

GENERAL SPECIFICATION

SURVEYS

GS EP GEO 217

**Near-surface 2D high-resolution seismic reflection
geophysical survey onshore**

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1. Scope

The General Technical Specification details the minimum standards required by Company for onshore Near-Surface High-Resolution Seismic Reflection geophysical surveys, meaning surveys targeted at the top 100 meters below ground level. However, should Company consider that any aspect of the work requires more detailed investigation, Company reserves the right to apply further Particular Technical Specifications (Exhibit A2).

All Equipment and Materials necessary to complete the survey in accordance with this Contract shall be supplied by Contractor. Such Equipment and Materials shall include all spare parts and spare Equipment units as may be necessary to provide normal and continuous operations, and shall be in good operating condition prior to the award of Contract.

Such Equipment shall be properly maintained in such a way as to assure accuracy within the tolerances set by the manufacturer. Contractor undertakes to provide a statement of the surveying accuracy of this Equipment.

The Work defined in these Specifications shall be performed in accordance with the Agreement.

The Work shall include the following phases:

- **Data acquisition phase**
- **Data processing phase:** this phase should be carried out in conjunction with acquisition to ensure that survey objectives are reached
- **Interpretation phase.**

Reports shall include measured and processed data and interpreted seismic sections as per objectives of the Particular Technical Specifications.

The final product shall be an Expert Report.

The Scope Of Work is included in the Particular Technical Specifications (a Contract Exhibit).

2. Reference documents

The reference documents listed below form an integral part of this General Specification.

External Documents

Unless otherwise stipulated, the applicable version of these documents, including relevant appendices and supplements, is the latest revision published at the effective date of this document.

Reference	Title
ASTM D7128 (reapproved 2010)	Standard Guide for Using the Seismic Reflection Method for Shallow Subsurface Investigation
ISO 80000-1	Quantities and units - Part 1: General

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Total General Specifications

Unless otherwise stipulated, the applicable version of these documents, including relevant appendices and supplements, is the latest revision published in the applicable yearly collection.

Reference	Title
GS EP GEO 210	Onshore Geophysical Site Survey - Cross Hole geophysical survey
GS EP GEO 211	Onshore Geophysical Site Survey - Seismic refraction geophysical survey
GS EP GEO 212	Onshore Geophysical Site Survey - Multichannel surface waves geophysical survey
GS EP GEO 213	Onshore Geophysical Site Survey – Micro-gravity geophysical survey
GS EP GEO 214	Onshore Geophysical Site Survey - Electric Geophysical Survey
GS EP GEO 215	Onshore Geophysical Site Survey - Radar Geophysical Survey
GS EP GEO 216	Onshore Geophysical Site Survey – Electro-Magnetic Geophysical Survey
GS EP GEO 401	GIS requirements for engineering site surveys and studies
GS EP GPA 202	Seismic HSE for Land Activities
GS EP GPA 203	Seismic HSE for Shallow Water and Transition Zone Activities
GS EP POS 003	Onshore land surveying and positioning works
GS EP POS 004	The use of Differential Global Navigation Satellite System

3. High-Resolution seismic reflection survey objectives and methodology

3.1 Seismic reflection survey objectives

High-resolution seismic reflection is a very effective method to map the structural extension of geological layers from the very near-surface to a depth of one to three hundred meters below ground (refer to [ASTM D7128](#)).

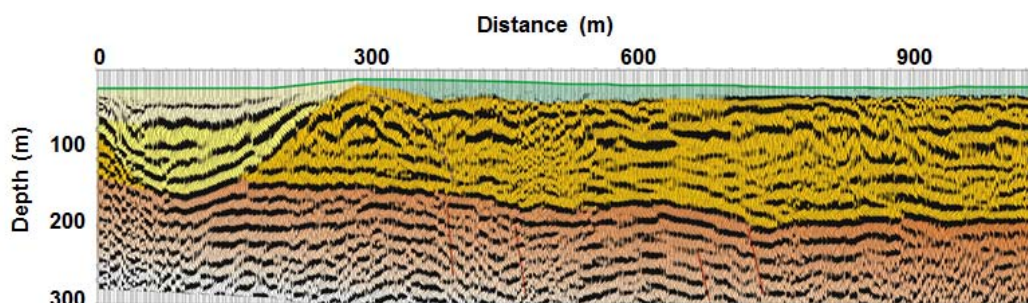
Applications are numerous and concern either geological, civil engineering, environmental or hydrological purposes:

- Determination of the thicknesses of geological units and mapping variation of depth to bedrock
- Search for paleo-channels beneath alluvium or other consolidated sediments
- Detection of faults which is of primary importance when studying earthquake hazards, or when searching for high-permeability pathways

- Detection of shallow water table
- Characterization of lateral changes in lithological units related to evolution of elastic properties or density of the materials (variation of reflection coefficient)
- Detection of gas accumulations to select appropriate location for drilling (indicator such as bright spots related to higher acoustic impedance due to gas accumulation).

