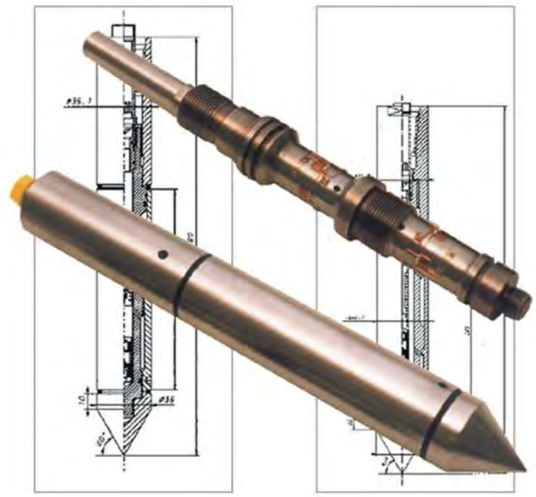
## Background

When using a drilling rig for cone penetration testing, a mechanical clamp can be mounted to the drilling head (by means of a special transition piece). The depth than can be achieved depends on the maximum downward thrust the rig can generate.

**Note:**
**While the pictures above may show a different type of drill rig, the principle to connect the transition piece to drill rig will remain the same. The transition piece will come with a pin connection that will fit into the auger box connection.**

## Description – Electrical CPT System



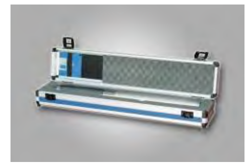
Electrical CPT probes make up the most advanced measuring method for Cone Penetration Testing. Since very sensitive load cells are used much more accurate readings than with mechanical CPT can be achieved. The electrical solution also allows for additional parameters to be measured in-situ, among others pore pressure, temperature, electrical conductivity, inclination etc.

The load cell signals are transmitted to the surface as an amplified analogue voltage signal via cable and converted to a 16 bit digital signal in the GME 500 data acquisition system. The latter is available in a portable and waterproof (IP65) version suitable for outdoor use, or an industrial 19" built-in version.

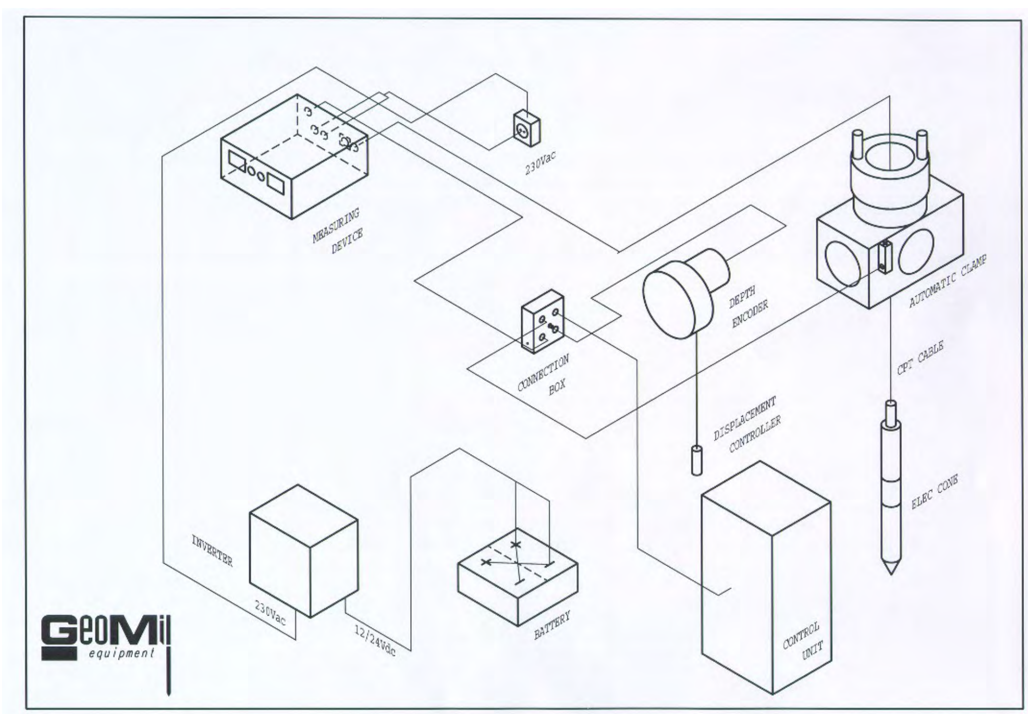
Geomil cones are equipped with tempered high quality steel parts and have state of the art load cells and electronic circuit boards, all designed by our engineers according to the latest requirements and in accordance with the ISSMGE and most other (inter)national standards.

