Anesthesia Tub Electrical Testing

The anesthesia tub (AT24W17H8) was tested with a Fish Guardian (FG5000) controller to determine electrical performance and shock intensity. This anesthesia tub consists of a 24” x 17” x 8” tub that uses two stainless steel electrode plates 16” x 6” placed on the 24” sides of the tub.

Tap water was used to fill the tub. The following table show how much water is used in the tub and the total current flow between the electrodes:

Tap Water		
Gallons	**Probe Current (mA)**	**Water Depth (inches)**
1	5	0.75
2	10	1.5
3	18	2.375
4	24	3.375
5	29	4.25
6	35	5.0

*Measured in the center of the tub. The tub was actually ½” deeper towards the sides

The Battery Voltages was 25.24 Volts and the Probe Voltage was 25.2 Volts.

Electrical Shock Background

Shock occurs because of the current flowing through a body not the voltage. However, there is a relationship between current, voltage and resistance called Ohm’s law. This is the equation:

$$Current = {}^{Voltage}/_{Resistance}$$

The reason that voltage is a factor in electrical shock is because the resistance of an object can have some fixed value for a given situation. Every situation may be different. When this occurs according to Ohm’s law the higher the voltage the more current will flow through the circuit. For humans current through the heart is life threatening. However, our skin resistance is very high which drastically reduces life threatening shock. When our bodies are wet the resistance goes down the likelihood of feeling a shock increase.

Shock Testing

Placing a hand with the thumb fully extended in the tub using 6 gallons of pure tap water with a Probe current of 35 mA no electrical pulsing or shocking should be felt. To better test the shocking ability salt was added to the water to increase the current flowing through the water. The following table describes the shocking ability of the system as a function of current density. A hand was placed in the tub where the thumb was not extended.

Shock Testing versus Current Density		
Salt (tsp)	**Probe Current (mA)**	**Comments**

0	35	Could not feel pulse
1	210	Slight tingle felt in the hand
2	430	Tingle felt stronger than with 210 mA
3	620	The tingle was noticeable
4	800	The tingle was stronger still
5*	975	Strong tingle, not likely to keep hand in the tub for a long time

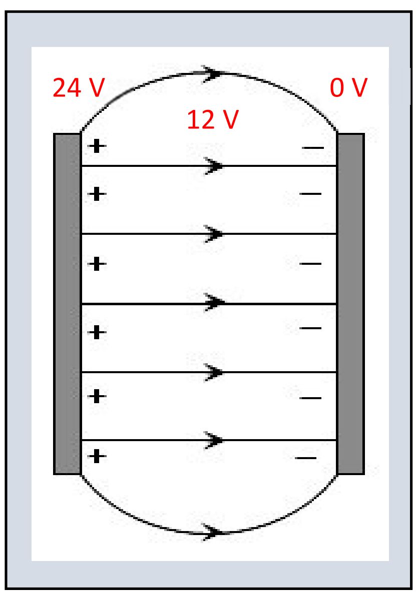
*Both hands were placed into the tub near the electrodes to maximize the shock hazard (see section below). The electrical pulses could be felt through the hands, arms, and chest. Both hands could also be placed in the tub parallel to the electrodes, one hand next to the other so that one could barely feel a tingle in your hands and arms.

Electrical Field Lines in the Tub

The electrical field lines in the tub point from one electrode to the other as show below. The controller uses a 24 Volt battery to create this electrical field. The Fish Guardian products have a 25 ms on time with a 125 ms off time giving a total cycle time of 150 ms. The higher the conductivity of the water the more current that will flow between the two plates. The voltage from one plate to the other will be the same as the battery voltage. An AC voltmeter can measure the pulsing AC Voltage from the controller. If you have a true RMS meter the RMS Voltage of the controller is given by the following equation:

$$Vmax_{rms} = Vmax_{Probe} * \sqrt{Duty\ Cycle} = 24 * \sqrt{{}^{25\ ms}/_{150\ ms}} = 9.798\ V$$

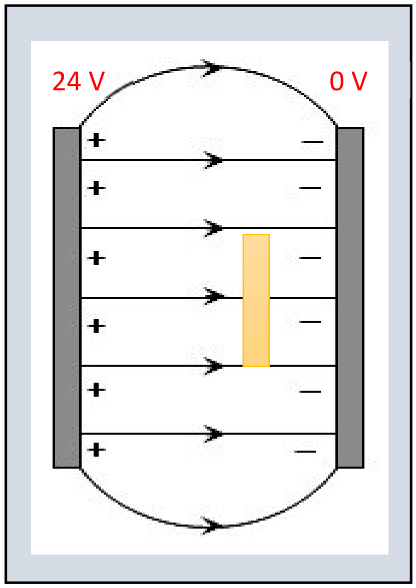
A true RMS meter will measure about 9.8 Volts at the electrodes. You can stick the probe tip in the water and move it from one plate to the other and you will see a linear change in the voltage as a function of distance. 4.9 Volts will be measured midway between the two electrodes (this is equivalent to half of the peak voltage. It was observed that the voltages in the corners of the tub that extend beyond the edges of the electrode plates have a drop of about 10% of the voltage. This suggests that fish located in this part of the tub will still feel 90% of the shock compared to being placed directly between the electrodes.



Voltage potential across you hand will determine the amount of shock you receive. For example, the following figures show the orientation of the hand for minimum and maximum shock.

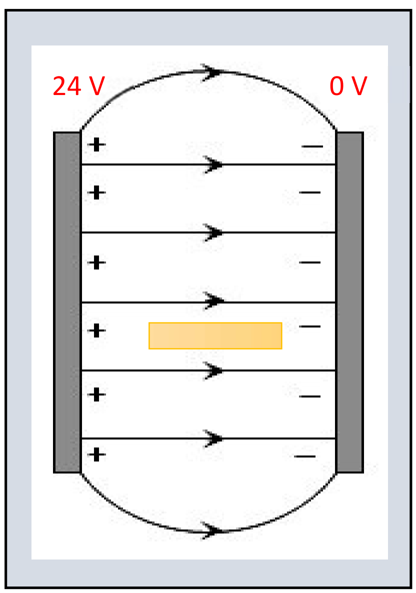
Orientation of the hand for minimum shock

If the hand is placed in the tub perpendicular to the electrical field lines (parallel to the electrodes) current will only be flowing through the thickness of the hand.



Orientation of the hand for maximum shock

If the hand is placed in the tub parallel to the electrical field lines (perpendicular to the electrodes) the current will be flowing through the entire width of the hand. Extending your thumb will increase the felling of shock even further.



Summary

The intensity of electrical shock felt in one hand is a function of the current flowing in the water and the orientation of the hand. If the hand is placed parallel to the electrical field lines (perpendicular to the electrodes) the shock will be more intense than if the hand is rotated 90 degrees to be parallel to the electrodes or perpendicular to the electrical field lines. The shock will also be proportional to the current which will be a function of the electrode voltage (in this case 24 Volts) and the conductivity of the water. Low voltage pulses like 24 Volts are safe for humans. For additional information see “Fish Anesthesia Electrical Safety”.