et al., 1984). The seismic source, geophone type, spread geometry, shots/point, and acquisition philosophy used to acquire the CMP profile lines will be based on the results of walkaway noise tests and geostatistical analyses. Data will be initially acquired and processed to delineate local stratigraphic, structural, and topographic features within the upper 200 m using state-of-the-art high-resolution methods and equipment. Once all interpretable reflections are fully processed, different methods will be evaluated for their use in extracting detailed velocity information as a function of depth and grid coordinates.

Following a geostatistical study of spatial estimation uncertainty using a radial 2½-D test array, reflection data will be acquired for a rectangular 2½-D survey geometry that is optimized to provide the best spatial distribution of measured physical properties in the most cost-effective manner. Line spacing, geophone spacing, and line orientations will address spatial, imaging, and interpolation requirements and budgetary constraints. Data acquisition and processing for the 2½-D production data will generally follow well-established shallow high-resolution data acquisition methodologies, emphasizing correlation of lines 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 velocity 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 tunnel 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. 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 velocity characteristics. This highly redundant method improves the accuracy of calculated shear-wave velocities and minimizes the likelihood of irregularities resulting from erratic dispersion curves corrupting the analysis.

Acquisition of surface-wave data will be consistent with the reflection survey. Data will be acquired along the same profile lines using the same receiver spacing. Because of the unique requirements of surface-wave measurement it will be necessary to use different sources, receivers, and geometry than used in the 2½-D reflection surveys. Shear-wave velocity maps generated along each profile line will be optimized for resolution, using several approaches whose purpose is to minimize smearing resulting from variable wavelength averaging. Data also will be acquired for surface-wave analysis for tomography and refraction studies.

Refraction/Tomography

Direct and refracted P-wave and S-wave arrivals will be analyzed using conventional methods (Palmer, 1981; Haeni, 1986; Lankston, 1990) and inversion techniques (Scott, 1977; Schneider et al., 1992; Ivanov et al., 2000). Use of direct and refracted arrivals for mapping distinct velocity contrasts between layers has been in routine use for everything from crustal seismic research (Steinhart and Meyer, 1961) to shallow groundwater studies (Haeni, 1978). It is an established, proven technique whose limitations are well documented (Soske, 1954; Sander, 1978). Methods to approximate solutions when physical conditions violate assumptions of the refraction method (Mooney 1981; Redpath 1973) are known. Recent research incorporating refraction inversion with shear-wave velocity calculations from surface wave data has provided encouraging results which seem to be insensitive to the velocity reversal problem (Ivanov et al., 2000).

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 applications 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 and refraction analyses. Using this approach requires little or no additional acquisition, but permits an additional property to be estimated within each cell

using a unique combination of computational techniques. Processing of data for tomographic analysis will use existing algorithms and standard methods, such as algebraic reconstruction (Peterson et al., 1985), curved-ray (Chiu et al., 1986), and transformation methods (Lo et al., 1988). Because surface-wave and/or refraction data will be used for turning ray tomographic reconstructions, evaluating the combination of computational techniques as described above will not adversely affect the economics of this study, whether the combination is successful or not.

Downhole/VSP

Surface-to-borehole data can be acquired to check the accuracy of velocity-field calculations and measurements obtained from the various seismic methods. It will be the responsibility of CRREL or its contractors to make available or to install boreholes on-site for ground-truth measurements. Borehole data integrated with surface-seismic measurements can be extended away from the hole site using geostatistical cokriging (Olea, 1999). Acquisition, processing, and interpretation of vertical seismic profiles (VSP) will follow well-established guidelines (Hardage, 1983). As with most seismic methods, adapting methods developed in the oil industry to shallow targets requires deviating from accepted "rules of thumb." To establish the degree of anisotropy, walkaway VSPs will be acquired along orthogonal lines with the borehole at the line intersection. Near-vertical offset VSP (ZVSP) will aid in correlation and eventually establishing precise ties between well-log data and reflection events interpreted on CMP stacked sections. Offset VSP (OVSP) profiles will assist with lithologic and structural interpretations as well as provide valuable velocity information.

Three-Component Recording

It will be necessary to understand the complete elastic vector wavefield in order to address problems mentioned in the program objectives section and to meet input requirements of model studies to be performed by the endusers of data from this project. We propose to record 3-component data along carefully selected portions of the 2½-D profile lines for incorporation into and use with coincidently acquired single-component survey data. Details of the seismic vector wavefield using sensors placed as close as one meter apart have not been well documented in the refereed literature. Placing geophones as little as five meters apart invites spatial aliasing of both surface waves and ground-coupled air waves (Steeples and Miller, 1998), so smaller geophone spacings must be used. As part of the initial testing, an unaliased set of vector-wavefield seismograms will be acquired using a Galperin geophone configuration for evaluation purposes. We will attempt to identify all coherent wave trains on each vector component of the seismograms and to examine their spectra. While the 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, and to target those features that are not clearly understood for continued investigation. We anticipate that CRREL or CRREL contractors will provide forward modeling to support the vector-wavefield seismogram analysis.

Modeling: An Aid to Interpretation

Modeling requirements beyond basis acoustic simulations used for planning and crude interpretation of body-wave arrivals on seismograms will need to be provided by CRREL or its contractors. Finite-difference modeling may be necessary to assist validating interpretations on shot gathers, CMP gathers, and CMP stacked sections. Confident identification of all aspects of the seismic wavefield will be an important complement to most seismic techniques employed in this study. Both forward and reverse modeling can be used for interpretation and quality control,

ensuring analyses utilize signal and not coherent noise. After determining the velocity structure (V_p and V_s) and attenuation values (Q_p and Q_s) from the various field data, the V_p, V_s, Q_p, and Q_s values should be used to generate a seismic model. This seismic model can be used to evaluate the relative importance of density across the range of expected values. It may also play an important role in the confident identification and study of dispersion curves, guided waves, refracted and reflected energy, and mode conversions. Model output will be needed for precise comparisons with original field data. The comparisons will be followed by refinements to the input parameters and appropriate reinterpretation of field data so that modifications can be made to techniques used in extracting V_p, V_s, Q_p, and Q_s from the data. Again, we emphasize that CRREL or its contractors will be responsible for all but the simplest and most basic modeling aspects of this project.

Geostatistical Analysis

Geostatistics is a branch of applied statistics that is especially relevant to geophysics in general and to this program in particular. Geostatistics measures the degree of relationship between observations of a property that have been made at locations in real space. Geostatistical methods can explicitly determine how uncertainty increases with distance from sample points, what is the optimum configuration of sample points, and what are the best estimates of the property at unsampled locations (Olea, 1999).

In Phase 3 of this program, geophysical measurements will be made along a radial pattern of six intersecting lines at successive 30° orientations (Figure 1). Spatial covariance functions modeled from these data will be used to detect any anisotropies in the geophysical fields, and to estimate the most efficient sample spacing needed to obtain data commensurate with the specified precision and maximum acceptable level of uncertainty. This information will be used to design the 2½-D survey of Phase 5 so that its orientation and shotpoint spacing are optimum.

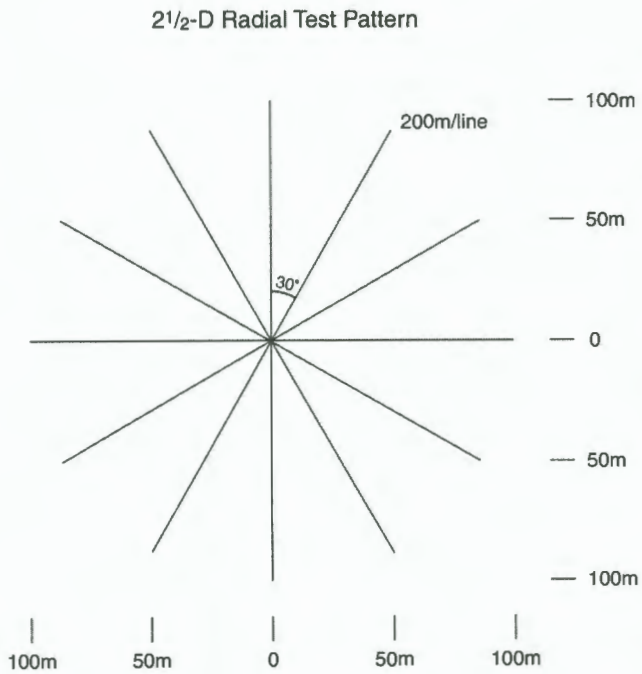


Figure 1

After data acquisition in Phase 5, geostatistical estimation procedures (kriging) will be used to interpolate from values of the geophysical properties measured at the geophone stations along the sampling lines to the three-dimensional array of points within the interior of the test volume. Kriging yields optimal estimates that are theoretically superior to estimates that could be produced by any other method. The kriging technique simultaneously estimates the associated uncertainty, in the form of a kriging variance. Kriging results can be interpreted as the "lowest likely" value, the "most likely" value, and the "highest likely" value for the geophysical property at every location within the surveyed volume. Co-kriging, a procedure that takes into account

the joint spatial statistics of several variables, will also be used to interpolate any petrophysical properties measured in the drill holes to the three-dimensional array.

The results of geostatistical analysis can be provided in the form of conditional stochastic realizations (Deutsch and Journel, 1998). Each realization is a three-dimensional array whose values conform exactly to the observed data at every control point along the seismic lines. At all interpolated locations, the values will follow the same statistical distributions as the observed data. Each realization is a "possible scenario" which has characteristics that are statistically identical to those actually observed. These realizations can be entered directly into simulation models and will be available to CRREL and its subcontractors if desired.

OUTLINE OF PROPOSED PROGRAM

Phase I

a. Studies will be conducted at the U.S. Army's Yuma Proving Grounds to extend our knowledge of the basic seismic properties of the site. It is anticipated that this experiment will augment previous walkaway studies using both compressional and shear receivers and sources. Testing will require one or at most two days with analysis consistent with data acquisition. It is the intent of this study to produce a representative sampling, an "average" compressional and shear wave velocity, surface wave dispersion curve characteristics, frequency range of seismic signal, velocity variability, and general attenuation properties. It will also be an objective of the team to assess site-access difficulties, coupling concerns, and logistical issues. Results will guide the approach used and parameters selected for phases II and III activities scheduled to commence near the beginning of the calendar year 2001. A copy of the high-resolution digital elevation model (DEM) of the test site will be transferred to the KGS and incorporated into a cartographic database for use in the project.

Phase II

b. Velocity and attenuation measurements will be made to establish ground truth in boreholes located within the study area. A realistic velocity-with-depth function and attenuation as a function of depth and frequency will be determined. These baselines will be used to evaluate the accuracy and effectiveness of each geophysical technique tested. A three-component hole-lock geophone and sledge hammer (and accelerated weight drop) will be used to record the borehole survey. Vertical samples will be taken on a 1-m interval, with source offsets from the borehole ranging from 2 m to 100 m. Velocity and attenuation tables will be tabulated on site. Borehole selection will be made by CRREL personnel and the PI's based on proximity to the test area, absence of contamination, and borehole construction.

c. Walkaway noise tests will be the basis for establishing accuracy and effectiveness of each seismic method evaluated. Walkaway noise testing will be dynamic and exhaustive, modified as dictated by the recorded data. A complete set of tests will be conducted at two separate locations within the test area. Sources and receivers selected for testing will be appropriate for the technique being evaluated. At least two different source-to-nearest receiver offsets will be used. Based on the maximum depth of interest, receiver spacing will likely be 0.5 m, with data acquired from both ends and the middle of the test spread. In addition, off-end data will be collected with 2 m and 122 m source-to-nearest receiver offsets. This configuration will provide maximum offsets in excess of 240 m for each source and receiver tested. These offset will likely be increased to as much as 1 km for refraction analysis. If explosive are necessary (as is likely for offsets exceeding 200 m), CRREL or its contractors will provide the high explosives, drill the necessary shot holes, and assign a properly licensed and permitted individual to handle and detonate the explosives.

d. All walkaway data will be coincidently processed to establish the ideal configuration for each technique. Processing will include calculations and comparisons of each technique to borehole-derived ground truth. A preferred source, receiver, offset, spacings, and recording parameters for each technique as well as the data-acquisition order will be established.

