Electrofishing Gear Electrode Resistance Determinations

Overview-

To determine resistances of electrodes in field situations, you must deploy your gear in “typical” field conditions (water depth, electrode submergence depth, bottom type). Once the electrodes are positioned, energize them, read volts and amps from the metering, and calculate resistance using Ohm’s Law. For energizing the electrodes, use the gear power source, as a generator, or an external source as a battery. You will need accurate metering with resolution to the nearest Volt or 0.1 Volt and 0.01 Ampere. If testing electrofishing units in moderate to high conductivity water with significant current demand, an ammeter to the 0.1 Amp should be sufficient.

This document provides guidance for making electrode measurements on various gear types, using an external power source and an internal power source. The external power source approach (*Battery Method*) is presented first with two parts. The first part covers resistance measurements for a 2-boom boat with the hull as the cathode. The second part addresses resistance measurements for electrofishing units with one anode and one cathode. This second part refers to measurements on backpack shockers, single-boom boat shockers, single-anode tow barges). The internal power source approach (*Power-on Method*) is presented at the end of this document.

Battery Method – Electrofishing Boat (2 boom) Resistance Determination

This is a simple method of determining total, anode and cathode resistance for a typical electrofishing boat using two *identical* boom anodes and the boat hull as the cathode. Besides the boat, booms and dropper anodes, one needs only a **12-volt battery** or two* (automotive or marine type), one set of automotive **jumper cables**, a short jumper to connect two batteries in series (if two batteries are used), and a **digital multimeter** for reading voltage to the nearest 0.1 volt and current to the nearest 0.01 amp or possibly to the nearest milliamp. To standardize the resistance values by conductivity, one needs a **conductivity meter** and a **thermometer** if the conductivity meter only displays specific conductivity, which is typical of less expensive conductivity meters. The needed value is ambient conductivity, Ca, which is easily determined from specific conductivity, Cs.
Ca = Cs x 1.02^(°C-25). Bring a **pencil**, **notepad** and a **calculator**.

Deploy the boom anodes as for electrofishing except do not plug them in. Attach one jumper cable to each boom at the ring or other suitable electrically conductive spot. Place the two batteries on the boat bow and connect them in series, or just place the one battery on the bow. Place the other end of each jumper cable on the bow near the batteries. Move the boat to a typical electrofishing position in the water body. Connect one jumper cable to the positive battery terminal. Connect the other jumper cable to one lead of the multimeter set to read current. Temporarily connect the other lead to the negative battery terminal to complete the circuit and record the current in amperes to the extent of your meter resolution.

Now take the multimeter out of the circuit as an ammeter and set it (setting and leads) to read voltage. Take the jumper cable which was attached to the multimeter lead and connect it directly to the negative battery terminal. Temporarily connect the multimeter leads to each battery terminal and measure the voltage while the circuit is completed and the battery is subjected to the same electrical load as for the current measurement.

Record the voltage under the load to three significant digits. Divide the voltage by the current and record the resistance to three significant digits. Standardize this resistance value to a conductivity of 100 µS/cm. To do this, simply multiply the "ambient" resistance by the ambient conductivity and divide by 100. **Label this value as $2R_A$.** It is called $2R_A$ because it is the resistance of two anodes connected in series.
Bring the boat back into shore and move the jumper cable from one boom to the boat hull. Move the boat back to the same or equivalent spot in the water body and **redo the current and voltage measurements and convert the resistance value to a conductivity of 100 µS/cm. Label** this resistance value R_{A+C}.

Now use these two resistance values and Ohm's Law to calculate the other desired values. First, divide $2R_A$ by two to derive R_A, the resistance for one boom anode. Subtract that from the R_{A+C} value to get R_C, the resistance for the boat hull acting as the cathode. In typical boat electrofishing, the two anode booms are used in parallel, so the resistance of both boom anodes is half the resistance of one boom anode. Divide R_A by 2 to derive $R_{½A}$. Therefore, the total resistance when electrofishing is $R_{½A+C}$. Divide $R_{½A}$ by the total resistance and multiply by 100 to express the anode resistance as a percent of the total resistance.

