

## AP Air Ion Counter Instructions

### Standard 2 million ions/cm<sup>3</sup> version-

The 6 m long ground cord should be used to connect the meter to earth ground for most types of measurements - especially if you are measuring near an ionizer.

Make sure the wind guard (black plastic cover) is in place over the top slot in the meter (again, for most types of measurement).

To adjust the OFFSET, set the POLARITY switch to the center position (halfway between "+" and "-") and set the other switch to STANDBY.

Turn the RANGE knob to "19.99".

Adjust the OFFSET knob so that the display reads zero +/- 2 counts (+/- 0.02).

After this step, the OFFSET might not need to be readjusted again, ever.

However, it should be checked at the beginning of each measurement session or if the temperature changes significantly.

If you change the knob to another range like "199.9", you will not need to readjust the OFFSET.

To measure, orient the meter so that the top slot (the one that is usually covered by the black plastic wind guard) is in the region of air or gas to be measured.

Select the POLARITY you want to measure.

The display will immediately jump to a high value (or a "1" or "-1" at the extreme left side of the display with no other digits showing) when you switch POLARITY, but it will stabilize within 10 seconds.

Then flip the right switch up to MEASURE. This will turn on the fan, and the display will read the correct number of thousands of ions per cubic centimeter in the air. For example, with the POLARITY set to "-", if the display reads "-0.86", this is 860 negative ions/cm<sup>3</sup>.

If it reads -12.63, it means 12,630 negative ions/cm<sup>3</sup> (=12.63 kilo-ions/cm<sup>3</sup>).

When not measuring, leave the right switch on STANDBY to conserve battery power (STANDBY uses 1/8 the power of MEASURE).

When measuring near a strong source of ions, the display may go over-range: it will read a "1" at the far left with no other digits.

Then switch the RANGE to a higher number, like 199.9 or 1999. The less sensitive ranges 199.9 and 1999 will respond faster than the 19.99 range, which uses slower electronic filtering.

For accurate readings of the average number of ions in a room, avoid measuring near charged plastic like synthetic fabric (clothing).

The excess charge will reduce both positive and negative ion counts in the vicinity. Sometimes ions do not mix well in a room.

There may be a cloud of negative ions in one area with almost no ions just a few inches away. Any fan (even a slow one) helps mix ions in a room.

Without some mechanism for circulating the air, you may see the ion count go low, then high, then low, irregularly as a "cloud" of ions sloshes back and forth.

This meter reads exclusively the negative ions in the air when POLARITY is on "-", and positive on "+".

A substantial number of both polarities can co-exist in the same volume of air.

If you see all three decimal points at the same time, the battery is low.

Unscrew the back to replace it with a common 9 volt alkaline battery.

Make sure that you put in the new battery so that the wire does not interfere with the motion of the fan.

A plug (included) can be inserted in the left side of the meter to monitor the output, which is a slowly-changing analog voltage.

This is a stereo plug in which the ground has been cut. (Only the tip and center contacts should be used.) An output of +1.999 volts (or -1.999 volts) represents full-scale of the meter, regardless of which RANGE is selected.

For example, if the tip pin is -1.5 volts (with respect to common, the center pin), and the RANGE is "199.9", which is a range of 199,900 ions/cm<sup>3</sup>, then the display will read "-150.0" and the actual ion concentration is 150,000 negative ions/cm<sup>3</sup>.

If the range is then changed to 1999, the display will read "-150" but the output will drop to -0.15 volt.

Note the case ("ground") is not common, but is instead +10V or -10V with respect to common, depending on the POLARITY selected.

The center contact of the plug is common and the tip is the output.

Do not connect the 20 foot ground cord to the meter case if the output is connected to your data acquisition (DA) system.

(There could be a ground conflict, but any ground current is limited to less than 1 ma and 10V.)

Instead, make sure that the ground of your DA system is earth grounded.

## **20 million ions/cm<sup>3</sup> version-**

This version of the meter is designed to measure near electric ionizers and other strong ion sources. It is not as sensitive as the 2 million version.

The three ranges of this version are exactly 10 times the ranges of the 2 million version.

They are (full scale) 199,900 ions/cm<sup>3</sup> ("199.9x10<sup>3</sup>"), 1,999,000 ions/cm<sup>3</sup>, and 19,990,000 ions/cm<sup>3</sup>.

The respective resolution of each range is also changed by a factor of 10; for example, at the most sensitive range ("199.9x10<sup>3</sup>"), the least digit is in units of 100 ions/cm<sup>3</sup> (0.1x10<sup>3</sup>).

All other controls function the same as the 2 million version.