Phase III

e. Contingent on walkaway tests and the VSP, a 2½-D radial test pattern will be deployed and all techniques with potential to meet the objectives at this site will be tested. Ideally, the borehole used to calibrate the site will be near the center of the radial pattern. Optimal source and receivers will be deployed for each technique with data acquired consistent with results from the walkaway noise tests. Based on initial estimates, an area approximately 250 m × 250 m will be necessary to accommodate this test pattern, within a 1 km square for long offset source stations. A long offset attenuation test will be undertaken that will require a moderate size charge of high explosive be detonated from more than a kilometer from the radial test pattern. Analysis of these data will provide insight into energy partitioning between body and surface waves. Acquisition, installation, and detonation of this test charge will be the responsibility of CRREL or its contractors.

Phase IV

f. Process each data set gathered using the radial test pattern. Estimate or calculate the velocity and/or attenuation as a function of depth for each spatial sample point (as a function of frequency and attenuation). Build a 2½-D velocity and attenuation matrix with each measurement appropriately located within a cell, based on the surface location of the measurement station and depth to target. Using geostatistical estimation, assign a confidence interval around each defined velocity or attenuation value.

g. Design an optimal 2½-D grid for spatial sampling and sample interpolation based on geostatistics. In consultation with CRREL and its subcontractors, determine the dimensions of cells for the 2-D and 3-D analyses, considering model requirements and the results of geostatistical analyses. Devise procedures for up-scaling or down-scaling cell estimates as needed to meet model requirements. Using the multiple measurements of velocity and attenuation and confidence estimates provided for each cell of the 2-D matrix, establish the "best" V_p, V_s, Q_p, and Q_s for each cell. Determine the optimum 2½-D survey design based on the radial test pattern for acquisition of seismic properties for the proposed 1 km × 1 km × 0.2 km survey volume.

Phase V

h. Acquire the data on a 2½-D survey as optimized by field testing and analysis as well as geostatistical analysis. Methods that provide meaningful physical property measurements will be used to acquire a **full-test volume** (200 m × 100 m × 200 m) of data.

i. Processing of all the data. Build a 2-D velocity and attenuation matrix with each measurement (using the previously validated method) appropriately located within a cell based on approximate surface location of measurement and depth.

j. Formulate a 3-D volume of cells with V_p, V_s, Q_p, and Q_s and confidence ratings for each. Interpolation will be done between sample lines using geostatistical kriging using optimal parameters determined during previous testing.

k. Evaluation by CRREL personnel to determine usability of provided test volume.

Phase VI

l. Acquire the data on a 2½-D survey as optimized by field testing and analysis as well as geostatistical analysis. Methods that provide meaningful physical property measurements as evaluated during development of full-test volume during Phase V will be used to acquire a **full volume** (no larger than1 km × 1 km × 200 m) of data.

m. Processing of all data. Build a 2-D velocity and attenuation matrix with each measurement (using the previously validated method) appropriately located within a cell based on approximate surface location of measurement and depth.

n. Formulate a full 3-D volume of cells at a size and format consistent with CRREL's needs and future use, including V_p, V_s, Q_p, and Q_s, all with confidence intervals. Interpolation will be done between sample lines using geostatistical approaches determined to be optimal during previous testing.

Phase VII

o. Develop insight into the overall problem by collecting and analyzing data from other geologic settings. These sites will be selected by CRREL and will be studied to optimize the development of "rules of thumb" that can be used in correlating remote sensing and geologic information from relevant tactical locations. Specific properties to be estimated and integrated with other relevant geologic data will include Vp, Vs, depth to bedrock, depth to water table, and other soil properties.

TEST SITE

Yuma Proving Grounds, Arizona

Based on need and availability of sites possessing the necessary near-surface materials, Yuma Proving Grounds, Arizona was selected by CRREL as the initial test site for this seismic characterization experiment. It will be the responsibility of CRREL to establish protocol and clearances with post command. KGS will provide all voice and data transmission frequency bands and wattage levels for radio communications. Copies of appropriate licenses for all radios will be available to CRREL upon request.

Future studies in association with Phase VII may be undertaken in any one of a variety of sites, most likely one of the Army's research sites in Alaska, Michigan, or Maryland.

SUMMARY OF EQUIPMENT, SPECIFIC TESTS, AND TIMELINE OF PROPOSED PROGRAM

1) Seismic system – Geometrics 240-channel R60 StrataView w/StrataVisor controller (p. 18)

2) Equipment and testing parameters (see pictures on pp. 13-18)
   - 100 Hz L-40A Mark Products geophones
   - single 4.5 Hz GS-11 Geospace geophones
   - single 14 Hz GS-11D Geospace horizontal geophones
   - double 40 Hz L-28E Mark Products geophones
   - triple 10 Hz U2w Mark Products geophones
   - single 3-component hole lock Geostuff geophone
   - single P-44 Mark Products hydrophone
   - single 28 Hz U2 Mark Products geophones
   - Galperin 3 component geophone bases (can be used with Mark Products phones above 27 Hz)
   - downhole 50 cal projectile source
   - Betsy 8 gauge surface projectile source
   - surface/downhole 30.06 projectile source
   - variety of combinations–hammer (20 lb, 16 lb, 8 lb, 2 lb) and
     –plate (1 sq ft × 1", 0.25 sq ft × 1", 2" shaft, 1" shaft, punch)
   - slide hammer impact source
   - IVI Buggy-mount high-frequency vibrator (15 to 500 Hz, 6000 lb peak force)
   - 8 & 12-gauge auger gun
   - RAWD (Rubberband Assisted Weight Drop) P-Wave
   - RAWS (Rubberband Assisted Weight Slam) S-Wave
   - Bolt LSS-6 Land Airgun

   Testing will include:
   - establishing source characteristics—record each source with borehole geophone
   - attenuation comparison surface to borehole
   - particle motion—vector field determinations
   - various source configurations
   - geophone response and sensitivity
   - several different types of linear sweeps within the 50-400 Hz range
   - number of shots or vibrations to obtain optimum vertical stacking
   - optimum receiver station spacing
   - source power and offset
   - determination of sampling interval (spatial and time) based on appropriate oversampling
   - 480-trace, pseudo-continuous walkaway with source offsets from 0.5 m to 120 m
   - digital filtering

3) Likely optimal design for surface seismic production:
   a. **Reflection—P-wave**: Vibrator (3 sweeps/station) or downhole 50 cal, 240 recording channels, 40 Hz geophones, 1 m receiver spacing, 2 m source spacing, and rolling fixed spread. It is very likely that this program could be scaled down by as much as 75% depending on analysis of testing.
   b. **Reflection—S-wave**: Vibrator (4 sweeps/station) or RAWD (6 impacts/station), 240 recording channels, 14 Hz geophones, 2 m receiver spacing, 4 m source spacing, and rolling fixed spread. It is very likely that this program could be scaled down by as much as 75% depending on analysis of testing.

c. **Surface Wave—S-wave**: RAWD (3 impacts/station), 60 recording channels, 4.5 Hz geophones, 1 m receiver spacing, 2 m source spacing, and an end-on rolling spread. It is very likely that this program could be scaled down by as much as 75% depending on analysis of testing. Land streamer technology may be applicable, providing a significant additional cost reduction.
d. **Refraction—P-wave**: RAWD (12 impacts/station) or Bolt LSS-6 Land Airgun (6 discharges w/60 cubic inch gun), 240 recording channels, 10 Hz geophones, 2.5 m geophone spacing, 30 m shot spacing, and fixed spread.
e. **Refraction—S-wave**: RAWS (20 impacts/station), 240 recording channels, 14 Hz geophones, 5 m geophone spacing, 60 m shot spacing, and fixed spread.

4) Likely optimal design for downhole seismic (VSP):
   - 3-component hole lock geophone and/or single hydrophone (depending on coupling)
   - 150 m maximum vertical profile
   - 1 m vertical station spacing
   - As many as 3 source offset positions
   - Source selection based on characteristics

5) Planned Research Schedule (assumes all methods are used on a 200 m × 200 m line spacing across a volume 1 km × 1 km × 0.2 km):

	Approx. Duration
Mobilization/Demobilization	4 months
Travel, 4 roundtrips (anywhere in contiguous US)	2 months
Walkaway noise testing/VSP	3 days
Walkaway noise test analysis/modeling	2 days
2½-D radial pattern	7 days
2½-D radial pattern data processing & analysis	2 months
2½-D optimized test grid data acquisition	7 days
Generation of 3-D seismic properties cells for test grid	3 months
2½-D optimized grid data acquisition	4 months
Processing 2½-D data	9 months
Generation of 3-D seismic properties cells	2 months

Appendix A



Minivib in P-wave configuration with high output value.



IVI Minivib in SH mass configuration.



Shear wave waffle plate footprint



Auger gun (12 gauge and 8 gauge).



Auger gun detached from transport and power vehicle (loader).



Downhole 30.06.



Downhole 30.06 with protective sheath being installed.



Silenced 30.06 projectile.



Loader-mounted downhole auger drill.



Hand held downhole source auger.



Left: Vehicle mounted downhole source drill with 50 cal. source transport and rear rack below water supply tank.



50 caliber downhole seismic source loading with 750 grain projectile.





Far left: 16 lb sledgehammer impacting steel striker plate.

Near left: Sledgehammers (20, 8, and 12 lb pictured); right pair outfitted with hammer switches.



Right: 16 lb slide hammer source with 16 in^2 contact plate.



Rubberband Assisted Weight Drop (RAWD) attached to tracked loader.



Double 40 Hz geophones with 14 cm spikes.



4.5 Hz geophone with steel base plate.



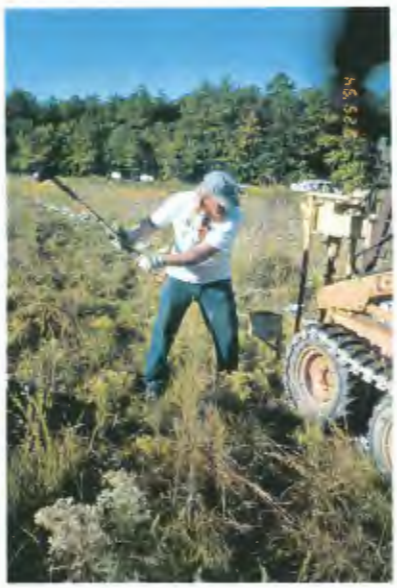
4.5 Hz geophones with spikes connected to 4 ft takeout, 60 pair seismic cables.



Triple 10Hz UltraPhones with 14 cm spikes.



Triple 10Hz UltraPhones planted in a 2 ft array.



Vehicle holding down shear wave block with steel endplates and teeth for ground coupling.



