

## SOP: Using the Kistler Force Transducer

### **A. What this SOP covers**

A force transducer is a versatile one dimensional force sensor in that it can measure compressive and tensile forces. The force transducer we have is a Kistler Type 9203 that has a piezoelectric crystal that responds in a predictable manner to force applied to it. The transducer's signal is transferred to a handheld type 5995A charge amplifier that both amplifies the signal and provides a read-out. The charge amplifier runs on a 9V battery.

This system can be used for a variety of force measurement tasks, and we have used it to measure load-bearing capacity of soil, burrowing force of fossorial lizards, and the force needed for an animal to penetrate a substrate. A variety of other uses are possible. This SOP covers the use of the system in general, and the assembly of the load-bearing capacity and burrowing force systems.

**Cautions:** Although the system is field portable, it is delicate and expensive, so use it with care and get in-person training prior to using it (this SOP is insufficient training on its own). The cable connecting the transducer and the charge amplifier is delicate, so do not tension it, kink it or bend it other than having it in loose coils. The force transducer can be damaged if it is grossly overloaded. If the readout on the charge amplifier starts flashing, stop applying force to the transducer immediately. **Never touch** the contacts between the cable and either the force transducer or the charge amplifier. It is only possible to do this when disconnecting or reconnecting the cable, so don't do this. The oil on your fingers will damage the contacts, which would then have to be cleaned professionally by Kistler. When not in use, the system should be stored in a Pelican case.

### **B. What you need before you start**

- Kistler Type 5995 Charge amplifier
- Kistler Type 9203 force transducer
- Connecting cable
- Load-bearing capacity adaptor or burrowing force set-up

### **C. Procedure**

1. Assembling the load-bearing capacity system
  - a. Take the black load-bearing capacity adaptor foot and ensure that it is firmly connected to the metal post with male threading. If it isn't, tighten the set screw in the foot.
  - b. Screw the post into the end of the force transducer and **tighten lightly**.
  - c. You are ready to measure load-bearing capacity.
    - Press the adaptor foot vertically into the substrate until the wide portion is just buried.
2. Assembling the burrowing force set-up
  - a. Screw the force transducer into the center hole of the 5 hole, ~2cm thick plastic block.
    - i. Note that the hole is threaded on only one side.
    - ii. Rotate the block, not the transducer so that you don't twist the connecting cable.
    - iii. Tighten lightly.

- b. Use an Allen wrench to screw the aluminum platform into the end of the force transducer.
  - i. Choose the aluminum platform that corresponds to the plastic tunnel you wish to use, which is dictated by the size of the animal.
  - ii. Tighten lightly.
- c. Insert the aluminum platform into the plastic block with the tunnel and attach the two plastic blocks using four bolts with washers.
  - i. The washers go right under the bolt heads (not between the plastic blocks).
  - ii. Tighten bolts to finger tightness.
- d. Add the desired amount of substrate to the tunnel, generally ~5 cm.
- e. You are ready to measure burrowing force.
  - Feed the animal head-first into the tunnel and stimulate it to burrow.

### 3. Taking force measurements

- a. Turn on the charge amplifier using the **On/Off** button.
- b. Press the **Menu** button to adjust the sensitivity and range.
  - i. “T” is the sensitivity – number of readout units per Newton.
  - ii. “R” is the range – maximum number of Newtons before the system is overloaded.
  - iii. There is an inverse relationship between sensitivity and range, to the higher one is, the lower the other.
  - iv. Use the **up** and **down arrow** buttons to change the sensitivity or range.
  - v. Use the **Menu** button to switch from sensitivity to range to measuring mode.
- c. Use the **up** and **down arrow** buttons in measuring mode to select the readout you want.
  - i. The read out cycles through Instantaneous, Minimum, and Maximum force.
  - ii. Maximum force is positive and measures compressive forces, including load-bearing capacity and burrowing force.
  - iii. Minimum force may be negative and measures tensile force.
- d. Press the **Reset** button to zero the readout.
  - The charge amplifier drifts considerably in more sensitive settings, so you may need to reset it multiple times to keep it near zero when you do the trial.
- e. Do your trial.
  - if the read out begins to flash, you have overloaded the force sensor, so stop applying force immediately. This is a warning to prevent damaging the sensor. If the readout begins to flash, you may need to switch to a higher range setting.
- f. Record your data.