### **200 million ions/cm<sup>3</sup> version-**

The three ranges of this version are exactly 100 times the ranges of the 2 million version.

They are (full scale) 1.999 million ions/cm<sup>3</sup> ("1999x10<sup>3</sup>"), 19.99 million ions/cm<sup>3</sup>, and 199.9 million ions/cm<sup>3</sup>.

The respective resolution of each range is also changed by a factor of 100; for example, at the most sensitive range ("1999x10<sup>3</sup>"), the least digit is in units of 1000 ions/cm<sup>3</sup> (1x10<sup>3</sup>).

All other controls function the same as the 2 million version.

### **AC power option (without rechargeable battery system)-**

This version of the meter can accept an AC adapter (included).

Note that the AC adapter disconnects the included battery whenever the adapter is plugged into the side of the meter, and does not charge the battery.

However, if you have the rechargeable battery system (below), disregard the previous sentence.

### **Rechargeable battery system option-**

With this option, a lithium-ion 9V battery is included along with a charger which doubles as an AC adaptor.

You simply leave the battery in place and plug the charger/adaptor in as needed.

The Air Ion Counter can be left turned on (or off) for any period of time with this adaptor plugged in, and the adaptor will power the meter.

A special power connector is used so it is not possible to plug in the wrong type of adaptor accidentally.

The battery needs recharging if all three decimal points become visible on the display.

Full recharge takes about 3 hours, but the adaptor can of course be left plugged in longer.

Typical Li-ion battery life per charge is 6 hours in the MEASURE mode (fan running).

This compares to 2-3 hours for an alkaline 9V battery.

The lithium-ion battery typically lasts 500 charges before dropping to 70% of capacity.

(Note that Li-ion batteries are the opposite of car batteries in that Li-ions last longer if kept cold and/or not fully charged.)

### **Air Ion Counter - Full Instructions (Standard Version of Meter)**

This meter (Air Ion Counter) pulls air into the slot in the top.

Then the air exits out the hole in the bottom.

The top slot, which is shielded by a snap-in black "wind-guard", should be pointed toward the area of air that you want to measure.

For reliable measurement, the meter's case should not have any static charge (static electricity) on it.

(See "How the Air Ion Counter Operates..." at the end of these instructions for an explanation.)

The case is conductive and will remain free of static charge if the meter is connected to earth ground through the long ground cord (supplied).

The meter's feet are also conductive so if they are sitting on a grounded metal sheet, there will be no static charge, and measurement will be accurate.

If you use the ground cord, the alligator clip side of the cord must be connected to earth ground.

A metal water pipe or faucet will work as a ground. Usually, the metal screw in a wall switch plate or outlet plate is also grounded, so it can be unscrewed a little in order to connect the alligator clip to the screw head.

The only times that the ground cord does not need to be used is if the meter can remain "un-charged" (that is, it remains at ground potential) even without the cord.

This can be done if the meter is not used near an ionizer and if the meter is touched at least once a minute by someone who is electrically connected to ground or who touches ground frequently.

If you are walking on carpet while holding the meter, you should try to touch a grounded object more frequently at least once every 10 seconds, or you should use the ground cord.

If the meter is connected to your data acquisition system, the ground cord should not be used.

A black wind-guard is snapped into the slot on the top face of the meter.

This wind-guard should generally remain in that position unless both "+" and "-" ion readings are greater than "2.00" (two thousand ions per  $\text{cm}^3$ ).

An explanation for this is in "How the Air Ion Counter Operates..." When measuring ions indoors, remember that if the air is not moving, it is also not mixing well.

This may lead to ion quantities that differ drastically from one area to another area in a room, even over a distance of a few cm.

A more uniform ion density will result if the air in a room is moving, such as from a fan, so it will be well mixed.

To operate the meter, flip the POLARITY switch to its center position, half-way between "+" and "-", and the MEASURE switch should be on STANDBY.

Then turn the RANGE knob to whichever of the three ranges is required. Usually this is 19.99 (thousand ions/ $\text{cm}^3$ ), which is the most sensitive range. It reads up to 19,990 ions/ $\text{cm}^3$ .

Wait until the display becomes stable to within +/-2 counts.

This will be about 10 seconds after the meter is turned on.

Adjust the OFFSET knob so that the display reads zero +/- 2 counts (+/- 0.02).

After this step, the OFFSET might not need to be readjusted again, ever.

However, it should be checked at the beginning of each measurement session or if the temperature changes significantly.

If you change the knob to another range like "199.9", you will not need to readjust the OFFSET. Then flip the POLARITY switch to whichever polarity ("+" or "-") you want to measure.

Wait for the display to become stable, but if a breeze is blowing and the air contains a large number of ions, the display may not become very stable.