14 Hz shear wave geophone planted with connector and cable takeout protected from ground moisture by a plastic tub.



14Hz shear wave geophone with level bubble.



P-44 hydrophone element with 250 ft max operating depth.



Three-component hole lock geophone with kevlar cable and controller.



A 240-channel Geometrics Strataview seismograph mounted on a 6-wheel John Deere Gator with rear operator seat.



Four 60-channel Geometrics Strataviews networked with a 240-channel roll-along switch, IVI Vib controller, time break conditioners, line checker, VHF radio, and powered by 6 deep cycle marine batteries.



Polaris ATV used to move cables, geophones, and other small equipment around the site.



Tractor-trailer for transporting the IVI Minivib and cables, geophones, and other heavy support equipment.



Crew cab truck with covered trailer used to transport ATVs, seismograph, electronic support equipment, and personnel.

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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 USA-CRREL as well as those included in this document.

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

1. In the event of electrical storms in the vicinity, all surface operations will cease if lightning strikes are closer than three miles (determined by 15 second count between lightning and thunder).

2. If conditions become excessive (i.e., temperature > 100° < 30° F), continuous day operations will be modified to minimize chances for heat- or cold-related medical problems. 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° F.

7. The seismic crew will operate with an established protocol for initiating seismic sources. The safety plan will be approved by the USA-CRREL 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.

11. All ammo will be cataloged and provided to YPG staff when initial site check-in occurs. YPG staff will be responsible for transport, storage, and issue of ammo once on-site and work has begun.

IV. SAFETY PERSONNEL

Safety Personnel and Emergency Contacts

1. Rick Miller (KGS)—Site Safety Officer
2. David Laflen (KGS)—Operations
3. Mark Moran, Steve Ketcham, and Dave Fisk (CRREL), Alan Tinseth (YPG)—Delegated Representatives and Site Supervisors
4. Chad Gratton (KGS)—Safety Coordinator
5. Joe Anderson (KGS)—Line Chief

Safety Meeting at Survey Site Date: _____

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

The following people were present today:

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Specific Safety Requirements

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

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

Fire/Explosion Prevention: No smoking or open fires are allowed in or around KGS vehicles. *The ammunition vehicle will be equipped with a fire extinguisher. The ammunition vehicle will always be in visual contact of a qualified crew member. All ammunition will be kept in steel ammunition cases stored (when not in use) in a locked steel container attached to the ammunition vehicle.* [*Italics* here denotes that this is the responsibility of YPG.]

Time of Work: Every effort will be made to expedite all work during clear daylight hours under unrestricted visibility, in good weather conditions. YPG limits workers to 14 hours per day and 60 hours per week. KGS will operate in shifts to accommodate these requirements.

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

All KGS staff will be required to comply with rules outlined with this plan and provided by YPG staff. Failure or inability of USA-CRREL or KGS personnel to comply with the site safety guidelines presented herein will be grounds for suspending all project work until compliance can be assured.

Copies of this Accident Prevention Plan will be available on the dashboard of project vehicles. Emergency call numbers and evacuation routes are included in this safety plan.

Compliance with the following KGS General Health and Safety Rules is required by the KGS of all its staff and any visitors working or present on the job site in all operations.

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

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

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

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

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

5. Use the safety equipment specified for the job.

6. Practice good housekeeping in the work area.

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

8. Do not take shortcuts. Use designated paths.

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

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

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

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

13. Operators of other equipment and motor vehicles, while on duty, shall not operate equipment or vehicles for a continuous period of more than 10 hours in any 24-hour period without at least eight consecutive hours of rest; nor shall any employees, while on duty, operate any equipment or motor vehicles after being in a duty status for more than 12 hours during any 24-hour period without at least eight consecutive hours of rest.

V. EMERGENCY INFORMATION

Police/Ambulance:	911
Medical Center:	Call on Range Radio for assistance
YPG Operations:	3333
Fire Department (YPG):	2949
Explosives Unit (YPG):	7197
LaFanta Motel:	520-329-1814
BW Coronado Motel:	520-783-4453 / 877-234-5567 toll free

CRREL-YPG Emergency Contacts

CRREL Project Coordinator	Mark Moran Office 603-646-4274
CRREL Site Coordinator	Dave Fisk Office 603-646-4571
YPG Site and Safety Coordinator	Alan Tinseth Office 520-328-6146 (DSN 899-6146)

KGS Emergency Contacts

Safety Coordinator and Project Manager
Rick Miller, Kansas Geological Survey
Cellular (in the field): 785-766-8636

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.)

Call Emergency Services on range radio. They will send appropriate assistance.

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	Rick Miller
Certified in:	First Aid	CPR	40hr OSHA	David Laflen
Certified in:	First Aid	CPR	~~40hr OSHA~~	Joe Anderson
Certified in:	First Aid	CPR	~~40hr OSHA~~	Chad Gratton

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 YPG 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 USA-CRREL, 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.

Downhole 8-gauge Auger Gun

One of the geophysical tests proposed to be employed requires the use of an auger gun (shotgun type device) to introduce energy into the ground (Healey et al., 1991). This device consists of a small skid-steer loader with an attached auger/screw. The operation consists of (1) screwing the hollow stem auger approximately 3 ft into the ground, (2) retrieving the center bit, (3) loading the shell in the firing tube and lowering the tube until it latches in place, (4) firing the gun by impacting the top of the firing tube with a small hammer, and (5) unscrewing the auger from the ground. The auger gun uses a *blank* 8-gauge or 12-gauge shotgun shells fired below the ground surface in a downward direction. The device is built to minimize any danger to persons handling and moving the device, as well as avoid leaving any residual materials in the ground. The shotgun shells will be secured in a specially designed steel, lockable, explosives box attached to a vehicle at all times. The operation/safety rules and regulations for the auger gun are presented as an appendix to this plan.

30.06 Downhole Projectile Source

Experiments will be carried out with a downhole projectile source. This source is a specially modified 30.06 rifle designed to be loaded and fired while secured to the ground in a downward direction. The firing tube is lowered about one foot into a 1" hole. A standard 30.06 rifle shell is loaded in the above-ground breech and then detonated so that air coupled wave (blast), gas, projectile, and shrapnel are contained within the 1" hole. The procedure calls for 1) drilling a 1" x 1' hole, 2) placing the firing tube in the hole (covering the end of the tube with a finger cot), 3) loading a 30.06 round into the above-ground breech, 4) locking the bolt in place, 5) assuming the firing position, 6) detonation, and 7) removal from the hole. The device has successfully and safely fired over 30,000 rounds since 1985. All rounds are stored in a secure steel box.

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 hard hat 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 value (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.

Bolt LSS-6 Land Air Gun

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

Control Measures

1) The careful and safe operation of the standard 4 wheel drive truck is well documented in the owners manual.
2) It is critical to always be aware of anyone near the device.
3) The raising of the gun for transport and lowering of the gun just prior to detonation is done with only part of the gun visible to the operator. It is critical that no one comes within 50 ft of the gun while in operation.
4) Hearing protection (down 30 dB) is required by anyone within 50 ft of the truck.

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.

50-cal. Downhole

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

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 en- lightened 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: *Use of Class "C" Shotgun Ammunition* (Auger gun / Buffalo gun / 50 cal. / 30.06)



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

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

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

Specific shotgun ammunition safety measures when KGS is managing ammo are as follows:

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

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

- Handling: Only Rick Miller or qualified alternate, KGS, will be allowed to access, handle, and load the shotguns. Shotgun loading and firing will be conducted in accordance with the attached "Operations/Safety Rules and Regulations for the Auger Gun."

- Firing Communication: Rick Miller, David Laflen, or Chad Gratton shall establish a series of warning signals to be used prior to and following each shot. An audio signal will indicate the beginning of a shot (or prior site specified requirements). He will review the precise warning procedures with all project participants at the initial site safety meeting, and will monitor compliance with these procedures.

- Safe Distances: All project personnel not authorized to handle the shotgun ammunition and guns must stay a distance of 10 feet away from the guns and shot locations. Non-project personnel will not be allowed in the work area.

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

Ammunition safety measures on-site are the responsibility of YPG demo staff. The previous protocols are KGS minimums and can serve as fall-back measures if YPG demo staff are so inclined.

Transportation. Transportation of the auger guns and ammunition is on a standard 2-ton flatbed truck and enclosed gooseneck trailer. The ammunition is carried in .50-caliber military-style ammo boxes. The ammo boxes are locked in 10-gauge steel boxes that are permanently bolted to the truck bed. The ammunition is classified as "Class C Explosive" by the U.S. Department of Transportation. No more than 2,500 rounds of ammunition will be transported to this project, packed in quantities of around 160 per container.

B. Work Item: *Modified Auger Gun*



Specific Hazards–Detonation outside downhole environment and hand entanglement in moving parts.

Control Measures–Safe gun practices (detailed in supporting documents), care and inspection of firing mechanism, and minimum standoff distance from source when under hydraulic power.

C. Work Item: *Downhole 50-cal.*





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

D. **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.

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



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

Control Measures

1) The careful and safe operation of the standard 4 wheel drive truck is well documented in the owners manual.
2) It is critical to always be aware of anyone near the device.
3) The raising of the gun for transport and lowering of the gun just prior to detonation is done with only part of the gun visible to the operator. It is critical that no one comes within 50 ft of the gun while in operation.
4) Hearing protection (down 30 dB) is required by anyone within 50 ft of the truck.

F. **Work Item:** ***MiniVib***



The MiniVib is a hydraulically powered vibrator designed to shake the ground in a very controlled fashion over about a 4 to 8 second time duration. The device is hydraulically powered with no moving parts that possess an entanglement potential. Energy is delivered to the ground by this

device through a hydraulically powered pad approximately 3 ft in diameter mounted on the belly of the vehicle. The pad is lowered from beneath the vehicle using the vehicle's weight as hold-down pressure. The pad is vibrated by a hydraulic servo delivering frequency-varying energy to the plate over a preset time duration. No moving parts are exposed with the maximum movement of the pad relative to the vehicle less than 2 in.

Control Measures

1) This vehicle is center articulating and requires care when turning that no one is within 20 ft of the vehicle.
2) Safe operation of the vehicle is documented in the operator's manual provided by the manufacturer.
3) Hearing protection is required within 50 ft of the vehicle.
4) All shields are to remain in place while the vehicle is in operation
5) Hydraulic pressures of more than 3000 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.

G. 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.

H. 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).

I. **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 repellant. 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. HANDLING AND DISPOSAL OF UNEXPLODED ROUNDS

The handling of live ammunition will be in complete compliance with sections VIII.A and B and seismic gun operation procedures (both sections of this report). In the event a round does not detonate using standard operating procedures, the seismic source will be left in place undisturbed for a minimum of 3 minutes. After this initial 3 minutes, the shell will be extracted to insure minimal contact with operators. The unexploded round will be placed in the metal container used for the storage of spent rounds. If the round is an 8-gauge it will remain in the sleeve for a minimum of 20 minutes after placement in the metal can prior to being placed in a metal can and locked in the steel containers attached to the truck. If it is a 50-cal. round it will remain in the can for 20 minutes before it will be removed and re-stored in a metal can in the metal transport boxes attached to the truck. The unexploded rounds will then be delivered to YPG demolitions staff for disposal at YPG.

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

XIV. REFERENCES

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

From the United States Department of Energy:

DOE Order 5480.16, *Firearms Safety*.

