

# INCLINED PLANE MEASUREMENT SYSTEM

## Model 235



## Operating Manual

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## 1.0 INTRODUCTION

The antistatic property of material is one of the most important factors in determining the effectiveness of a static control product. However, It is the most difficult parameter to measure on a consistent and repeatable basis. A number of different test procedures are currently in use, but the one that has gained considerable acceptance in the electronics industry is the Modified Inclined Plane Test.

This test basically measures the charge developed on Teflon and Quartz cylinders rolled down a sample of test material mounted to a plane set at a predetermined angle. Teflon and Quartz cylinders are used because they represent increasingly negative and increasingly positive portions of the Triboelectric Series. Other materials such as brass and gold plated brass can also be used. A Series obtained from Mil Std 883 is shown in Figure 1.0-1.

The apparatus required to perform this test utilizes both basic measuring instruments and several accessory items. The ETS Model 235 Inclined Plane Measurement System is a complete system specifically designed to perform the Inclined Plane Test defined in ESDA ADV11.2 Appendix B (large cylinders-std, small cylinders-optional) in a consistent and repeatable manner. The complete System includes the following instrumentation and accessories:

1. Adjustable inclined plane with cylinder release mechanism
2. Specimen holders (8 ea.)
3. Teflon and Quartz cylinders (36 ea.) -1"x1" (25.4x25.4mm)
4. Nanocoulombmeter with 3.25" Faraday cup and foot operated READ/ZERO switch
5. Balanced AC Ionizer with foot operated ON/OFF switch
6. Ultrasonic cleaner
7. Stainless steel cylinder holding trays
8. Metal tongs with grounding cable

In addition, a portable charged plate monitor for verifying ionizer balance and an automatically controlled humidity chamber are also available with the System.

Positive	Human Hands
+	Rabbit fur
	Glass
	Mica
	Human Hair
	Nylon
	Wool
	Fur
	Lead
	Silk
	Aluminum
	Paper
	Cotton
	Steel
	Wood
	Amber
	Sealing wax
	Hard rubber
	Nickel, copper
	Brass, silver
	Gold, platinum
	Sulfur
	Acetate rayon
	Polyester
	Celluloid
	Orlon
	Polyurethane
	Polyethylene
	Polypropylene
	PVC
	KEL F
Negative	Silicon
-	Teflon

Figure 1.0-1: Triboelectric Series (Mil Std 883 Version)

## 2.0 EQUIPMENT DESCRIPTION

The standard Model 235 Inclined Plane Measurement System is supplied with all the components listed in Section 1.0. However, the System can be ordered with optional or deleted accessories as required. The following are descriptions of the various standard components and optional accessories:

### 2.1 Model 236 Adjustable Inclined Plane

The Model 236 Adjustable Inclined Plane, shown in Figure 2.1-1, consists of a 0.25" (6mm) thick aluminum plate that forms the plane mounted to a sturdy steel tripod. The plane is 12" (305mm) long by 4" (102mm) wide and incorporates a pair of hold-down rails for mounting thick test specimens. The adjustable post that holds the Plane assembly can be rotated over a 45° arc. The built-in scale enables any desired angle within this arc to be selected. The stand also can be adjusted for height to accommodate the different angles selected for the plane.

Removing the mounting rails exposes locating studs for retaining the removable magnetic stainless steel specimen holders shown in Figure 2.1-2 supplied with the system.



Figure 2.1-1: Inclined Plane

Located at the top of the Plane is a moveable flap that acts as the release mechanism for the cylinders. It incorporates a pair of hold-down rails to accommodate additional test material to equalize the height of thick test

specimens. The release mechanism is activated manually by slightly rotating the knob located on the side of the plane.

The System is supplied with 8 magnetic stainless steel specimen holders with strip magnets to mount thin specimens. This is sufficient to handle most testing requirements that usually require either 3 or 6 specimens. The specimen holders enable the user to pre-mount the test specimens and then place them into the humidity chamber for conditioning and test. This is especially convenient when testing thin films. Additional specimen holders are available as an optional accessory.

Thirty-six pieces each of 1"x1" (25.4x25.4mm) Teflon and Quartz cylinders are supplied with the system. Each cylinder can be used up to 3 times before it has to be cleaned. There is a slight difference in the diameters of the Teflon and Quartz cylinders, and where the exact contact area is required to compare absolute charge levels, it is recommended that the cylinder diameters be measured.