In that case, wait at least 10 seconds after flipping the POLARITY switch. Then flip the MEASURE switch upward. This will turn on the fan, and you should hear the fan running.

Because nearby objects may carry a charge, the inlet slot (at the top) should be kept reasonably far (such as 2 feet or 60cm) from any solid object.

To do this you can hold the meter at arm's length while measuring.

Solid objects and the clothes you wear are often electrically charged and alter the number of ions present in their vicinity.

You'll see that the number of ions/cm<sup>3</sup> is usually higher in the center of a room away from any furniture than it is directly next to any furniture.

This meter will take correct readings even near solid objects, however, the ion count is usually fairly low near solid objects.

Do not move the meter while you are reading the number on the display (Hold it still each time you read it).

This will keep the displayed number more stable.

If you switch POLARITY from "+" to "-" or "-" to "+", wait at least 10 seconds before the reading will be accurate.

If while you are measuring, the number of ions in the air is quite large, the meter will read over-range.

This is shown by a "1" in the extreme left of the display, and no other digits will be visible.

If this happens, turn the RANGE knob clockwise to a higher number.

For the standard 2 million range meter, the number of ions per cubic centimeter is whatever is shown on the display multiplied by 1000.

For example, if the RANGE knob is set at 199.9 and the display reads "-125.7", it means 125,700 negative ions per cm<sup>3</sup>.

The polarity shown on the display (blank if positive, "-" if negative) should be the same as what you set on the POLARITY switch.

If the polarity on the display does not agree with what is on the POLARITY switch, check that the OFFSET is correct; with POLARITY in the center position and the meter on STANDBY, the display should read near zero.

Only in one special circumstance will these two polarities not agree.

If, for example, the POLARITY switch is set to "+", and the air near an ionizer has 1 million negative ions per  $\text{cm}^3$  but relatively few positive ions, the display will actually read a small negative number, which is about  $1/5000$  of the number of the opposite polarity. In this example, the display will read negative 1 million  $\times 1/5000 =$  negative 200 ions per  $\text{cm}^3$ , even though the POLARITY switch is set at positive. (In an example like this, it will be obvious by measuring both "+" and "-", that the "-" is very high compared to "+".)

One more feature of the meter should be noted: if the POLARITY switch is set to its center position and the meter is on MEASURE, the meter will read  $1/10$  of the sum of the number of positive ions/ $\text{cm}^3$  minus the number of negative. If the number of positive ions equals the number of negative ions/ $\text{cm}^3$ , the display will read zero.

For example, if there are 100,000 negative ions/ $\text{cm}^3$  present, and only 10,000 positive ions/ $\text{cm}^3$ , then the display will read  $(10.0 - 100.0) \times 1/10 = -9.0$  if the POLARITY switch is set to the neutral position.

This means that if all the positive ions in the air were neutralized by negative ions, there would still be an excess of negative ions ( $90,000/\text{cm}^3$ ), but the meter, when set to the neutral POLARITY position, will read  $1/10$  of this excess.

Therefore, if you want to take a quick reading of the total excess number of ions/ $\text{cm}^3$  (whatever is left over if positive and negative neutralized each other to whatever extent possible), switch the POLARITY to neutral, flip the MEASURE switch upward, and multiply the number on the display by ten.

Battery drain is about 4 mA on STANDBY, and 35 mA on MEASURE (with the fan running).

An alkaline 9 volt battery life is about 60 hours on STANDBY, and 2-3 hours on MEASURE. (If you have the rechargeable system, battery life is twice as long.)

The meter is shipped with a battery inside.

When the battery voltage drops below about 7.4, all three decimal points (. . .) will become visible.

Then unscrew the back of the meter and replace the battery. (With a rechargeable system, do not remove the back; simply plug in the charger. Full charge takes 3 hours.)

Be careful to position the battery so that the wires do not interfere with the motion of the fan. If the battery has become very weak (below 5.9 volts) and is not replaced before then, it may cause the three decimal points (. . .) not to display properly so it will not indicate low battery.

Or it may cause all numbers on the display to be blank. If this occurs, then when you turn on the fan (MEASURE), either the fan will not turn at all, or it will turn slowly and you will hear by the sound that it is turning more and more slowly. In this case, you should replace the battery.

The meter's case is coated with a conductive paint and it should not be cleaned with solvents.

If cleaning is required, use only water and a cloth, and only on the outside.

If the inside of the meter becomes very dusty, you might notice the following effect: when the meter is on 19.99 range, and STANDBY, in an area with very few ions, the display will settle at a more negative number when POLARITY is "-" than when POLARITY is "+".