A typical and complete electrical CPT system comprises:

- Electric cone: Geomil offers compression or subtraction type cones with either a $10cm^2$ or $15cm^2$ cross-sectional area.
  The electric cones can measure the cone resistance ($q_c$), the local sleeve friction ($f_s$) and the inclination (i). Optionally the pore pressure (u), temperature (T) and one- or two-axial inclination can be measured as well. The cones can also be provided with environmental or seismic adapters.
  All Geomil cones come in a handy portable case, protecting the cone from damage while transporting. The calibration data are provided both as print file and as data file on a high capacity USB Flash Hard Drive.



- Electric CPT cable. The purpose built cables come in any length to suit the client's requirements, are provided with specially molded waterproof Lemo connectors (gold-plated), and combine extreme flexibility with a long life cycle.
- Pushing clamp or automatic push/pull clamp with built-in proximity switch. The clamp pushes the cone and tubes into the soil and pulls them out again. The proximity switch triggers the data acquisition system to start the recording.
- Data acquisition system (8 analogue and 4 digital channels) for A/D conversion and automatic recording.
- Computer (notebook, desktop, industrial or equivalent) for automatic recording of the CPT data.
- CPTest acquisition software with an easy-to-use user interface.
- Fully automated depth registration system with rebound compensation.
- CPTask presentation, interpretation and analysis software.