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

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

From the United States Department of Defense:

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

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

SAFETY ANALYSIS

Potential Hazard	Consequences	Mitigation/Prevention Mechanism
Lost/Stolen Ammunition	Personal injury or property damage from unauthorized use.	Implementation of system to issue daily ammunition allotment and control inventory, in addition to physical control of ammunition at all times.
<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.

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

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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

KGS 05/1999

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):

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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

KGS 05/1999

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):

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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

KGS 05/1999

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

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

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

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

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

B. Cleaning

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

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

C. *Firing*

1. Assumptions

NONE

2. Never Do's

Move from downhole placement with shell in chamber
Gun loaded with no one standing on plate
With one person on plate
With knees locked
Extract a shell in less than 2 minutes that does not detonate
Without both operators aware of detonation
Drop a loaded round
Return a mis-fire to live round canisters

March 24, 1987

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

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

Operational Safety Rules

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

Downhole Mode

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

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

Surface Mode

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

5/10/92

OPERATION/SAFETY RULES AND REGULATIONS
FOR THE

AUGER GUN

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

Operation and Safety Regulations

1) Each day the Site Safety Officer (SSO) must brief all members of the seismic crew on the proper operation and maintenance of the auger gun.

2) Prior to set-up on any location the site must be cleared of all potential underground hazards and utilities. The 'tip-over' potential of a site (directly related to topography) must also be considered prior to access with the loader.

3) The firing rod is never transported or stored loaded or in firing mode (locked into the auger) prior to downhole placement of the auger.

4) The firing rod is stored unloaded (no sleeve snapped onto the bottom) in the left side storage holster during downhole placement and in-field movement.

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

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

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

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

Improved Shallow Seismic-Reflection Source: Building a Better Buffalo

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

SUMMARY

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

INTRODUCTION

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

The most commonly used seismic sources on shallow engineering surveys have fallen under two main categories: explosives or weight drops. The explosive category includes both high explosives and 'guns'. Weight-drop sources include everything from mechanically assisted vertical mass impacts (usually >20 kg mass) to human-assisted vertical mass impacts (sledge hammers, malls, and thors). Recent advances in high-frequency engineering sources have come predominantly under the 'gun' classification. Development of a downhole shotgun capable of generating a consistently high frequency source wavelet with only minimal increase in expense and effort over hammers, spurred the shallow seismic-reflection industry. Downhole shotgun sources possess significantly more energy in the 200 to 600 Hz range in comparison to hammer sources (Pullan and MacAulay, 1987).

DESIGN AND TECHNIQUE

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

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

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

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

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

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

RESULTS

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

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

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

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

CONCLUSION

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

ACKNOWLEDGMENTS

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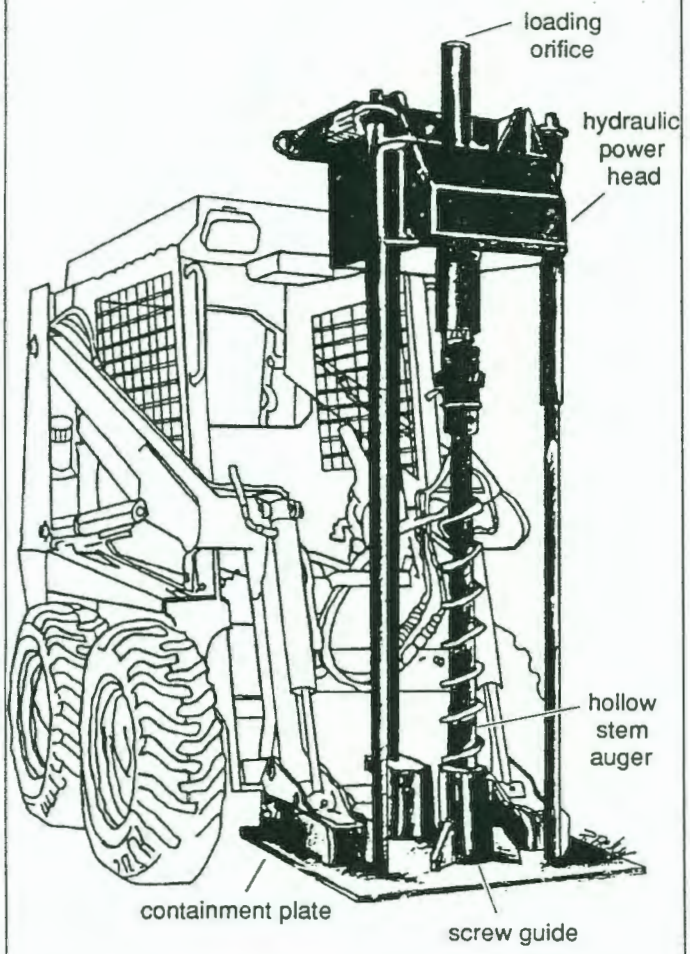


Fig. 1 Diagram represents the auger gun in above-ground position. Modified buffalo-gun portion of the auger gun is not shown, but is conceptually the same as previously documented (Pullan and MacAulay, 1987).

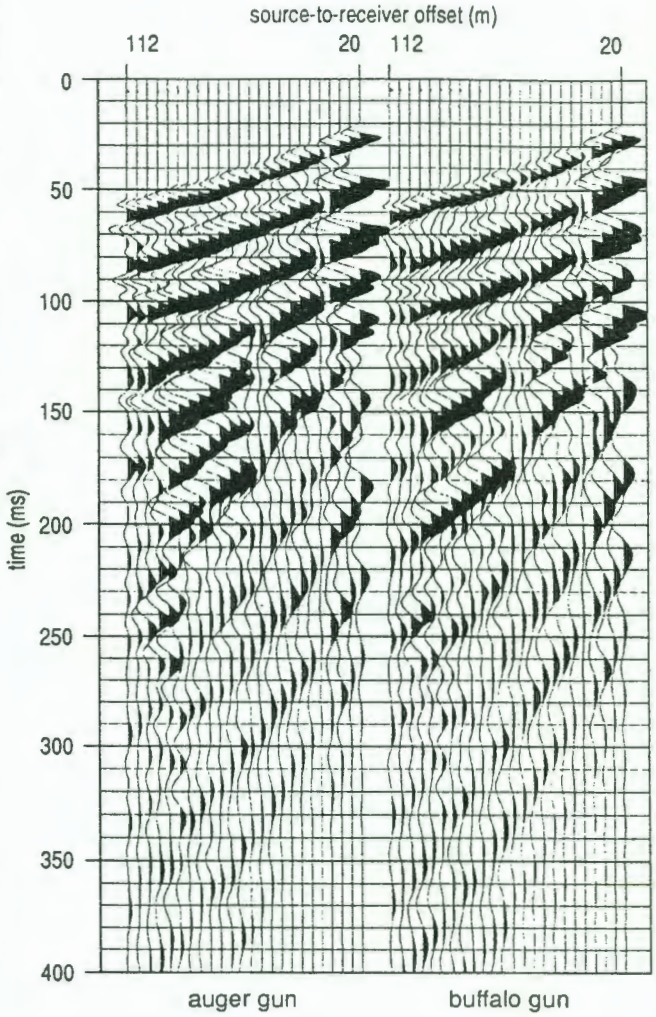


Fig. 2 Auger gun field file (left) compared to the buffalo gun (right).

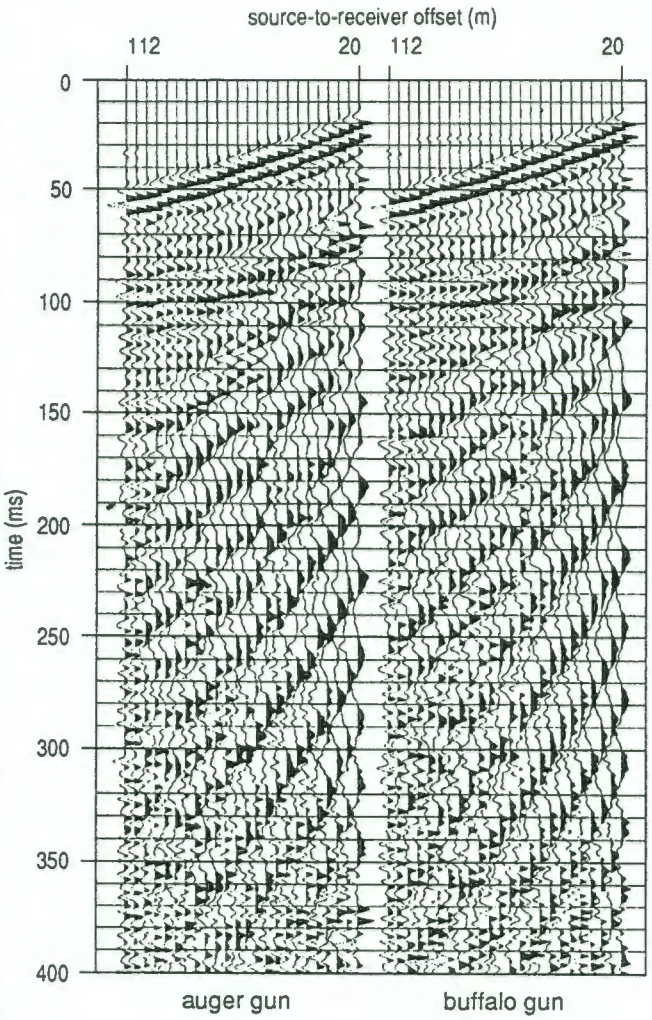


Fig. 3 A 150 Hz digital low-cut filter enhanced the 80 ms reflection event on both the auger (left) and buffalo (right) guns.

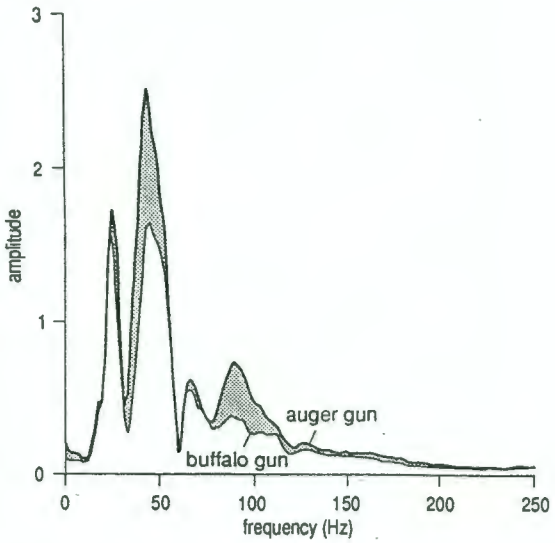


Fig. 4 The darkened area represents the difference between the lower curve (buffalo gun) and the upper curve (auger gun).