This method may be also applied, in association with other methods such as microgravity, for the detection of air-filled sub-surface cavities and tunnels.

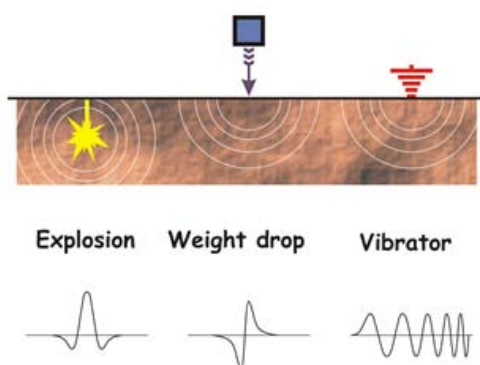
Figure 1: Example of seismic reflection section showing a paleo-channel



3.2 Methodology

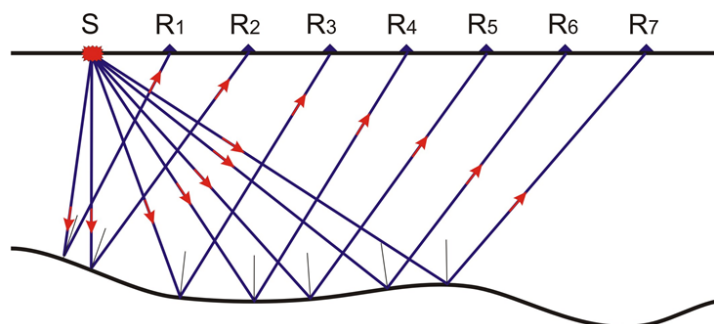
The seismic reflection method consists of generating seismic waves into the ground, using an energy source such as dynamite, weight drop or vibrator.

Figure 2: Different land seismic sources



Those seismic waves are partly reflected back to the surface by each reflecting geological interface.

These reflected energy waves are then recorded over a predetermined time period (called the record length) by receivers deployed at the surface.

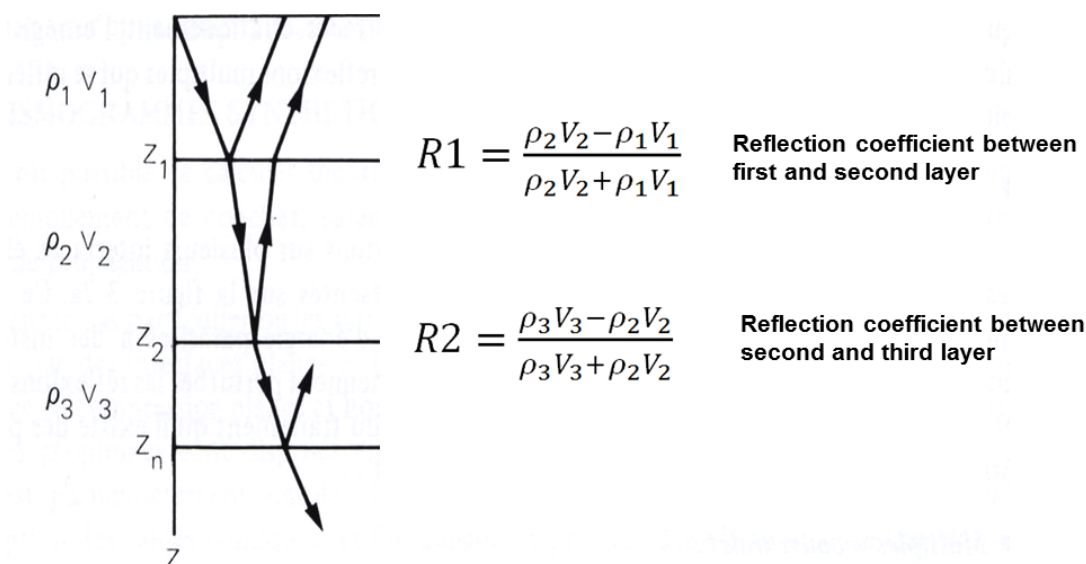
Figure 3: Reflection ray paths


Efficiency of the method will mainly depend on the acoustic impedance contrast between the different geological interfaces. Acoustic impedance is given by the product of mass density and seismic wave velocity.

Acoustic impedance $I = \rho V$, where ρ is the density of the layer and V its seismic velocity.