Schematic configuration of electrical CPT

# VMS-GeoMil

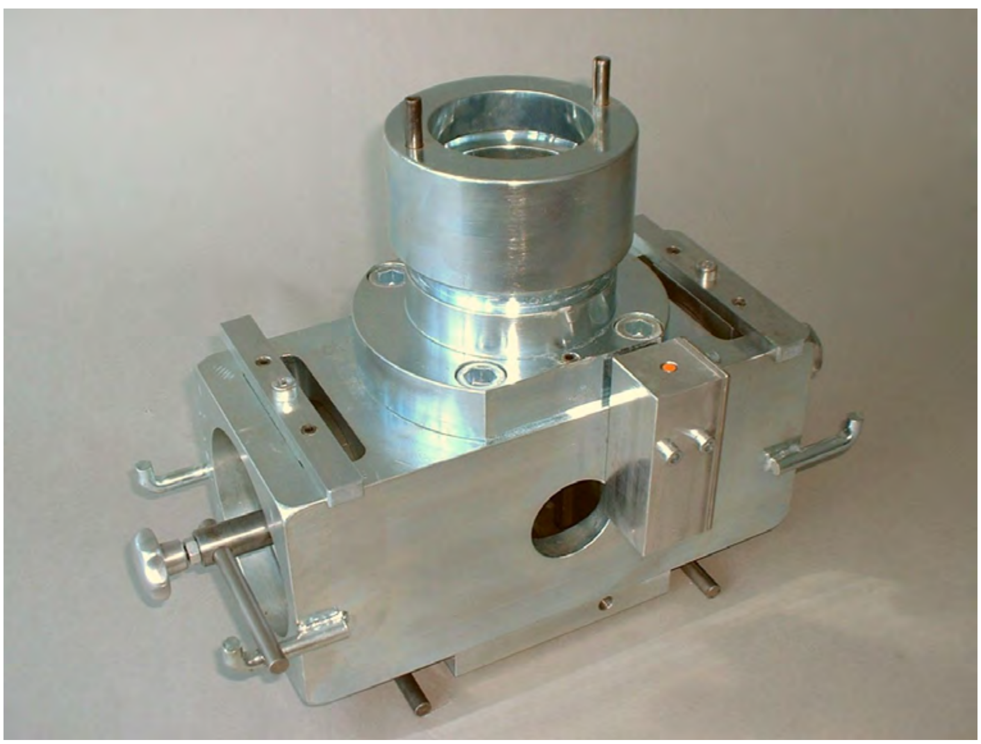
## Description – Automatic Clamp 3655

Geomil Equipment manufactures a wide range of clamps, mainly used for pushing and/or pulling or to secure the remaining rod string during the pulling process.

In general, clamps simplify the CPT operation and therefore substantially reduce the effective time required for a test. Our Automatic Clamping Device type 3655 allows automatic pushing and pulling of both CPT (36 mm) and casing tubes (55 mm). The clamp is equipped with specially tempered clamping blocks, ensuring non-slipping operation and a long lifetime.

Switching from CPT to casing tubes or vice versa takes only seconds, making the clamp especially suitable for operations where flexibility is required (e.g. soft top layers, nearshore operation).

The clamp is provided with a proximity switch, which is used to trigger the depth registration of the data acquistion system. This means that with the clamp in place the depth registration system will function completely automatically.



**Note:**
**The picture above shows the clamp with our standard nut (at the top of the clamp) to connect the clamp to a penetrometer. In this case the nut will be replaced by a transition piece that is connected to the drilling head and the clamp is then bolted to this transition piece as shown on page 3**

## Description – Seismic CPT System

Seismic Cone Penetration Testing (SCPT) has proven to be a very valuable geotechnical tool in facilitating the determination of low strain in-situ compression (P) and shear (S) wave velocities. The P-wave and S-wave velocities are directly related to the soil elastic constants of Poisson's ratio, shear modulus, bulk modulus and Young's modulus. The accurate determination of P-wave and S-wave arrival times from the recorded time series is of paramount importance to the evaluation of reliable seismic wave velocities.

The seismic CPT acquisition is conducted with a seismic adapter, attached to a CPT(U) cone. The adapter is designed such that the seismic sensors record the soil profile's response to low strain seismic disturbances.

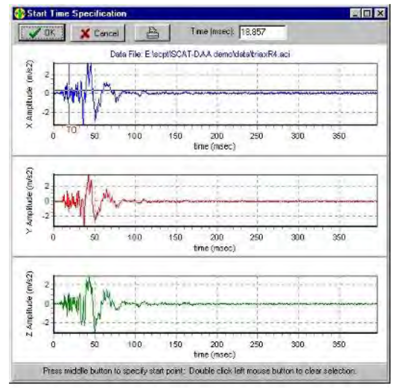

In SCPT testing, two types of sensors are typically used: velocity (i.e. geophones) and acceleration (i.e. accelerometers). A seismic sensor can be satisfactorily modeled as a linear second order system, with a characteristic natural frequency and damping factor, which transforms the sensor input of body waves and associated random noise propagating through the earth into an electrical signal.

For a good definition of the frequency spectrum of the recorded signal, i.e. to avoid smearing, the Geomil seismic adapter is equipped with accelerometers (1 Hz - 10 kHz) instead of geophones (typically 10 - 300 Hz).

To simplify the data acquisition, all hardware and software components are designed to run with a notebook computer connected to a "Signal Conditioning System", rather than the traditional seismograph. For quality assessment and proper data analysis, the frequency filtering of data is done after acquisition and not during the recording. The measured values are transferred as voltage signals by means of a cable connected on surface to the "Signal Conditioning System" where CPT data is separated from the seismic data.
The CPT data are classically logged by the GME acquisition unit and further processed by the acquisition software CPTest© running on a computer with a *Microsoft Windows* 32bit operating system.

