

TDI-Brooks Gravity CPT Stinger

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The purpose of the Gravity CPT Stinger system is to transport a cone penetrometer down to the seabed to gather dynamic PCPT cone data from the mud line to 10-20 ft BML. In addition to its 2,000 lb driving head with lifting bale and coupling, the rig comprises a self-contained PCPT cone penetrometer that measures tip resistance, sleeve friction and pore pressure using standard ASTM protocols (**Figure 1**). The Gravity CPT Stinger system is deployed using the same winch, A-frame, and process as for gravity coring. Upon approach to seabed, the tool is inserted into the soil to about 10 ft BML (15 or 20 ft BML with extensions) at winch speed, using the downward momentum of the driving head.



Figure 1. Photo of TDI-Brooks Gravity CPT Stinger System.

Once the cone insertion/push is complete into the soil less than 3 sec after entry, the system is immediately retracted from the seabed and retrieved to the deck and cone data are downloaded from the probe for evaluation and analysis. The tool is readied for the next deployment, typically in less than 5 minutes, making numerous deepwater measurements per day feasible, depending only on water depth and winch speed. The maximum water depth for the Seabed CPT system is 3,000 m.

As a result, high quality in-situ dynamic PCPT data can be rapidly acquired from the mudline to 10 to 20 ft BML in a safe, rapid, and cost-effective manner. Data from the probe are logged 200 times per second. This logging rate allows the cone parameters to be measured at sediment intervals no larger than 2 cm even at ballistic velocities approaching 5 m/sec. Parameters so-

logged include tip resistance (Tsf), sleeve friction (Tsf), pore pressure (psi), cone acceleration (m/sec^2) and cone tilt ($^\circ$) from vertical. We can calibrate these dynamic cone data to static CPT data and strength data derived from gravity or piston core sections acquired at the same sites. Such comparisons between the static CPT measurements from the cone push at 2 cm/sec with the velocity-corrected dynamic CPT data acquired during the tool's insertion have been remarkably good at all test sites to-date. Multiple "pogo" drops are possible with the 4-hour battery logging capacity before retrieving the tool to deck.

After the tool is retrieved from the seabed to the deck, the CPT cone assembly is removed from the coupling end of the driving head and brought into the lab for data retrieval and processing. The cone's data logger is first connected via USB cable to a laptop computer, and then the raw data file generated from the Stinger drop-and-push is copied to the project folder of the laptop. The resulting raw data file on the laptop is then renamed to reflect the Site/Drop ID and opened with a CPT-Stinger program designed for processing the data into a format usable by the commonly used CPeT-IT program of GeoLogismiki Geotechnical Software.

After opening the raw data file, the user specifies some standard information including Stinger probe length and cone serial number. The user then uses the proprietary program to perform a double integration of the accelerometer data. In this manner, a very accurate and reliable measure is derived of freefall distance in the water and freefall distance in the soil.

The program then calculates the proper Tip Resistance baseline, Friction Sleeve baseline, Pore Pressure baseline, Cone Push duration, Cone Push rate, insertion time and distance into the soil, maximum penetration of the cone BML, and the cone depth upon coming to rest from ballistic insertion. The program then produces a so-called COR file, which is formatted suitably for use with the CPeIT software. This file includes the baseline-corrected measurements of Tip Resistance (Tsf), Sleeve Friction (Tsf), and Pore Pressure (psi) for the duration of the cone push into the soil. In this COR file, each of the baseline-corrected cone load cell values is individually corrected for the velocity effect on the cone readings. Effective Tip Resistance values are corrected by the following formula:

Adjusted Tip Resistance = Velocity Correction Factor x Baseline-Corrected Tip Resistance

Dynamic values for Sleeve Friction and for Pore Pressure have their own velocity correction factors. The resulting adjusted data are calibrated by overlaying the dynamic data with existing static data or soil strength data at the same or nearby site. The COR files are small enough to be emailed from the vessel to the engineers in the office.

Tool Specifications

1. Weight: 2,000 lb
2. Length: 5 ft driving head + 5 ft PCPT cone = 10 ft total length (15 or 20 ft optional)
3. Rated Depth: 3,000 m
4. Typical Cone Penetration Depth: 10 ft
5. Typical Insertion Time: 3 sec
6. Deployment System Rating: 4,000 lb SWL

7. Descent Velocity Limit: 5 min/sec (300 m/min)

Cone Specifications

1. The cone measures:
 - a. Tip Resistance (Tsf) calibrated to 10,000 lbs
 - b. Sleeve Friction (Tsf) calibrated to 1,400 lbs
 - c. Pore Water Pressure (psi) calibrated to 5,000 psi
 - d. Vertical Acceleration (m/sec^2) calibrated to ± 3 g
 - e. X and Y Tilt ($^\circ$) calibrated from vertical
2. The cone has a 15-cm^2 projected end area and conforms to ASTM International Designation: D 5778-07, Standard Test Method for Electronic Friction Cone and Piezocone Penetration Testing of Soils.
3. 10,000-lb tip load cells for initial pushes into unknown soil conditions. The full scale output corresponds to a tip resistance of 360 Tsf. The load cell will survive a force of 15,000-lbs without damage.

Data Acquisition Specifications

1. The analog-to-digital conversion uses 16-bits for a resolution of 1 in 65,000 counts.
2. The sample rate is 200 samples per second.
3. The memory capacity is 24-hours of data from the six sensors. The memory is non-volatile and will retain data in the event of a power loss.
4. The start command can be:
 - a. An operator programmed time,
 - b. A signal from the accelerometer indicating the corer has dropped.
 - c. A combination of a and b.
5. The battery life during continuous logging is a minimum of 4-hours.
6. An interface unit allows the download of the cone data to a laptop computer. The laptop is be used to initialize the cone and document cone and site identification data.
7. A full charge of the battery is achieved in less than 2 hours.