Figure 2.1-2: Sample holders and Teflon and Quartz cylinders

## 2.2 Nanocoulombmeter

The ETS Model 230 Nanocoulombmeter, shown in Figure 2.2-1, is used to measure the charge on the cylinders after rolling down the plane. The instrument is powered by two standard 9 Volt alkaline batteries that are readily accessible from the rear panel. A BAT LO indicator warns of low battery voltage (<12V). The front panel consists of a 3½ digit LCD readout with ½" (12mm) numerals, a 3-position rotary RANGE selector switch, a READ/ZERO switch, a 1.0 Volt CAL output, BAT LO warning indicator, POWER ON/OFF switch and the BNC Faraday cup INPUT signal connector.



Figure 2.2-1: Model 230 Nanocoulombmeter

The rear panel consists of the battery compartment, optional 115 VAC Power Module input jack, a GROUND terminal for referencing the instrument to ground, a remote READ/ZERO output jack, and a Recorder Output BNC connector.

The foot operated READ/ZERO switch plugs into the remote READ/ZERO output jack on the rear panel. This enables the user to control the Nanocoulombmeter while operating the Inclined Plane. The remote switch, when plugged in, overrides the READ/ZERO switch on the front panel.

A 0-1.99 Volt signal is available at the Recorder Output corresponding to a 0-full scale reading of the RANGE selected.

The Faraday cup consists of 3.25" diameter inner sensing cup and a 4" (102mm) diameter by 6" (152mm) high outer shell mounted in an adjustable stand to that enables the user to align the cup angle with the Inclined Plane. This assembly is shown in Figure 2.1-3. In addition, a conductive foam pad is inserted in the bottom of the sensing cup to cushion the shock of the cylinders dropping into it. The cup is connected to the Nanocoulombmeter via a 3' (92cm) long Teflon insulated coaxial cable.

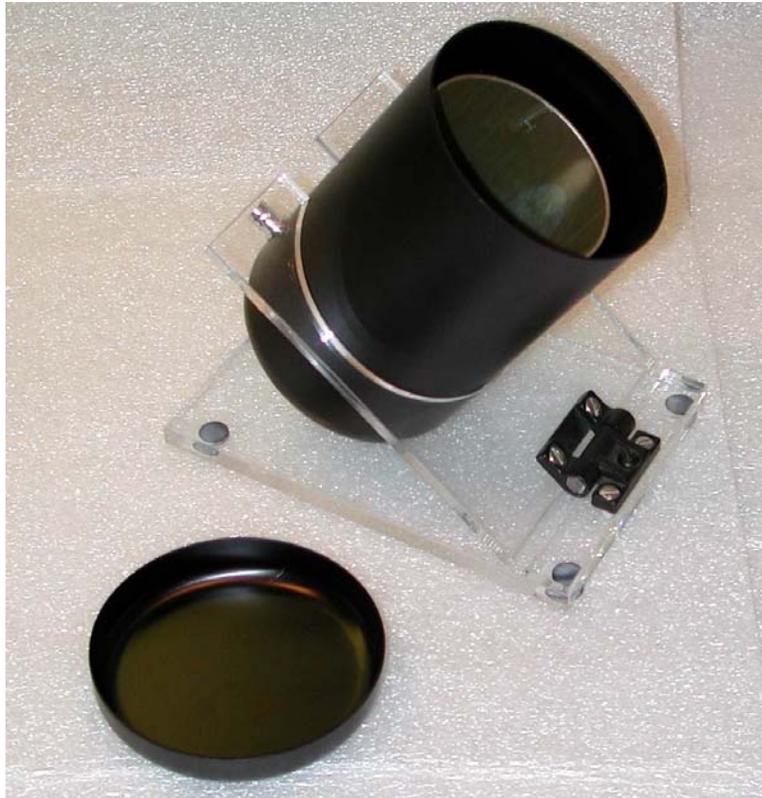


Figure 2.1-3: Faraday cup mounted in holding fixture

### **2.3 Ionizer**

A balanced AC ionizer is included to neutralize the charge on the test specimen and the Teflon and Quartz cylinders prior to making a measurement. The ionizer emits both positive and negative ions. An object with a positive static charge will draw negative ions from the airflow out of the ionizer. Conversely, an object with a negative static charge will draw positive ions from the airflow. Charged objects remaining in the airflow will remain neutralized. The ions are attracted to the oppositely charged object and neutralize the charge on the object. The ionizer incorporates a variable speed fan and a heater. A foot operated power switch is provided to control the operation of the ionizer while making a measurement.