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

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

SUMMARY

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

INTRODUCTION

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

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

DESIGN AND TECHNIQUE

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

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

FREQUENCY AND AMPLITUDE

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

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

SAFETY

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

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

CASE STUDY

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

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

Downhole .50-caliber Field Files and Spectrum

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

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

ACKNOWLEDGMENTS

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

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

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

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

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

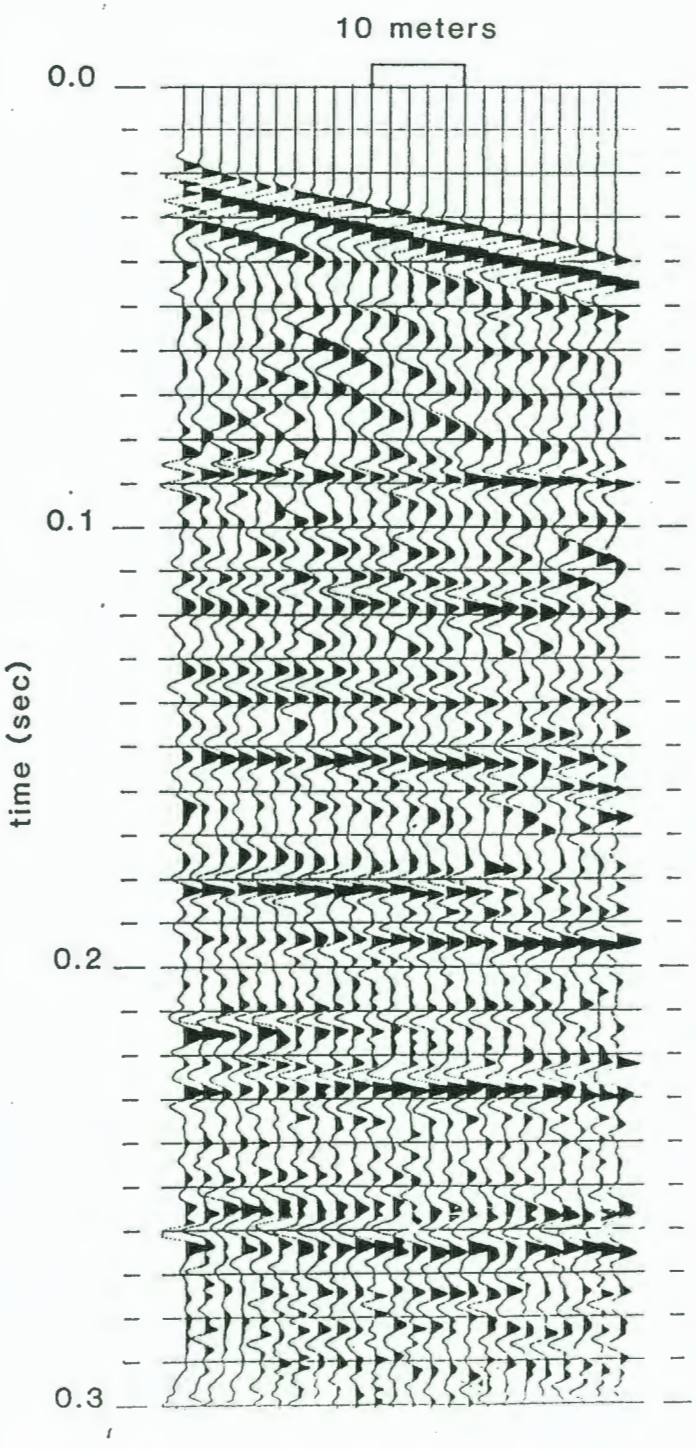


FIG. 2. This single-shot field file with an AGC applied illustrates the high frequencies and therefore the resolution easily obtainable with a downhole .50-cal.

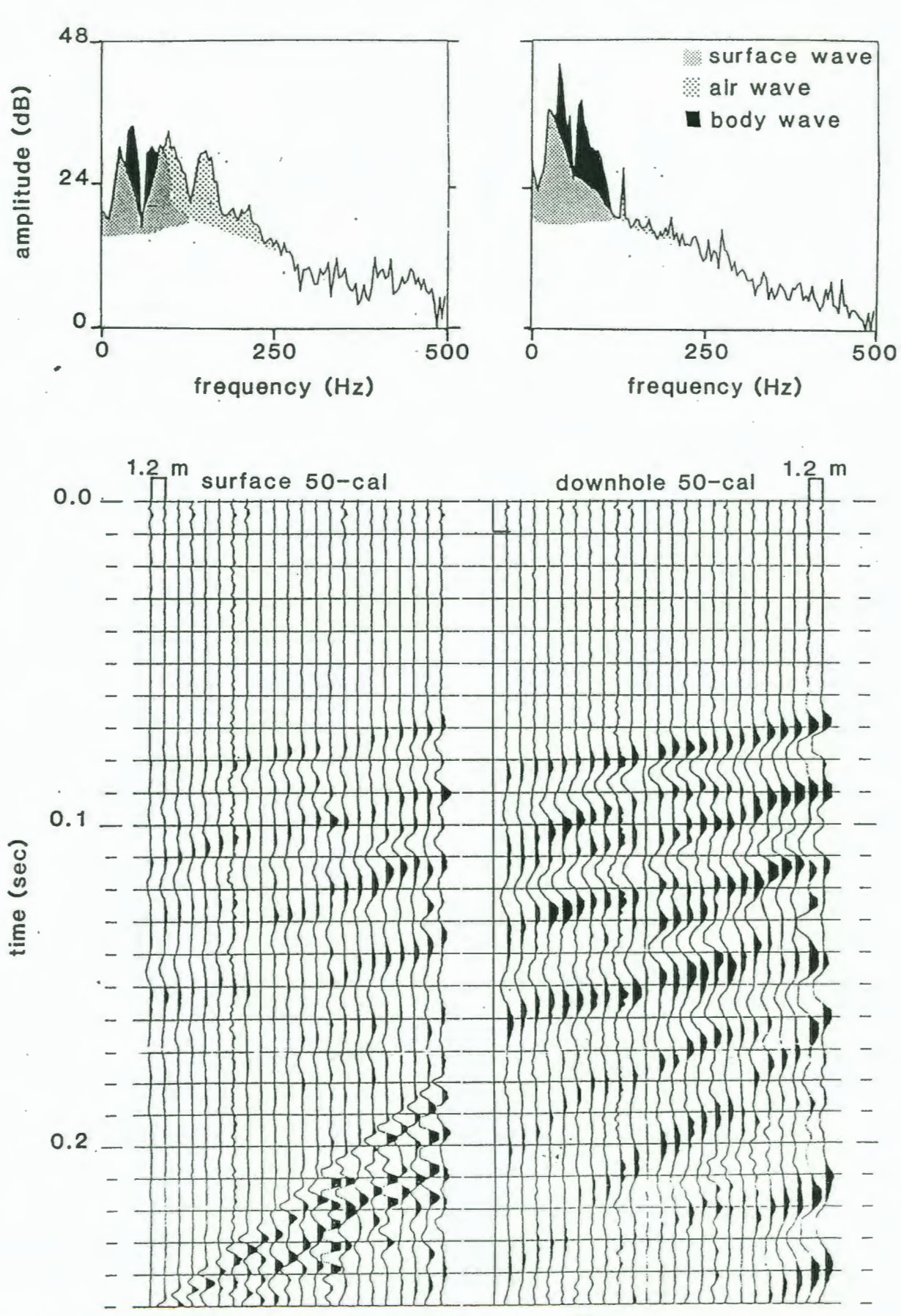


Figure captions:

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

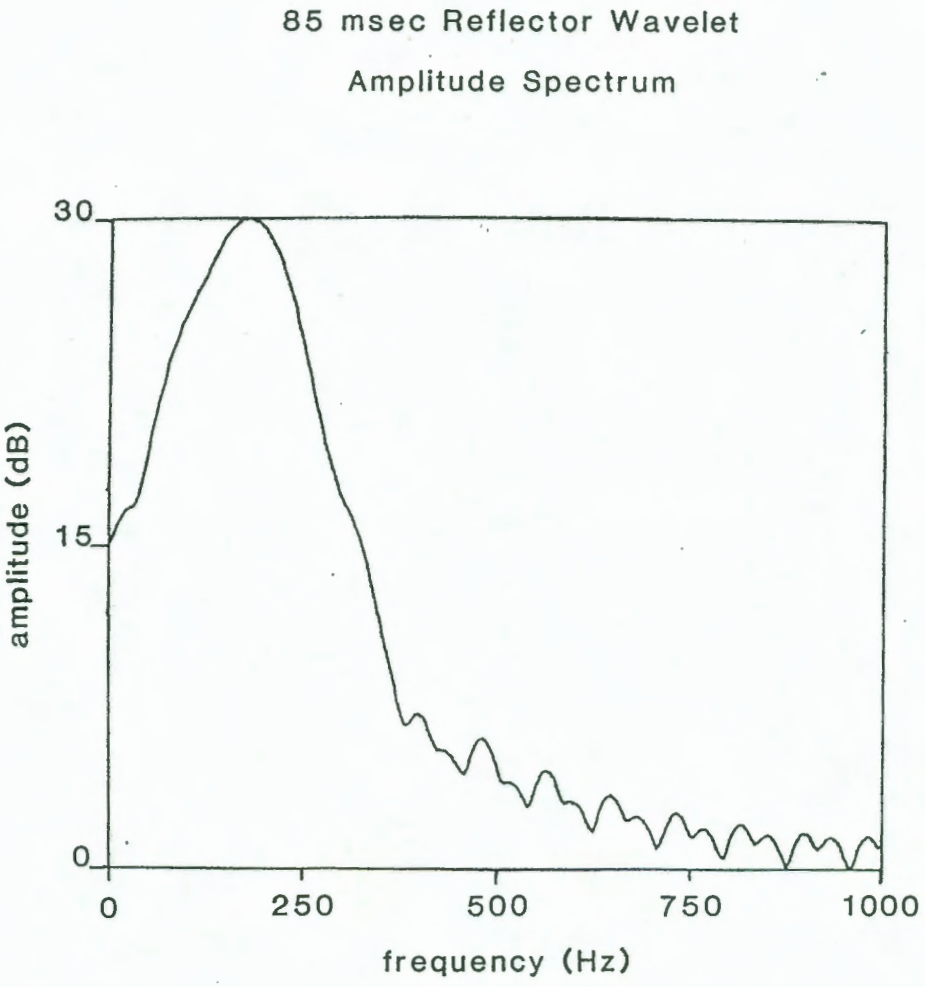


FIG. 3. -The amplitude spectrum of the reflection pulse at 85 msec is almost 3 octaves

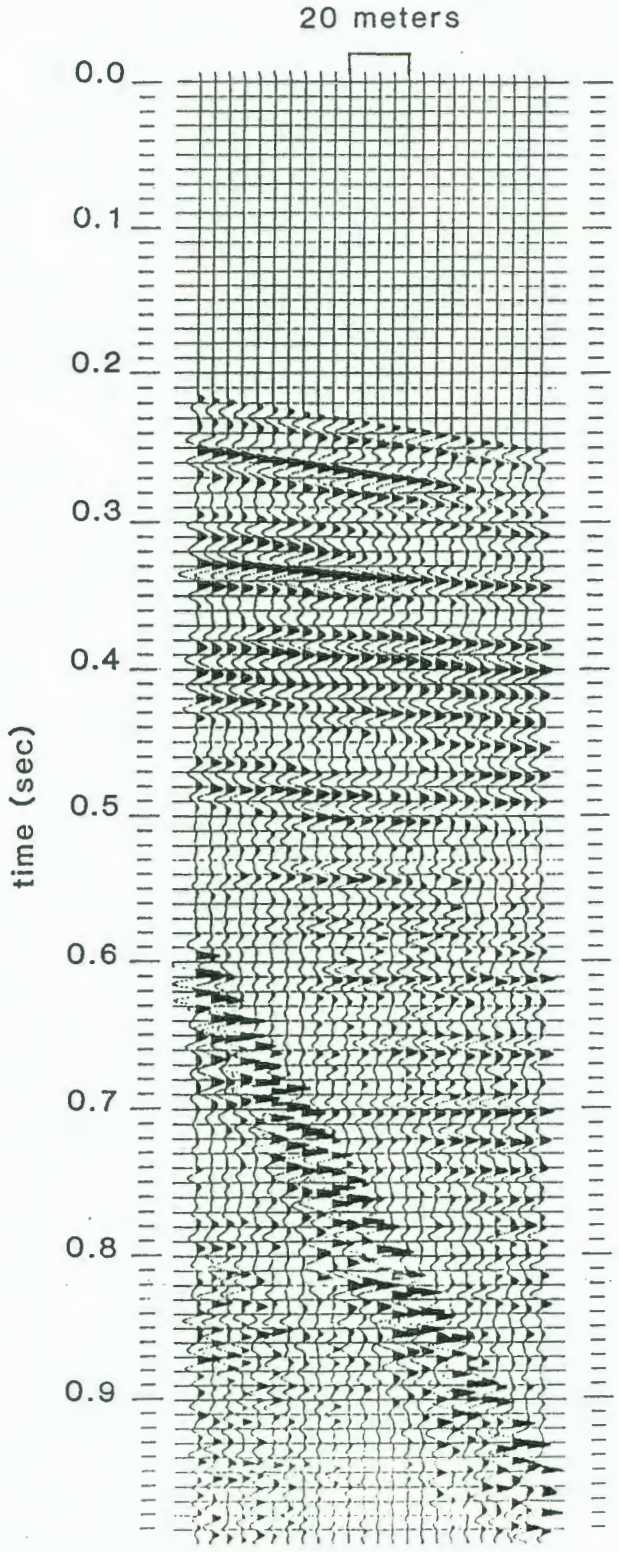


FIG. 4. —This stacked field file has 100 Hz reflection energy as deep as 1100 meters.

