

GENERAL SPECIFICATION

SURVEYS

GS EP GEO 210

Onshore Geophysical Site Survey Cross hole geophysical survey

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1. Scope

The content of this General Technical Specification indicates the minimum standards required by Company for cross-hole geophysical survey. However, should Company consider that any aspects of the work require more detailed investigation, Company reserves the right to apply further Particular Technical Specifications.

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 for such Equipment. 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 is to be carried out in conjunction with data acquisition in order to be sure that surveyed area is acceptable.
- **Interpretation phase.**

Reports shall include measured and computed data and interpreted cross-sections as per the objectives of the Particular Technical Specification

The final product shall be an Expert Report.

The scope of the Work is included in the Particular Technical Specifications.

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
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 102	Onshore geotechnical soil survey
GS EP GEO 401	GIS requirements for engineering site surveys and studies
GS EP GPA 202	Seismic HSE for Land Activities
GS EP POS 003	Onshore land surveying and positioning works
GS EP POS 004	The use of Differential Global Navigation Satellite System

3. Cross hole survey objectives and methodology

3.1 Cross-hole survey objectives

Cross-hole seismic measurement is a well-to-well technique used to determine the in-situ dynamic soil moduli at small strains. Main applications are related to earthquake engineering and characterisation of the soil response to cyclic and dynamic solicitations for critical structures including but not limited to:

- Storage tanks
- Refinery
- Compressors
- Multi-storey buildings
- Nearshore structures.

Dynamic Young modulus (E_d), dynamic shear modulus (G_d) and Poisson's ratio (ν) of the different geotechnical units are calculated from the cross-hole measured velocities (V_s and V_p) using the following formulae:

$$\nu = (V_p^2 - 2V_s^2) / 2 \cdot (V_p^2 + V_s^2)$$

$$E_d = 2\rho \cdot V_s^2 \cdot (1 + \nu)$$

$$G_d = \rho \cdot V_s^2$$

where ρ is the density of the materials.

The ultimate objective of the cross-hole survey is to provide for each soil layer identified within the investigated depth the above mentioned required parameters (E_d , G_d , ν , V_s and V_p) together with an expert interpretation of the obtained values.

3.2 Methodology

The cross-hole technique is based on performing direct measurements between 3 vertical boreholes drilled at a typical spacing of 5 to 10 meters. It should be noted that the single-hole

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technique (down-hole) is not accepted by Company, in respect of the above mentioned objectives.

The methodology consists of simultaneously introducing a seismic source and 2 receivers in the three adjacent boreholes, and to measure at successive geological levels the seismic velocities of both compression (Vp) and shear (Vs) waves.

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.

4.2 Abbreviations

Ed	Dynamic Young Modulus
Gd	Dynamic Shear Modulus
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
v	Poisson's ratio
Vp	P-wave velocity
Vs	S-wave velocity
WGS 84	World Geodetic System 1984

5. Borehole requirements

If no geotechnical data is made available by Company in close vicinity of the cross-hole survey area, at least one of the boreholes (all boreholes if required by site conditions and if approved by Company) shall be used for the geological/geotechnical characterisation of the site. The geotechnical investigation shall be performed in accordance with General Specification [GS EP GEO 102](#).

5.1 Cross-hole geometry

The cross-hole measurement requires the drilling of three in-line vertical boreholes down to the target depth as defined in the Particular Technical Specifications. Reference is made to Figure 1. The distance (centre to centre) between boreholes shall be 5 m between the intended source (E) and the first intended receiver (R1) and 5 to 8 m between receivers R1 and R2.