### **2.4 Cleaning and Handling Accessories**

An ultrasonic cleaner along with a formulated cleaning concentrate, stainless steel cylinder holding trays, and a pair of metal tongs with ground lead are supplied as single group of accessories.

### **2.5 Optional Accessories**

The following are additional equipment available for performing the inclined plane triboelectric test as generally specified:

### 2.5.1 Automatically Controlled Humidity Chamber

The ETS Model 5506 Humidity Control Chamber along with the ETS Series 5000 Automatic Humidity Controller (not shown), shown in Figure 2.5-1, provides the controlled humidity environment of 12 +/- 3% R.H. required.



Figure 2.5-1: Controlled Environment Chamber

### 2.5.2 Ion Balance Detector

This test requires an ionizer with a balanced ion output. To verify that the ionizer being used is actually putting out a balanced ion stream, an ion balance detector is required. This consists of an ETS Model 212 Static Meter with Model 205C Charged Plate Detector. When installed onto the Static Meter and placed in front of the ionizer the system can measure the level of ionizer imbalance with a resolution of 1 Volt.



Figure 2.5-2: Ion balance monitor

## **3.0 SET-UP**

### **3.1 Inclined Plane**

The Inclined Plane is shipped completely assembled, but with the plane section and the legs in a folded position. Spread the leg of the tripod base to the fully opened position. Loosen the wing nut on the face of the nomenclature panel and adjust the plane to the desired angle. Currently, the 15° setting is the angle specified. Other angles that are used are 30° and 45°. Another adjustment on the main shaft adjusts the spread of the legs, which in turn, controls the height of the system. If the thick specimen hold-down rails are to be used then leave them in place. If not then remove the two 12" (305mm) rails. In most cases the specimen holders will be used. Material too thick for magnetic attachment can be easily attached using tape.

The release flap also contains a pair of hold-down rails. These are used to mount a piece of material or a spacer to provide a minimal contact surface to the cylinder during activation when thick samples are being tested. A spacer is provided to compensate for the thickness of the magnetic specimen holders.

### **3.2 Nanocoulombmeter and Faraday Cup**

Connect the Faraday cup to the Nanocoulombmeter INPUT BNC connector using the 3' (92cm) Teflon insulated coaxial cable provided. Plug the connector from the READ/ZERO foot switch into the mating jack located on the rear panel of the instrument. If a chart recorder or other type of recording device is being used, connect it to the BNC connector on the rear panel at this time.

Place the Faraday cup into the acrylic base and adjust the angle of the cup so that a cylinder rolled down the Inclined Plane will fall into the cup without hitting the side of the cup. The angle is adjusted and locked in place by first loosening, then tightening the screw on the side of the hinge.

### **3.3 Ionizer**

Plug the ionizer power cord into the foot switch AC receptacle. Plug the AC plug from the switch into a 110 VAC outlet. A convenient location for the ionizer, when testing is being performed in a humidity chamber, is towards the right rear of the chamber behind the Inclined Plane.

## 4.0 OPERATION

### 4.1 Sample Preparation

The Inclined Plane Measurement System utilizes 4" x 12" (102x305mm) test specimens. Cut samples to this size and mount the required number of specimens (usually, either 3 or 6 specimens per each sample type) to the sample holders using the ½ " (12.5mm) wide magnetic strips.

If thick samples are to be tested, either use the mounting rails on the inclined plane to secure the specimens or tape them onto the sample holders. When the sample holders are used the rails must be removed from the plane.

Cut a 1'x3.5" (25x89mm) piece of the thick sample material and mount it onto the release flap using the hold-down rails. Adjust its position so that minimal contact is made with the cylinder placed in the separation between the flap and the sample mounted onto the plane when the flap is raised to release the cylinder. When using the sample holder electrodes, install the supplied spacer onto the flap. If thick material is taped to the sample holders then add a piece to the spacer.

It is important to minimize any charging of the cylinder due to the action of the release mechanism. There may have to be some adjustments to the exact location of the spacers to achieve minimum parasitic charging and a smooth roll of the cylinder down the plane and into the Faraday cup.

After preparing the samples, place them into the humidity control chamber set at a relative humidity of 12 +/- 3% R.H. for a period of 48 hours prior to test. Current electronic and military standards use 12% as the test environment, but other humidity levels may also be used.

### 4.2 Cylinder Preparation

The test cylinders can be very easily charged through handling and can be altered when placed in contact with material having transferable coatings. It is critical that the cylinders be clean and neutralized prior to performing any tests. The use of an ultrasonic cleaner along with a formulated cleaning solution is required to achieve the necessary cleanliness.

