SPT Energy Calibration
(SPTE)

The International Reference Test Procedure for the Standard Penetration Test (SPT) (1989) states that "In situations where comparisons of SPT results are important, calibrations shall be made to evaluate the efficiency of the equipment in terms of energy transfer."

Gregg Drilling & Testing, Inc. utilizes a Pile Dynamics, Inc. Pile Drive Analyzer® (PDA) system to calibrate SPT systems. The SPT system is a complicated dynamic mechanical system involving the hammer, anvil rods, sampler wire rope, and winch (or cathead), *Figure SPTE*.

The PDA system measures the energy by inserting a 4-foot long instrumented AWJ or NWJ rod section into the rod string above the ground surface and immediately below the SPT hammer. This section is equipped with strain gauge transducers, to measure force, and piezoresistive accelerometers, to measure the acceleration history that is required to derive velocity. Instrumenting opposite sides of the rod helps to reduce the effects of non-uniform hammer impacts on the recorded signals.

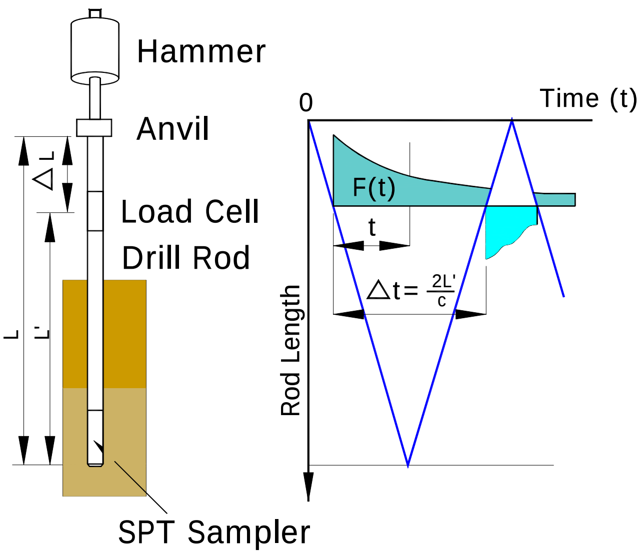

Figure SPTE

The system acquires data for both the Force Squared-Time (F2) method and the Force Velocity (FV) method. It is recommended that greater emphasis be placed on the results of the FV method over the F2 method because it is valid for non-uniform rod cross-sections and does not require empirical correction factors.

The energy transferred to the instrumented rod section was computed from the dynamic force and velocity records by the two methods mentioned above. The FV method uses both the force and velocity records to calculate the maximum transferred energy as:

$$FV = \int F(t)V(t)dt$$

The integration is performed over the time period from which the energy transfer begins (non-zero) and terminates at the time when the energy transfer reaches a maximum value. This method is theoretically correct for all rod lengths regardless of the 2L/c stress wave travel time (L= rod length, c = stress wave speed in the rod) and the number of changes in rod cross sectional area. This method is used for calculating and reporting N_{60} values from the recorded SPT and LPT blow counts.

The energy ratio ER (expressed as a percent of the theoretical energy of a standard SPT system – 140 lb hammer falling 30 inches), is computed as:

$$ER = \frac{FV}{\text{Rated Hammer Energy}}$$

The other method of computing energy transfer, F2, uses only the force record trace up to the 2L/c travel time cut off as:

$$F2 = cEA \int F(t)^2 dt$$

E = Modulus of Elasticity of the drill rod
A = Rod cross sectional area
c = stress wave speed of the rod

In this equation the integration time starts at the hammer impact time and ends at the return of the stress wave (or where the force trace crosses zero) after impact. This method was the basis for the original ASTM standard D4633-86 entitled "Standard Test Method for Stress Wave Energy Measurement for Dynamic Penetrometer Testing Systems". For this method to be valid, the integration cut-off time and the first zero force must occur between 0.9 (2L/c) and 1.2 (2L/c). Data that does not meet these criteria are flagged as invalid.

Tabular results from the energy measurements are presented to the client. The relevant columns are below the 'Average Energy' header. The Force Velocity values are reported for both the entire trace (MAX) and up to the 2L/c time. The Force Squared-Time method has been reported up to the 2L/c time. These values have been reported as a percentage of the theoretical energy of a standard SPT test (140 pound hammer falling 30 inches). A rated hammer energy of 350 ft-lbs was used for the calculation of ER so that direct comparisons between hammers could be made. The FV method at 2L/c was used for calculating equivalent N_{60} values. For completeness, the average peak force and the average peak velocity values have been reported.

The objective of the dynamic measurements is to determine the energy ratio or efficiency of the SPT system. The measured energy ratio is used to normalize the recorded SPT N values to an industry accepted standard efficiency of 60% (N_{60}).

For a detailed reference on SPT Energy Measurements refer to Daniel et. al., 2000.