If after you wait at least 30 seconds after switching POLARITY, the difference between the displayed numbers on "-" and "+" is more than 0.10 ( $100 \text{ ions}/\text{cm}^3$ ), then some dust or lint is inside, forming a slightly-electrically-conducting bridge between the internal collector plate and the metal chamber which surrounds the collector plate.

This dust is what causes a difference between the "STANDBY" the "+" and "-" readings.

To clean out the dust, turn off the meter and pull the black wind guard off from the top of the meter.

Then look at the brass square (collector plate) inside. The three wires that are connected to it go up through (3) holes.

Make sure that no dust or lint touches any of the three wires where it goes through the holes.

Then make sure the brass has no dust or lint that touches between the brass square and the right or left side of the metal chamber, and make sure the brass square is centered (left & right). If it is not in the center, it can be pushed or pulled to center it.

Blow out any dust, or clean with a strip of writing paper or a wire, if any dust is inside.

If cleaning is done properly, the difference in the display reading in still air (you may have to cover the top of the meter with your hand to stop the air flow) between "+" and "-" should be less than 0.10 (100 ions/cm<sup>3</sup>). If you make this measurement in a room with moving air and a large number of ions present, the difference in reading between POLARITY "+" and "-" is supposed to be large.

That is why the test should be in still air with a normally low ion count (less than 0.50, of both "+" and "-" ions).

## Problems

If the fan does not rotate when the MEASURE switch is flipped to the up position, flip the switch between MEASURE and STANDBY a few times. (Sometimes some dust may prevent the MEASURE switch from going fully to the "up" position).

If that doesn't work, turn off the meter and unscrew the back.

Spin the fan with your finger to make sure it can turn freely.

Sometimes the battery is replaced in a position so that the battery wire interferes with the fan motion.

If so, change the battery position.

The fan blade is on a small steel shaft. If the fan blade is positioned too far forward or backward on this shaft, it may hit something and not be able to turn.

Just use your finger or pry with a flat-head screwdriver to push the fan backward or forward so it can turn freely.

If the fan seems to be getting slower (the sound of the fan has a lower and lower pitch), replace the battery.

If all 3 decimal points show, or if the display remains blank when turned on, replace the battery by unscrewing the back (or plug in the charger, if applicable).

If the number displayed changes frequently and does not remain stable, make sure the meter is grounded.

Sometimes a screw or metal object that is supposed to be "earth grounded" is actually not, and if you connect the alligator clip of the ground cord to that, the meter may be unstable.

Check by measuring the resistance with a multimeter between the jack on the ground cord and a water pipe. It should be less than 100 K ohms.

Another way to check is to charge yourself by pointing a negative ionizer toward yourself for a few seconds, and then touch the jack on the ground cord. It should spark if it is connected to earth ground. If it does not spark, try the same test by touching a water pipe.

If you spark when you touch a water pipe but not when you touch the jack on the ground cord, the ground cord is not connected to earth ground, and you should find a good earth ground to connect to.

If you are measuring the output of a negative ionizer and you notice that the meter is detecting a large number of positive ions (especially when the inlet slot is pointed away from the ionizer), it means the meter is not properly grounded.

That is, the meter is charging to a very high negative voltage.

The voltage is so high that it is causing the air near it to spark and produce ions.

The positive ions in the air are then attracted to the negatively-charged meter. This can create a very large number of positive ions, and the meter will detect a small fraction of them even if the POLARITY is set to "-".

## **How the Air Ion Counter Operates (and How to Take Accurate Readings)**

This meter operates by sampling the air, which is pulled into the slot in the top and exits out the round hole in the bottom, at the rate of 400 cm<sup>3</sup> per second.

While inside the meter, either negative or positive ions (depending on how the POLARITY switch is set) are taken from the fast-flowing air and deposited onto an internal collector plate.

The number of elementary charges per second that hit the collector plate is measured (by measuring the voltage of the collector plate, which is connected to ground through a 10 G ohm resistor).

The POLARITY switch selects which polarity of ions (+ or -) will be measured.

This switch forces the voltage of a metal chamber, which surrounds the collector plate, to be either +10, 0, or -10 volts with respect to common.

If POLARITY is set at "+", the chamber will be at +10 volts and the positive ions in the air inside the chamber will be accelerated away from the outer walls of the chamber and toward the common (zero volts) central collector plate. At this "+" setting, negative ions will actually be accelerated away from the collector plate so in that case, the collector plate will only detect positive ions, and not detect negative ions.

Similarly, if the POLARITY is set at "-", the collector plate will only detect negative ions.