Rules of Thumb: Boat hulls should have a resistance of about 15-20 ohms at 100µS/cm. Anode resistance should be about 60-70+% of the total resistance. Total resistance should be about 25-60 ohms at 100µS/cm.

*Two batteries may be needed in low water conductivity to increase the current applied for better instrument readings.

Meter Readings

Specific Conductivity __________ Temperature ________

Ambient Conductivity __________

2 Boom electrode system (booms in circuit only)

V _________

I _________

1 Boom electrode system (boom and boat hull or "cathode" droppers in circuit)

V _________

I _________

Resistance Calculations

$2R_A$ _________

R_A ___________

$R_{½A}$ _________

R_{A+C} _________

R_C ________

$R_{½A+C}$ _______ (total electrode resistance of a unit with 2 anodes & 1 cathode)

$R_{½A} \div (R_{½A+C}) \times 100$ _______ (% of power going to the anode)

Battery Method - Electrofishing Gear (1 anode, 1 cathode) Resistance Determination

This method can be used with a variety of gears that deploy 1 anode and 1 cathode. In addition, this process can be used to determine the resistance of any single electrode. You'll need the same test equipment as with the 2-boom EF boat determination. Take or calculate ambient water conductivity.

Deploy two "identical" anode electrodes as for electrofishing (typical water depth, submergence level). Spread the anodes apart as far as practical. Attach one jumper cable to each electrode at a suitable electrically conductive spot. Place the two batteries (preferred) on the ground and connect them in series, or just place the one battery on the ground. Place the other end of each jumper cable on the ground near the batteries. Connect one jumper cable to the positive battery terminal. Connect the other jumper cable to one lead of the multimeter set to read current. Temporarily connect the other lead to the negative battery terminal to complete the circuit and **record the current in amperes to three significant digits**.

Now take the multimeter out of the circuit as an ammeter and set it (setting and leads) to read voltage. Take the jumper cable which was attached to the multimeter lead and connect it directly to the negative battery terminal. Temporarily connect the multimeter leads to each battery terminal and measure the voltage while the circuit is completed and the battery is subjected to the same electrical load as for the current measurement.

Record the voltage under the load to three significant digits. Divide the voltage by the current and record the resistance to three significant digits. Standardize this resistance value to a conductivity of 100 µS/cm. To do this, simply multiply the "ambient" resistance by the ambient conductivity and divide by 100. **Label this value as $2R_A$.** It is called $2R_A$ because it is the resistance of two anodes connected in series.

Next, disconnect one of the anodes and replace with a cathode. Move back to the same or equivalent spot in the water body and **redo the current and voltage measurements and convert the resistance value to a conductivity of 100 µS/cm. Label** this resistance value R_{A+C} (total electrode resistance of the gear).

Now use these two resistance numbers to calculate the other desired values. First, divide $2R_A$ by two to derive R_A, the resistance for one anode. Subtract that from the R_{A+C} value to get R_C, the resistance for the cathode.

Divide R_A by the total resistance (R_{A+C}) and multiply by 100 to express the anode resistance as a percent of the total resistance.

Rules of Thumb: Total resistance of many backpack shockers often is around 300 Ohms at 100µS/cm. The % power allocated to the anode usually is closer to 50%.

*Two batteries may be needed in low water conductivity to increase the current applied for better instrument readings. This is especially true with the small electrodes used for portable electrofishing gear.