Olin MATERIAL SAFETY DATA

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

SECTION I - IDENTIFICATION

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

SECTION II - NORMAL HANDLING PROCEDURES

PRECAUTIONS TO BE TAKEN IN HANDLING AND STORAGE

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

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

SECTION III - HAZARDOUS INGREDIENTS

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

SECTION IV - FIRE AND EXPLOSION HAZARD DATA

FLASH POINT METHOD	OSHA CLASSIFICATION	FLAMMABLE EXPLOSIVE LIMITS	LOWER	UPPER
Not Applicable	Explosive		-	-

EXTINGUISHING MEDIA

Deluge with water, material is self-oxidizing. Flood with water to fight fire and to cool shells.

SPECIAL FIRE HAZARD & FIRE FIGHTING PROCEDURES

Evacuate area. Fight fire from an explosion resistant location.

SECTION V - HEALTH HAZARD DATA

THRESHOLD LIMIT VALUE

None established. (Inorganic recm. std.-air: TWA 0.15 mg (Pb)m^3 (ACGIH 1984-85)

SYMPTOMS OF OVER EXPOSURE

Eye irritation, fatigue, disturbance of sleep.

EMERGENCY FIRST-AID PROCEDURES

SKIN	Contact of skin with shells presents no health hazard.
EYES	Flush thoroughly with water. If an irritation occurs, call a physician.
INGESTION	Ingestion of shells not a possible route of exposure.
INHALATION	Remove victim to fresh air.

Chemical Industrial Ammunition 8 Gauge CAS No. Not assigned

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

ACUTE ORAL LD 50	Not applicable	CARCINOGENICITY	Not carcinogenic
		MUTAGENICITY	May be mutagenic
ACUTE DERMAL LD 50	> 2 g/kg	EYE IRRITATION	May be an irritant
		PRIMARY SKIN IRRITATION	Not an irritant
ACUTE INHALATION LC 50	Not known		

PRINCIPAL ROUTES OF ABSORPTION
Inhalation, dermal

EFFECTS OF ACUTE EXPOSURE
Fatigue, disturbance of sleep, eye irritation.

EFFECTS OF CHRONIC EXPOSURE Anemia, central nervous system depression, toxicity to kidneys, reproductive system and fetus.

SECTION VII - SPILL AND LEAKAGE PROCEDURES (Control Procedures)

ACTION FOR MATERIAL RELEASE OR SPILL

Remove all sources of ignition. Wear goggles and gloves. Use non-sparking utensils during cleanup. If containers are damaged, wear NIOSH/MSHA approved dust respirator. Follow OSHA regulations for respirator use. (See 29 CFR 1910.134). Minimize powder contamination. Clean up and place in an approved DOT container. Isolate and do not seal. Label "Small Arms Ammunition". Wash all contaminated clothing before reuse.

In the event of a large spill use the emergency telephone number shown on the front of this sheet.

TRANSPORTATION EMERGENCY, CONTACT CHEMTREC 800-424-9300

WASTE DISPOSAL METHOD

Dispose of contaminated product, empty containers and materials used in cleaning up spills or leaks in a manner approved for this material. Consult appropriate federal, state and local regulatory agencies to ascertain proper disposal procedures.

SECTION VIII - SHIPPING DATA

D.O.T. CLASS	Class C Explosive ORM-D

SECTION IX - REACTIVITY DATA

STABLE X UNSTABLE AT ____ °C ____ °F	HAZARDOUS POLYMERIZATION	MAY OCCUR	
		WILL NOT OCCUR	X
CONDITIONS TO AVOID	Open flame, heat, sparks, shock or percussion, pressure		
INCOMPATIBILITY (Material to Avoid)	Acids, alkalis, oxidizing materials (contents)		
HAZARDOUS DECOMPOSITION PRODUCTS	Lead fume, carbon monoxide		

SECTION X - PHYSICAL DATA

MELTING POINT	N/A	VAPOR PRESSURE	N/A	VOLATILES	N/A
BOILING POINT	N/A	SOLUBILITY IN WATER	N/A	EVAPORATION RATE	N/A
SPECIFIC GRAVITY (H_2O = 1)	N/A	pH	N/A	VAPOR DENSITY (Air = 1)	N/A

INFORMATION FURNISHED BY: C. C. Noonan (203) 789-5436 DATE November 16, 1985

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

Olin CORPORATION
120 Long Ridge Road, Stamford, Connecticut 06904
OCEAN® Network
EMERGENCY PHONE 1-800-OLIN-911

Material Safety Data Sheet

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

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

IDENTITY (As Used on Label and List)	Note: Blank spaces are not permitted. If any item is not applicable, or no information is available, the space must be marked to indicate that.
All Shotshell Ammunition	

Section I "Small Arms Ammunition"

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

Section II — Hazardous Ingredients/Identity Information

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

DOT - "Small Arms Ammunition"
Class C Explosive

UPS ORM-D

Section III — Physical/Chemical Characteristics

Boiling Point		Specific Gravity (H_2O = 1)	
Not applicable		Not applicable	
Vapor Pressure (mm Hg.)		Melting Point	
Not applicable		Not applicable	
Vapor Density (AIR = 1)		Evaporation Rate (Butyl Acetate = 1)	
Not applicable		NOT Applicable	

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

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

Section IV — Fire and Explosion Hazard Data

Flash Point (Method Used)	Flammable Limits	LEL	UEL
Not applicable	Not applicable	NA	NA

Extinguishing Media
Material is self oxidizing; flood with water to fight fire and cool shells.

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

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

Section V — Reactivity Data

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

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

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

Hazardous Polymerization	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 location?

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

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

Signs and Symptoms of Exposure: Refer to health hazard above.

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

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

Section VII — Precautions for Safe Handling and Use

Steps to Be Taken in Case Material is Released or Spilled

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

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

Precautions to Be Taken in Handling and Storing

Refer to released or spilled data above.

Other Precautions

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

Section VIII — Control Measures

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

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

Protective Gloves: Not applicable Eye Protection: Safety glasses when shooting

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

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

• USGPO: 1988-491-329/63775

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

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SECTION #1 - PRODUCT IDENTIFICATION:

CENTERFIRE PRODUCT FAMILY		
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

CENTERFIRE PRODUCT FAMILY		
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:

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

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 protoporphryn 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

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

Product:	Cartridges, Small Arms
Trade Name:	**CENTERFIRE RIFLE, PISTOL & REVOLVER LOADED ROUND**
CAS Registry No.:	N/A
CAS Name:	N/A
Formula:	N/A
Molecular Weight:	N/A
Grade:	N/A

HMIS Rating

Health:	**2**
Flammability:	**0**
Reactivity:	**1**

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.	**Projectile**	Lead, Copper, Zinc, Antimony
2.	**Brass Shellcase**	Copper, Zinc, Nickel
3.	**Propellant**	Nitrocellulose, Nitroglycerin, Dibutyl Phthalate, Graphite
4.	**Primer**	Copper, Zinc, Lead, Antimony, Barium, Lead Styphnate, Tetrazene

LIST OF HAZARDOUS CHEMICALS
(In Alphabetical Order)

CAS or Chemical Name: ANTIMONY
CAS Registry Number: 7440-36-0
Exposure Standards:
PEL (OSHA)..... TWA 0.5 mg/m^3
TLV (ACGIH) ..... TWA 0.5 mg/m^3

CAS or Chemical Name: BARIUM
CAS Registry Number: 7440-39-3
Exposure Standards:
PEL (OSHA)..... TWA 0.5 mg/m^3
TLV (ACGIH) ..... TWA 0.5 mg/m^3

CAS or Chemical Name: COPPER
CAS Registry Number: 7440-50-8
Exposure Standards:
PEL (OSHA)..... TWA (fume) 0.1 mg/m^3
TWA (dust, mist) 1.0 mg/m^3
TLV (ACGIH) ..... TWA (fume) 0.2 mg/m^3
TWA (dust, mist) 1.0 mg/m^3

CAS or Chemical Name: DIBUTYL PHTHALATE
CAS Registry Number: 84-74-2
Exposure Standards:
PEL (OSHA)..... TWA 5 mg/m^3
TLV (ACGIH) ..... TWA 5 mg/m^3

CAS or Chemical Name: GRAPHITE
CAS Registry Number: 7440-44-0
Exposure Standards:
PEL (OSHA) ..... (Natural Graphite) (Transitional: TWA 50 mppcf) TWA 2.5 mg/m^3
(Synthetic Graphite) (Transitional: TWA Total Dust: 15 mg/m^3 ; Respirable Fraction: 5 mg/m^3)
TWA Total Dust: 10 mg/m^3; Respirable Fraction: 5 mg/m^3
TLV (ACGIH) ..... TWA 2 mg/m^3 (respirable dust)

CAS or Chemical Name: LEAD
CAS Registry Number: 7439-92-1
Exposure Standards:
PEL (OSHA)..... TWA 0.05 mg/m^3
TLV (ACGIH) ..... TWA 0.15 mg/m^3
BEI 50/L in blood, 150/g creatinine in urine

Trade Name: LEAD STYPHNATE
CAS or Chemical Name: LEAD TRINITRORESORCINATE
CAS Registry Number: 63918-97-8
Exposure Standards: None established.

CAS or Chemical Name: NICKEL
CAS Registry Number: 7440-02-0
Exposure Standards:
PEL (OSHA)..... TWA Soluble Compounds: 0.1 mg/m^3
TWA Insoluble Compounds 1.0 mg/m^3
TLV (ACGIH) ..... TWA 1.0 mg/m^3
(Proposed: TWA 0.05 mg/m^3 ; human carcinogen)

Trade Name: NITROCELLULOSE
CAS or Chemical Name: CELLULOSE TETRANITRATE
CAS Registry Number: 9004-70-0
Exposure Standards: None Established

CAS or Chemical Name: NITROGLYCERIN
CAS Registry Number: 55-63-0
Exposure Standards:
PEL (OSHA)..... Transitional; TWA CL 0.2 ppm (skin)
STEL 0.1 mg/m^3 (skin)
TLV (ACGIH) ..... TWA 0.05 ppm (skin)

CAS or Chemical Name: TETRAZENE
CAS Registry Number: 109-27-3
Exposure Standards: None established.