## **Three effects can interfere with ion readings, and should be avoided:**

- 1) If the plastic case of the Air Ion Counter has a significant static electric charge, either "+" or "-", the meter will read too low.
- 2) For example, if the POLARITY switch is set to "+", and the plastic case of the meter is accidentally carrying excess positive charge, the case will repel positive ions that are in the air.
- 3) Therefore, + ions won't enter the top slot and the reading will be too low.
- 4) Even if the POLARITY switch is then changed to "-", the meter will continue to read too low, because negative ions will be attracted to the (positive) case and will not enter the meter properly at the top.
- 5) Therefore, the case must be connected to ground (with the supplied long cord) unless you are sure that the case does not have a static charge. When measuring near a negative ionizer, this grounding is essential, because the ionizer will rapidly charge the case negative.
- 6) Also, any highly charged objects (objects with a lot of "static electricity", including clothing made of synthetic cloth, and plastic objects that have been handled or rubbed recently) should be kept away from the area where ions are being measured.
- 7) This surface charging can affect any plastic object near an ionizer, including the plastic enclosure of an ionizer (if the ionizer is not well designed). In this situation, an ionizer may produce a large number of negative ions immediately after it is turned on, but then the output of negative ions reduces to near zero after a time interval of a few seconds or more.



- 8) (If this happens, the enclosure of the ionizer in question should be redesigned to be electrically conductive and it should be connected to earth ground).
- 9) Any battery -operated ionizer will also have a similar problem unless its enclosure is connected to ground.
- 10) That is, the battery-powered negative ionizer will charge more and more positive until it can emit no more negative ions, because the negative ions are attracted back to the ionizer and never leave the vicinity.

Another effect that can interfere with ion detection is that ions are usually not distributed uniformly throughout a volume.

This is especially important indoors. In a room, a slight air breeze can blow an area of high ion concentration away from the ion counter and then later the breeze may blow the ions back toward the ion counter.

Therefore the number displayed may be high, but then go to near zero, and back to a high number again.

A similar (irregular) distribution of ions occurs near an ionizer.

Usually in an ionizer the ions travel out from an electric needle.

If the air in the room is not moving, the ions travel only to a distance of about 200 to 300 cm away from the needle, and then the ions stop and travel back to the ionizer or to other grounded objects that are nearby.

Also the number of ions is large in the straight forward direction, but is much smaller at wide angle, more than about 45°, away from forward.

Therefore an ion counter that is held about 250 cm away from an ionizer (straight in front of the needle) may read low, then high, then low, etc.

This is because the distance that ions travel varies between 200 and 300 cm, and slight breezes in the room can blow the "cloud" of ions backward and then forward.

The same high-low-high can occur at the side of an ionizer, for example, only 50 cm away.

The direction of the "beam" of ions coming out may change because of slight room breezes.

If a fan is used to mix the air in the room, the distribution of ions will become more uniform, and measurements will be much more stable.

The fan will make the ions travel out to all areas of the room.

If the wind guard at the top of the Air Ion Counter is removed, the reading will become more sensitive to stray static electricity.

For example, if the wind guard is not in place on top, and the top is moved toward a positively charged surface, the display will show a large positive number as long as the top continues to move closer to the TV screen.

When the motion stops however, the display will settle back to near zero after about 5 seconds.

In fact, this effect can be used to measure the charge on surfaces; when approaching a surface at a certain speed, the display will read the correct polarity of the surface and will show a number proportional to the amount of surface charge.

When you are measuring air that has mostly negative or mostly positive ions (but is not an equal mix of both positive and negative ions), then the measured number of ions per  $\text{cm}^3$  will not change much if the wind guard is removed.

(The number is usually about 5% high if the wind guard is removed).

However, a mix of positive and negative ions is less stable, and the number of ions/cm<sup>3</sup> will decrease every time the air must go around a sharp turn, such as at the wind guard.

This sharp turn causes positive and negative to neutralize each other partially. As a result, the wind guard may reduce the number of positive (and also negative) ions/cm<sup>3</sup> by 5% to 25%, with the highest reduction occurring at the highest ion density.

For this reason, the wind guard should not be used if the reading is high for both positive and negative ions.

That is, if, with the wind guard installed, you measure the number of both positive and negative ions/cm<sup>3</sup> and both numbers are higher than 2.00 (two thousand ions/cm<sup>3</sup>), you should remove the wind guard for accurate readings.

If only one (or neither) polarity is above 2.00 (thousand ions/cm<sup>3</sup>), the readings will be accurate whether or not you keep the wind guard installed, but the wind guard helps shield the Air Ion Counter from static electricity.

It also is useful if reading outside in windy conditions, because it limits the wind speed inside the Air Ion Counter.