Meter Readings

Specific Conductivity __________ Temperature ________

Ambient Conductivity __________

2 similar electrodes that serve as anodes

V _________

I _________

1 anode and 1 cathode

V _________

I _________

Resistance Calculations

$2R_A$ _________

R_A ___________

R_{A+C} _________ (total electrode resistance of a unit with 1 anode & 1 cathode)

R_C ________

$R_A \div (R_{A+C}) \times 100$ ______ (% of power going to the anode)

Power-on Method – Electrofishing Boat (2 boom) Resistance Determination

This is another simple method of determining total, anode and cathode resistance for a typical electrofishing boat using two identical boom anodes and the boat hull as the cathode. Peak values of voltage and current for calculating resistance can be taken

1) directly from the control box with a peak-reading voltmeter and multimeter of sufficient resolution (to nearest Volt and to nearest 0.01, 0.1, or 1.0 Ampere) or

2) from a **digital multimeter or scopemeter** for reading voltage to the nearest volt or 0.1 volt and current to the nearest 0.1 amp, 0.01 amp (preferably), or possibly to the nearest milliamp. Current measurements will require a current probe (clamp). If using AC or continuous DC, typical commercial multimeters can be used in concert with a transformer-type current clamp (AC only) or a Hall-effect current clamp (AC & DC). If using pulsed DC, a peak-reading digital multimeter in concert with a Hall-Effect current clamp is required.

To standardize the resistance values by conductivity, one needs a **conductivity meter** and a **thermometer** if the conductivity meter only displays specific conductivity, which is typical of less expensive conductivity meters. The needed value is ambient conductivity, Ca, which is easily determined from specific conductivity, Cs.
Ca = Cs x 1.02^(°C-25). Bring a **pencil**, **notepad** and a **calculator**.

Deploy both boom anodes as for electrofishing and plug them in. Move the boat to a typical electrofishing position in the water body. Start with a sufficient power level so that current output is a few to several peak amperes (200 – 300 V in moderate water conductivities, more voltage in lower conductivities and less at higher conductivities).

If reading directly from the control box, record peak volts and peak amps to the greatest resolution of your meters. If using external meters, for voltage measurements, attach the anode lead to the anode electrode on one boom and the negative lead to the hull. Measure peak voltage. Next, remove the leads from the meter and the boom electrode, and attach a clamp ammeter. Use the clamp ammeter on one of these locations:

cathode cable to the hull, or

anode cable before the node (split) to the booms, or

anode cable to each boom (add amperage readings for a total amperage).

Record the voltage and current to the extent of the meter resolutions.

Divide the voltage by the current and record the resistance. Standardize this resistance value to a conductivity of 100 μS/cm. To do this, simply multiply the "ambient" resistance by the ambient conductivity and divide by 100. **Label this value as** $\mathbf{R_{½A+C}}$. This resistance value, $\mathbf{R_{½A+C}}$, is the total electrode resistance with 2 booms.

Now, disconnect or better, disconnect and raise, the boom not connected to a lead. **Redo the current and voltage measurements and convert the resistance value to a conductivity of 100 μS/cm. Label** this resistance value $\mathbf{R_{A+C}}$, the total electrode resistance using only one boom.

Now use these two resistance values and Ohm's Law to calculate the other desired values. First, subtract $\mathbf{R_{½A+C}}$ from $\mathbf{R_{A+C}}$ to derive $R_{½A}$, the resistance for both anode booms combined. Multiply $R_{½A}$ by 2 to find $R_{A,}$ the resistance of one boom. Subtract R_A from the R_{A+C} value to get R_C, the resistance for the boat hull acting as the cathode.

In typical boat electrofishing, the two anode booms are used in parallel, so the resistance of both boom anodes is half the resistance of one boom anode. Therefore, the total resistance when electrofishing is $\mathbf{R_{½A+C}}$. Divide $R_{½A}$ by the total resistance and multiply by 100 to express the anode resistance as a percent of the total resistance.

Rules of Thumb: Boat hulls should have a resistance of about 15-20 ohms at 100µS/cm. Anode resistance should be about 60-70+% of the total resistance. Total resistance should be about 25-60 ohms at 100µS/cm.

Meter Readings

Specific Conductivity __________ Temperature ________

Ambient Conductivity __________

2 Boom electrode system

V _________

I _________

1 Boom electrode system

V _________

I _________

Resistance Calculations

$R_{½A+C}$ _________

R_{A+C} __________

$R_{½A}$ _________

R_A _________

R_C_________

$R_{½A} \div (R_{½A+C}) \times 100$ _______ (% of power going to the anode [2-booms])