CAS or Chemical Name: ZINC
CAS Registry Number: 7440-66-6
Exposure Standards: None established.

III. HAZARDS IDENTIFICATION

Emergency Overview: Accidental fire or explosion may cause severe injury or death.

Potential Human Health Effects:

Skin Contact: May cause allergic reaction (sensitization) in susceptible individuals.

Eye Contact: Lead dust and fumes can irritate the eyes causing redness and discharge.

Inhalation: Inhalation of lead dust or fumes may cause irritation to nose, throat, upper respiratory tract and lungs. Irritation may lead to bronchitis, headache, lowering of blood pressure and weakness.

Ingestion/Absorption: Ingestion may cause severe headache, nausea, vomiting, abdominal pain, fatigue, diarrhea, trembling, ringing in ear and salivation.

Carcinogenicity Information: This product is not classified a carcinogen by IARC, OSHA, NTP or EPA. Lead is classified a carcinogen by IARC.

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 *HMIS 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.

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

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

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

Proper Shipping Name:	Cartridges, Small Arms
Hazard Class:	ORM-D
UN/NA No:	N/A
Packing Group:	N/A
Shipping Label:	None required.
Special Information:	**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

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

XVI. OTHER INFORMATION

NFPA Rating: Not established.

NPCA-HMIS Ratings:

Health:	2
Flammability:	0
Reactivity:	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.

XVII. LIST OF ACRONYMS

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

For additional information, please contact:

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

(800) 243-9700

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.

GENERAL MOTORS CORPORATION
MATERIAL SAFETY DATA SHEET

SECTION I

PRODUCT NAME OR NUMBER (as it appears on label) ALL MODELS OF DELCO BATTERIES	GM COMMON CODE
MANUFACTURER'S NAME Delco Remy Division, GMC	EMERGENCY TELEPHONE NO. (317) 646-3080
ADDRESS (Number, Street, City, State and Zip Code) 2401 Columbus Avenue, Anderson, IN 46018	MANUFACTURER'S D-U-N-S NO.
HAZARDOUS MATERIAL DESCRIPTION, PROPER SHIPPING NAME, HAZARD CLASS, HAZARD ID NO. (49 CFR 172.101) Battery, Wet, Filled with Acid, (Corrosive Material) Class 8 - UN2794	
ADDITIONAL HAZARD CLASSES (as applicable)	
CHEMICAL FAMILY Liquid Content • Sulfuric Acid	FORMULA Liquid Content - H_2SO_4

SECTION II — INGREDIENTS
(list all ingredients)

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

SECTION III — PHYSICAL DATA

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

SECTION IV — FIRE AND EXPLOSION HAZARD DATA

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

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

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

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

SECTION VI-REACTIVITY DATA

STABILITY	UNSTABLE		CONDITIONS TO AVOID
	STABLE	X	

INCOMPATIBILITY (materials to avoid) Oxidizing or reducing materials.

HAZARDOUS DECOMPOSITION PRODUCTS: When heated, can emit highly toxic fumes.

HAZARDOUS POLYMERIZATION	MAY OCCUR		CONDITIONS TO AVOID
	WILL NOT OCCUR	XX	

SECTION VII-SPILL OR LEAK PROCEDURES

STEPS TO BE TAKEN IN CASE MATERIAL IS RELEASED OR SPILLED
Lime or soda may be used to neutralize and/or flush with large volumes of water. Contain spill.

WASTE DISPOSAL METHOD
According to local, state, and federal regulations for acid or lead scrap.

CERCLA (Superfund) REPORTABLE QUANTITY (in lbs) 1,000 lbs.

RCRA HAZARDOUS WASTE NO. (40 CFR 261.33) D002

VOLATILE ORGANIC COMPOUND (VOC) (as packaged, minus water) NA

☒ Theoretical 4 lb/gal ☐ Analytical NA lb/gal

SECTION VIII-SPECIAL PROTECTION INFORMATION

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

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

PROTECTIVE GLOVES (specify type) Rubber

EYE PROTECTION (specify type) Splash-proof safety g

OTHER PROTECTIVE EQUIPMENT
Use rubber boots and acid-proof clothing for major spills.

SECTION IX-SPECIAL PRECAUTIONS

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

OTHER PRECAUTIONS

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

PLEASE COMPLETE QUESTIONNAIRE AND RETURN TO.

Name (print) Robert A. Chisman

Signature Robert A. Chisman

Title Senior Industrial Hygienist

Date May 8, 1991

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^3	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_{50} 5750 mg/kg
Ammonium Sulfate	12-22	7783-20-2		Oral (Rat) LD_{50} 3000 mg/kg
Calcium Carbonate	<2	1317-65-3	10 mg/M^3	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_2O = 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 ☐ Stable ☒	Conditions to Avoid:	N/A
Incompatibility (Materials to Avoid):	Strong alkalis, Mg, oxidizers that can release chlorine per NFPA 43A		
Hazardous Decomposition Products:	NH_3 and/or PO_x may be evolved		
Hazardous Polymerization:	May Occur ☐ Will Not Occur ☒	Conditions to Avoid:	N/A

SECTION 5 — HEALTH HAZARDS

Threshold Limit Value:	OSHA nuisance dust limit of 15 mg/M3 or ACGIH nuisance dust value of 10 mg/M3 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 ☐ No ☒ I.A.R.C. Monographs: Yes ☐ No ☒ OSHA: Yes ☐ No ☒

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 Ansul 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
3 Serious Hazard
2 Moderate Hazard
1 Slight Hazard
0 Minimal Hazard

1 HEALTH
0 FLAMMABILITY
0 REACTIVITY

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

INGREDIENT	PERCENT	TLV/PEL	V.P.	CAS.#
Solvent refined, hydrotreated, heavy paraffinic distillate	50-60	5 mg/m^3*	-	64742547
Solvent refined, hydrotreated, middle distillate	0-25	5 mg/m^3*	-	64742467
Severely hydrotreated light naphthenic distillate	0-25	5 mg/m^3*	-	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.
% VOLATILE VOLUME: N.A.
VAPOR DENSITY: N.A.
APPEARANCE/ODOR: dark amber/slight odor
SP. GRAVITY (WATER=1): 0.89
EVAPORATION RATE: N.A.
SOLUBILITY IN WATER: Insoluble
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[1]: 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_{50} (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

[1]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

2.0 PHYSICAL DATA (continued)

Boiling Point, 760 mm Hg, °C (°F):	160 - 360 (320 - 680)
Specific Gravity (0 °F) (H_2O = 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[2]:	Health: 0 Flammability: 2 Reactivity: 0
Flammable Limits (% by volume in air):	Lower: 0.6 Upper: 7.0
Extinguishing Media:	CO_2, 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_2), 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.)

[2]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.

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.

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 lipoid 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^3)	ACGIH TLV STEL/ Ceiling (C) ppm (mg/M^3)	ACGIH TLV Skin notation?	OSHA PEL TWA ppm (mg/M^3)	OSHA PEL STEL/ Ceiling (C) ppm (mg/M^3)	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:	Yes	Sudden Release of Pressure Hazard:	No
Delayed (Chronic) Health Hazard:	Yes	Reactive Hazard:	No
Fire Hazard:	Yes		

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):

Component:	Effect:
Diesel Engine Exhaust	Cancer

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

Fuel Oil (68476-30-2)

Toxic Substances Control Act (TSCA):

Reported in TSCA Inventory as:	Product	Components
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.

MATERIAL SAFETY DATA SHEET

PRODUCT SA 825 0012

ELL-BEE LITHIUM M-P GREASE

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



SECTION I

1 WITCO MANUFACTURING DIVISION OR SUBSIDIARY	EMERGENCY TELEPHONE MANUFACTURER (913) 782-5800
2 ADDRESS (NUMBER, STREET, CITY, STATE, ZIP CODE)	CHEMTREC 1-(800) 424-9300
3 CHEMICAL NAME OR FAMILY: Petroleum Hydrocarbon	4 FORMULA: NA

SECTION II — CHEMICAL AND PHYSICAL PROPERTIES

CHEMICAL	PHYSICAL
5 HAZARDOUS DECOMPOSITION PRODUCTS: Carbon monoxide, carbon dioxide	8 FORM: Semi-solid
6 INCOMPATIBILITY (KEEP AWAY FROM): Strong oxidizing agents such as: hydrogen peroxide, chromic acid, bromine	9 ODOR: Mineral Oil
7 LIST ALL TOXIC AND HAZARDOUS INGREDIENTS: None	10 APPEARANCE: Grease
	11 COLOR: Amber
	12 SPECIFIC GRAVITY (WATER = 1) RT: 0.924
	13 BOILING PT.: NDA °C / °F
	14 MELTING PT.: NA °C / °F
	15 SOLUBILITY IN WATER AT 25 °C: Negligible
	16 % VOLATILE (BY WT %): NA
	17 EVAP. RATE (= 1): NA
	18 VAPOR PRESSURE (mm Hg at 20 °C): NA
	19 VAPOR DENSITY (AIR = 1): NA
	20 pH AS IS: NA
	pH ( )
	STRONG ACID: –
	STRONG BASE: –
	STABLE: X
	UNSTABLE: –
	21
	22 VISCOSITY SUS AT 100 °F: < 100 / 100 OR > XX
	23 NA

SECTION III — FIRE AND EXPLOSION DATA

24 SPECIAL FIRE FIGHTING PROCEDURES: Fire fighters should wear an approved self contained breathing apparatus.	26 FLASH POINT (METHOD USED) Above C.O.C. 190 °C 374 °F
	27 FLAMMABLE LIMITS %: NDA LOWER ____ UPPER ____
25 UNUSUAL FIRE AND EXPLOSION HAZARDS: Dense smoke	28 EXTINGUISHING AGENTS: ☒ DRYCHEMICAL ☒ CO_2 ☐ WATERSPRAY ☒ FOAM ☒ WATERFOG ☒ SAND/EARTH ☐ OTHER ____

SECTION IV — HEALTH HAZARD DATA

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

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

MATERIAL SAFETY DATA SHEET

PRODUCT SA 825 0012

SECTION V — SPECIAL PROTECTION INFORMATION

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

SECTION VI — HANDLING OF SPILLS OR LEAKS

PROCEDURES FOR CLEAN-UP (41)

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

WASTE DISPOSAL (42)

By methods consistent with local, state and federal regulations.

SECTION VII — SPECIAL PRECAUTIONS

PRECAUTIONS TO BE TAKEN IN HANDLING AND STORAGE (43)

Keep containers closed.

SECTION VIII — TRANSPORTATION DATA

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

SECTION IX — COMMENTS

54: KEEP OUT OF REACH OF CHILDREN!!

