A4144

Proper Use of Cone Penetrometers for Detecting Soil Compaction

University of Wisconsin-Extension

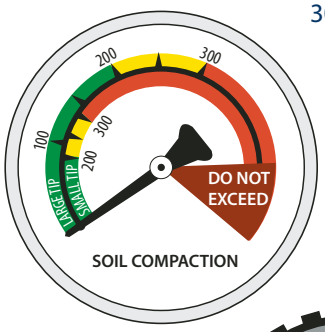
Soil compaction can decrease soil health and crop yield because it degrades soil structure and reduces root growth, plant available water and water infiltration, plant nutrient uptake, and overall plant vigor. Determining if compaction is present near the soil surface or in the subsoil is therefore important, and using cone penetrometers (also often referred to as compaction meters) can help determine if a soil suffers from compaction. This publication describes cone penetrometers and provides guidelines for their proper use.

CONE PENETROMETER DESIGN

Cone penetrometer design standards for soil compaction were developed by the American Society of Agricultural and Biological Engineers (ASABE) to help maintain uniform and consistent measurements between products from different manufacturers.

The top of the penetrometer has a T-shaped handle for the user to apply the force and a display to show the measure of force; both dial and digital readouts are available.

The shaft is a stainless steel rod, usually with marked increments. On the end that enters the soil is a changeable 30 degree cone tip. The cone has a slightly wider base diameter than the shaft (this area is referred to as the cone's shoulder). The two recommended cone sizes are ½ inch and ¾ inch, which refers to the diameter at their respective bases. Typically, the ½ inch cone is used under most conditions, and the ¾ inch cone is used in softer soils, such as peats.

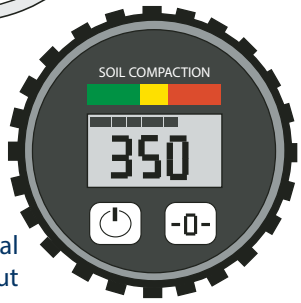


Analog dial readout

30 degree cone tips

¾ inch tip

½ inch tip



Digital readout

Shaft has incremental markings to gauge depth

PENETRATION FORCE

Pushing a penetrometer into the ground requires force. This penetration force (or resistance) is similar to how the roots of a growing crop have to push down through the soil.

Since the penetration force is calculated using the cone's base diameter, the value is referred to as the cone index and can be expressed in units of pounds per square inch (psi) or other metric equivalents. Penetrometers that have a dial gauge provide scales for both the ½ and ¾ inch tips. Digital penetrometers account for tip size and may have advanced features like GPS and internal data logging.

Generally, a cone index value of **300 psi** or greater is indicative of soil compaction. However, it is important to note that this value is just a starting point for detecting compaction and that other factors will influence the interpretation of the result.

The soil moisture and texture of a soil affects the difficulty or ease with which a penetrometer can be pushed into the ground. If a soil is dry, it will require more force to push in the penetrometer compared to the same soil if it were wet. Similarly, it will be easier to push a penetrometer into a soil with a high clay content relative to one with less clay as the tip and rod of the penetrometer will slide more easily. In addition, the root system of different crops will vary in the ability to penetrate through compacted soil. There might even be differences between varieties of the same crop.

See the following page for a list of guidelines and considerations.

T-shaped handle

PENETROMETER USE GUIDELINES

As noted on the previous page, **the 300 psi threshold is a good starting point** for assessing compaction, but it might not be applicable for all conditions. Take into account the following recommendations:

- **Avoid taking measurements when soil is too dry or too wet.** Soil moisture between field capacity or slightly drier is best. It is advised to take measurements a few days after a rainfall event.
- **Use a low compaction area as a reference.** Areas near a fence row or other low or no traffic areas can provide a baseline for comparison.
- **Take multiple readings using a zig-zag pattern in the field where compaction is suspected**, similar to a soil sampling pattern.
- **Apply a steady and constant rate when inserting the penetrometer into the ground.** A jerking motion will result in erroneous measurements.
- **Replace tips if wear or deep scratches are visible.** Pay close attention to the cone's shoulder.

Shallow compaction *(less than 6 inches below soil surface):*
High readings will be observed as soon as the penetrometer is pushed into the ground if shallow compaction is detected. The force needed to push the penetrometer will decrease after this depth.

Subsoil compaction *(greater than 6 inches below soil surface):*
Readings will be relatively low at shallow depths but will markedly increase when subsoil compaction is detected. Make note of the depth at which the effort needed to push the penetrometer increases. This is the depth to the upper boundary of the compacted soil layer. Keep pushing through the subsoil compacted layer until there is a sudden decrease on penetration resistance. Make note of the depth; this is the bottom depth and is very useful for proper setup of tillage equipment. Most commercial penetrometers have equally spaced markings to help with noting these depths. If compaction is detected below 6-inch depth, subsoiling may be warranted:

- ✓ *Subsoiling is expensive, and benefits should be considered against cost.*
- ✓ *Between 30-50 hp per shank is needed to pull a subsoiler.*
- ✓ *Subsoiling is not permanent, especially if the practices that created the compaction are not addressed.*
- ✓ *When subsoiling, leave two to three untreated strips for comparison.*

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