The signal conditioned seismic data is A/D converted and then processed by **SC(1-15)-DAC™** software from Baziw Consulting Engineers (BCE). The SCPT systems can be expanded up to 15 channels (30 channels if two A/D boards are used), but typically uniaxial (**SC1-DAC**), biaxial (**SC2-DAC**), triaxial (**SC3-DAA**), and true interval six channel systems (**SC6-DAA**) are used.

In general terms, the seismic cone is advanced to the depth of interest using a hydraulic reactionary pushing force generated by a static penetrometers.

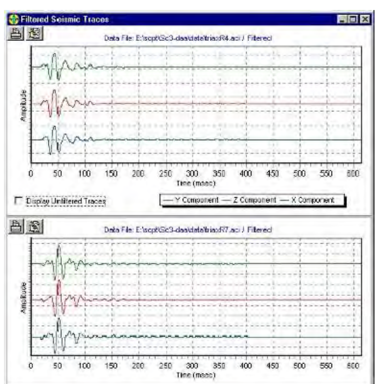



An important factor in SCPT is the generation of clean, strong and reproducible source wavelets. The particle motion of the P-wave is in the direction of the ray path, while the particle motion of the S-wave is perpendicular to the ray path. The S-wave can be polarized both parallel (SH) and perpendicular (SV) to the ground surface. When a P or SV wave strikes a boundary both SV and P-waves are generated. A SH wave will only generate SH-waves at boundaries and therefore simplifies shear wave seismic analysis.

Seismic sources are designed to generate either dominant P- and SV-waves (e.g. Buffalo gun fired in the ground) or dominant SH waves (e.g. hammer beam). The hammer beam comprises of applying a hammer blow laterally to the sides of special designed plates fixed to the penetrometer. The hammer beam generates excellent polarized SH wavelets and it is commonly applied in reverse polarity analysis (Baziw, 1988).

BCE provides both the **SC(1-15)-DAC™** data acquisition and the **SC(1-15)-RAV™** data reduction, analysis and visualization software packages. **SC(1-15)-RAV™** implements patented (i.e., US Patent #5,177,709 and Canadian Patent #2,077,387) DSP software in deriving seismic velocities and attenuation Q values from SCPT data.

From the recorded time series, arrival times for the S-waves and P-waves are determined and corresponding velocity profiles derived. The accurate arrival time estimates are critical so that the investigator is confident in the derived velocity estimates.




P-wave and S-wave incremental velocity determination is directly dependent upon the quality of the recorded seismic time series and the ability to extract the desired wavelets (i.e., P or S) understudy. The seismic P and S body waves and ambient background and electrical noise constitute the recorded seismic time series. The ability to spectrally identify and digitally isolate the desired wavelets requires fast response and high bandwidth sensors. Slow response and low bandwidth seismic sensors may result in unrecoverable distortions in the recorded time series.

Accurate in-situ P-wave and S-wave velocity profiles are essential in geotechnical foundation designs. These parameters are used in both Static and Dynamic Soil Analysis where the elastic constants are input variables into the models defining the different states of deformations such as elastic, elasto-plastic, and failure (Finn, 1984).

Another important use of estimated shear wave velocities in geotechnical design is in the liquefaction assessment of soils. Since the shear wave velocity is influenced by many of the variables that influence liquefaction (eg., void ratio, soil density, confining stress, stress history, and geologic age), it is an excellent index of liquefaction.

The seismic cone has proven to be a very accurate and reliable tool in the determination of Vs and Vp profiles. The many advantages of the seismic cone include excellent soil probe coupling, a controllable source, and cost effectiveness because it is a retrievable probe. Details of the seismic cone, the downhole test procedures, and comparisons with the crosshole results at several sites have been described by Campanella et al (1986).