SIGNATURE Ray D. Thornton TITLE Manager Technical Compliance

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

SUPERSEDES _____

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

MATERIAL SAFETY DATA SHEET

Tox no. : 042840

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

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

CHEMICAL AND PHYSICAL PROPERTIES

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

HAZARDOUS AND OTHER DISCLOSED INGREDIENTS

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

Exposure Limit Abbreviations

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

REGULATORY INFORMATION

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

SIGNAL WORD

DANGER -- CORROSIVE

HAZARDS

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

M S D S
(CONTINUED)

Tox no. : 042840

TARGET ORGANS AND MEDICAL CONDITIONS

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

Lungs
Teeth
Skin, Eyes, and Respiratory System

ACUTE TOXICITY INFORMATION

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

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

SAFE HANDLING AND STORAGE

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

FIRE, EXPLOSION AND REACTIVITY INFORMATION

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

Ford

M S D S
(CONTINUED)

Tox no. : 042840

PROTECTIVE MEASURES AND TREATMENTS

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

NOTES TO PHYSICIANS

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

SPILLS, LEAKS AND DISPOSAL

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

SPECIAL REMARKS

This is an acidic material.

U. S. DEPARTMENT OF TRANSPORTATION INFORMATION

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

The chemical name(s) appearing below under "NAME" must appear as part of shipping name IF the amount being shipped in each container exceeds the quantity shown under "RQ" below. The letters "RQ" must also appear as part of the shipping name, in the form:
shipping name, chemical name, RQ.
For U.S. shipments from Ford Facilities, consult the "Ford Hazardous Material Transportation Control Program" Manual, otherwise consult 49CFR172.

------CAS--	RQ(lbs)	-NAME----------
7664-93-9	2777	SULFURIC ACID

M S D S
(CONTINUED)

Tox no. : 042840

Print Date : 04/02/90

PREPARATION INFORMATION

Health and safety information has been evaluated by:

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

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

This is the last page of this MSDS.

MATERIAL SAFETY
DATA SHEET

AMOCO REGULAR LEAD-FREE GASOLINE

MSDS NO: 02003992

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

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

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

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

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

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

HEALTH HAZARD INFORMATION

EYE

EFFECT: High concentrations of vapor/mist may cause eye discomfort.

FIRST AID: Flush eyes with plenty of water. Get medical attention if irritation persists.

PROTECTION: None required; however, use of eye protection is good industrial practice.

SKIN

EFFECT: Prolonged or repeated contact can defat the skin and lead to irritation and/or dermatitis.

FIRST AID: Wash exposed skin with soap and water. Remove contaminated clothing, including shoes, and thoroughly clean and dry before reuse. Get medical attention if irritation develops.

PROTECTION: Avoid prolonged or repeated skin contact. Wear protective clothing and gloves if prolonged or repeated contact is likely.

INHALATION

EFFECT: Vapour harmful. High vapor concentrations can cause headaches, dizziness, drowsiness and nausea. See Toxicology Section.

FIRST AID: If adverse effects occur, remove to uncontaminated area. Give artificial respiration if not breathing. Get medical attention.

PROTECTION: Use with adequate ventilation. Avoid breathing vapor and/or mist. If ventilation is inadequate, use NIOSH/MSHA certified respirator which will protect against organic vapor/mist.

HEALTH HAZARD INFORMATION - CONTINUED

INGESTION

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

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

FIRE AND EXPLOSION INFORMATION

FLASHPOINT: -45°F

FLAMMABLE LIMITS: UPPER: 7.6% LOWER: 1.3%

AUTOIGNITION TEMPERATURE: 495°F

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

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

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

REACTIVITY INFORMATION

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

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

STABILITY: Burning can be started easily.

CHEMICAL AND PHYSICAL PROPERTIES

BOILING POINT: 80°F TO 430°F, Range

SOLUBILITY IN WATER: Negligible, below 0.1%.

SPECIFIC GRAVITY (WATER = 1): 0.75

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

VAPOR DENSITY (AIR = 1): 3 TO 4

STORAGE AND ENVIRONMENTAL PROTECTION

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

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

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

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

TOXICOLOGICAL INFORMATION

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

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

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

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

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

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

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

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

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

REGULATORY INFORMATION

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

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

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

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

COMPONENT/CAS NUMBER
Ethylbenzene (100-41-4)
Toluene (108-88-3)
Xylene (1330-20-7)

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

SECTIONS 311 AND 312 OF SARA AND 40 CFR PART 370:
This product is defined as hazardous by OSHA under 29 CFR Part 1910.1200(d).

SECTION 313 OF SARA AND 40 CFR PART 372:
This product contains the following substances, which are on the Toxic Chemicals List in 40 CFR Part 372:

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

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

SUPPLEMENTAL INFORMATION

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

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

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

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

SUPPLEMENTAL INFORMATION - CONTINUED

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

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

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

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

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

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

ISSUE INFORMATION

BY:

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

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

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

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

MATERIAL SAFETY DATA SHEET

SECTION I

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

SECTION II - HAZARDOUS INGREDIENTS

PAINTS, PRESERVATIVES, & SOLVENTS	%	TLV (Units)	ALLOYS AND METALLIC COATINGS	%	TLV (Units)
PIGMENTS	N/A		BASE METAL	N/A	
CATALYST	N/A		ALLOYS	N/A	
VEHICLE	N/A		METALLIC COATINGS	N/A	
SOLVENTS	N/A		FILLER METAL PLUS COATING OR CORE FLUX	N/A	
ADDITIVES	N/A		OTHERS	N/A	
OTHERS	N/A				

HAZARDOUS MIXTURES OF OTHER LIQUIDS, SOLIDS, OR GASES	%	TLV (Units)
Methyl Alcohol	38	200ppm
Nonylphenol Surfactant CAS # 68412-54-4	.001	
Triphenylmethane CAS # 2650-18-2 EPA TSCA List- Yes	Tr.	

SECTION III PHYSICAL DATA

BOILING POINT (°F.)	N/A	SPECIFIC GRAVITY (H2O=1)	.951
VAPOR PRESSURE (mm Hg)	N/A	PERCENT VOLATILE BY VOLUME (%)	N/A
VAPOR DENSITY (AIR=1)	N/A	EVAPORATION RATE	N/A
SOLUBILITY IN WATER	Complete		
APPEARANCE AND ODOR	Blue-aromatic		

SECTION IV FIRE AND EXPLOSION HAZARD DATA

		Lel	Uel
FLASH POINT (Method used) T.C.C. 112 F	FLAMMABLE LIMITS		
EXTINGUISHING MEDIA Dry chemical, CO_2 or Alcohol foam			
SPECIAL FIRE FIGHTING PROCEDURES Wear self-contained breathing apparatus			
UNUSUAL FIRE AND EXPLOSION HAZARDS Vapor is heavier than air and may travel considerable distance to an ignition source.			

(Continued on reverse side)

SECTION V HEALTH HAZARD DATA

THRESHOLD LIMIT VALUE
Methyl Alcohol- 200ppm, 8 hour time- weighted average

EFFECTS OF OVEREXPOSURE
Ingestion- Poisonous, causes blindness, perhaps death. Inhalation- Narcosis, headache, nausea, loss of consciousness. Skin- Drying, irritation. Eye- Burning.

EMERGENCY AND FIRST AID PROCEDURES
Ingestion- Induce vomiting of conscious person, call M.D. Inhalation- Remove person to fresh air. Skin- Remove contaminated clothing and wash with water. Eyes- Flush eyes with water for at least 15 min. Contact a physician immediately.

SECTION VI REACTIVITY DATA

STABILITY	UNSTABLE		CONDITIONS TO AVOID: Sparks, heat and flames.
	STABLE	X	

INCOMPATABILITY (Materials to avoid)
None

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

HAZARDOUS POLYMERIZATION	MAY OCCUR		CONDITION TO AVOID
	WILL NOT OCCUR	X	

SECTION VII SPILL OR LEAK PROCEDURES

STEPS TO BE TAKEN IN CASE MATERIAL IS RELEASED OR SPILLED
Place leaking container in well ventilated areas, eliminate ignition sources. Avoid run-off into storm sewers and ditches which lead to natural waterways

WASTE DISPOSAL METHOD
Incineration, biological treatment of dilute solution.

SECTION VIII SPECIAL PROTECTION INFORMATION

RESPIRATORY PROTECTION (Specify type)

VENTILATION	LOCAL EXHAUST: When appropriate to control employee exposure.	SPECIAL
	MECHANICAL (General)	OTHER

PROTECTIVE GLOVES: Neoprene or rubber gloves

EYE PROTECTION: Chemical safety goggles

OTHER PROTECTIVE EQUIPMENT

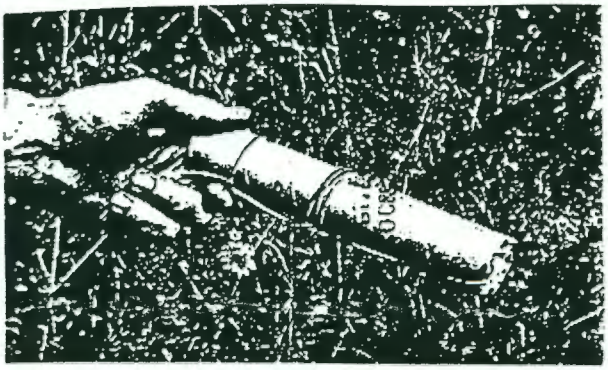
SECTION IX SPECIAL PRECAUTIONS

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

OTHER PRECAUTIONS

Revised 1-9-90

seisPRIME/E® Emulsion Seismic Explosive



EXCELLENT FOR "MINI-HOLES" AND VERTICAL STACKING

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

Although classified as high explosive, seisPRIME/E emulsions are no headache and have excellent resistance to accidental detonation by friction impact.

Spiral-wound 1/4 to 1/2-pound paper cartridges are easily capped a 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 a "mini-hole" applications. seisPRIME/E in the one-pou size is packaged in thin-walled, easy couplir cartridges for vertical stacking or larger downhc shots.

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

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

STATICMASTER® Electric Detonators for Seismic Exploration



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

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

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

PROPERTIES AND SPECIFICATIONS

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

REDUCED SENSITIVITY TO EXTRANEOUS ELECTRICITY

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

OPERATING AIDS

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

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

PACKAGING

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

HAZARDOUS CHEMICAL MATERIAL SAFETY DATA SHEET

(Conforms to the Requirements of 29 CFR 1910.1200)

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

1. NAME AND ADDRESS OF MANUFACTURER:

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

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

3. MEDICAL EMERGENCY TELEPHONE NUMBERS:

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

4. THE MATERIALS DESCRIBED IN THIS DATA SHEET ARE:

HAZARDOUS CHEMICAL INGREDIENTS

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

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

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

Note: See MSDS for Ammonium Nitrate Plus Fuel Oil

6. PHYSICAL AND CHEMICAL CHARACTERISTICS:

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

nd = No Data d = Dissociates na = Not Applicable

7. PHYSICAL HAZARDS:

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

8. HEALTH HAZARDS:

	A.N.	D.O.
Carcinogen	N	N
Corrosive	N	N
Highly Toxic	N	N
Irritant	N	N
Sensitizer	N	N
Toxic	N	N
Target Organ Effects	N	N

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

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

10. PERMISSIBLE EXPOSURE LIMITS: No Data

11. LISTINGS:

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

12. GENERALLY APPLICABLE PRECAUTIONS FOR SAFE HANDLING AND USE:

HYGIENIC PRACTICES:

Avoid Skin and Eye Contact. Avoid Breathing Blasting Fumes.

PROTECTIVE MEASURES DURING REPAIR AND MAINTENANCE OF CONTAMINATED EQUIPMENT:

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

PROCEDURES FOR CLEANUP OF SPILLS AND LEAKS:

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

13. CONTROL MEASURES:

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

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

PERSONAL PROTECTIVE EQUIPMENT:

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

14. EMERGENCY AND FIRST AID PROCEDURES:

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

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