At normal incidence the reflection coefficient $R = (I_2 - I_1) / (I_2 + I_1)$.

$$R = \frac{\rho_2 V_2 - \rho_1 V_1}{\rho_2 V_2 + \rho_1 V_1}$$

Figure 4: Reflection coefficient


4. Units and abbreviations

4.1 Units

Only the ISO **International System** of units ([ISO 80000-1](#)) shall be used in all relevant measurements, processing and reporting.

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4.2 Abbreviations

GIS	Geographical Information System (chart database)
DGPS / GPS	Differential / Global Positioning System
RTK	Real-Time Kinematics (DGPS system)
SEG-2	Society Exploration Geophysicists format 2
SEG-Y	Society Exploration Geophysicists format Y
Vp	Velocity of Seismic compressional wave
ρ	Density
I	Seismic impedance: product of seismic compressional wave velocity and density of the material
R	Reflection coefficient: ratio of the amplitude of the reflected wave to the amplitude of the incident wave
dB	Decibel
VSP	Vertical Seismic Profile
CMP	Common Mid-Point profiling
AGC	Automatic Gain Control
NMO	Normal Move-Out corrections
WGS 84	World Geodetic System 1984
HSE	Health Safety and Environment
ERP	Emergency Response Plan
QA/QC	Quality Assurance/Quality Control
HAZID	Hazard Identification

5. Seismic spread layout

Definition of the spread layout parameters depends on target depth, and resolution required on this target.

Main parameters include location of survey lines, source and receiver geometry, number of active channels and fold (multiple coverage rate).

Contractor shall request all available information from Company, to finalize his technical proposal, such as geological context, results of previous geophysical investigations, access to the site and state of the ground surface.

Contractor shall endorse Company's requirements in terms of spread layout. If Contractor considers that the proposed spread layout may not achieve Company's objectives, Contractor shall propose an alternative layout, which shall be properly justified and ultimately approved by Company.

5.1 Determination of source and receiver geometry

Determination of source and receiver geometry includes determination of the source-receiver offset with receiver spacing.

The geometry shall be defined following two steps:

- A first step of design proposed and justified on the basis of numerical modelling results
- A second step of final survey design proposed on the basis of a preliminary in field data acquisition test, performed at the beginning of the survey in close collaboration with Company's representative.

The object is to obtain the optimal acquisition window to separate target reflections from coherent noise, with visualisation of the reflected waves on several adjacent seismic traces, which fully and coherently sample the target reflection wavelet.

5.1.1 Numerical modelling

When sufficient preliminary information are available, such as known seismic properties, layer/target geometry, or logging results performed in a nearby borehole (sonic, density, resistivity, gamma logs), it is strongly recommended that Contractor should in advance perform forward modelling to generate a synthetic seismogram.

Results of modelling will be very useful to identify the best acquisition geometry, in order to separate target reflections from coherent noise events such as direct waves, refractions, air waves and surface waves (ground roll).

Figure 5: Example of forward modelling to define optimal acquisition window

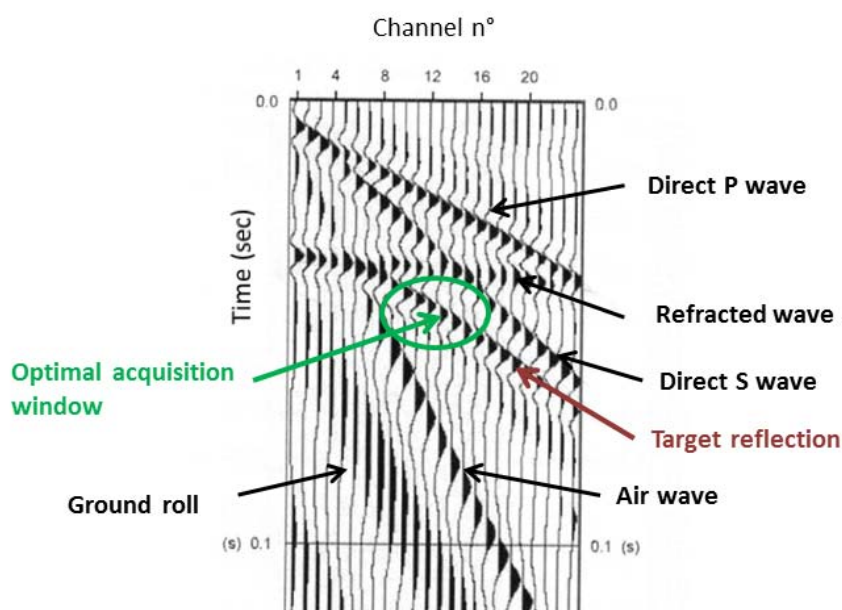


Figure 5 gives an example of forward modelling showing the optimal acquisition window (in green), located in the centre of the seismogram between channels 8 and 16.