Mix a solution of cleaner by adding 1 ounce of "BRANSON GP Formulated Cleaning Concentrate" to 10 ounces of deionized water (10:1 mix ratio). Fill the ultrasonic cleaning system with the above mixture. Place the cylinders of a given type in the cleaning basket and lower it into the cleaner. The cylinders should remain in the cleaner for at least 5 minutes. Remove the cylinders from the cleaner and immerse them in a bath of fresh deionized water, followed by immersion into a bath of methyl alcohol.

The cylinder surface must never be handled or touched by any object. If a cylinder must be touched, the metal tongs should be used and then only the ends should be touched.

Place the Teflon cylinders into one stainless container and the Quartz cylinders into the other container. If the cylinders are not going to be used or placed into a humidity chamber immediately, it is recommended that the containers be covered with the lids provided to prevent any dust accumulation on the cylinders.

Place open containers holding the cylinders in the humidity chamber, if one is being used, the same time as the samples and allow them to condition at the desired humidity for at least 48 hours.

### **4.3 Making Measurements**

Turn on the Nanocoulombmeter and allow it to warm-up for approximately 1 minute prior to use. Turn on the ionizer and allow it to warm-up for at least 10 minutes prior to test. It is recommended that the ionizer be plugged directly into the power outlet during warm-up. The ionizer should be set to the LOW Fan Speed and the HEATER should be turned off. Check the ionizer balance using the optional ETS Charged Plate Detector or other type of charged plate monitor. The output of the ionizer should be balanced to within +/-10 Volts.

After warm-up, plug the ionizer back into the foot switch receptacle. Select a test specimen by grabbing it by the edges (do not touch the surface of the material). Activate the ionizer with the foot switch and hold the sample test surface in front of it for a few seconds to neutralize any charge. Then mount the sample holder onto the plane by lining up the mounting studs on the plane with the holes in the holders.

Take a cylinder from the stainless steel container by grabbing the edges with the grounded metal tongs. Activate the ionizer and slowly pass the cylinder in front of the air stream, then place the cylinder onto the release flap, centered latterly. With the ionizer still activated, place the right hand on the release knob. Without performing any additional operations, deactivate the ionizer. Wait several seconds and with minimum movement, gently rotate the release knob counterclockwise. As soon as the cylinder begins to roll down the inclined plane, depress the READ/ZERO foot switch.

The cylinder should roll straight down the plane and into the cup without hitting anything on the plane or the edge of the cup. After approximately 2 seconds read the charge on the Nanocoulombmeter DPM and then release the READ/ZERO foot switch.

Take the tongs and grab the sides of the cylinder and remove it from the Faraday cup. A cylinder can generally be reused 3 times. However, if the test sample has a surface treatment that can transfer to the cylinder, such as pink poly, then the cylinder should only be used once. If a cylinder is accidentally dropped, handled or otherwise compromised, then it must be replaced with a clean one. Damaged cylinders should not be used for test.

Repeat the above test 3 times for each specimen. If the readings are not reasonably close then additional readings should be taken. Re-evaluate the testing procedure and also use a fresh cylinder for each subsequent measurement.

Place the used cylinders into a third container. **DO NOT PUT THEM BACK INTO THE ORIGINAL CONTAINERS.**

Repeat the above procedure for each of the test specimens.

Generally, each specimen will be tested 3 times with the Teflon cylinder and 3 times with the Quartz Cylinder. In addition, for indication, 3 specimens of the sample are tested, and for certification, 6 specimens should be tested.

As a minimum, the individual measurements, the average for each specimen and then the average charge for all of the specimens of the given sample should be recorded. The individual specification to which the test is being performed will dictate any additional data processing, such as the standard deviation, that should be provided.

A sample data sheet is shown in Figure 4.3-1



The user can check the calibration of the instrument at any time by using the supplied 0.10 uf, 1% polystyrene capacitor. This capacitor, when charged to 1.00 Volt, will produce a reading on the DPM of 100 +/- 2 nC.

Connect the clip lead of the calibration check capacitor provided to the ground terminal on the rear panel or to the outer shell of the Faraday cup. Select the 200 nC RANGE. Touch the lead from the capacitor to the CAL output connector on the front panel. Place the READ/ZERO switch in the READ mode and then touch the capacitor lead to the inner can or directly to the BNC input connector. The DPM should read 100 +/- 2nC.

The other ranges can also be checked with the same capacitor using an external precision voltage source. 10 Volts applied to the capacitor will produce a reading of 1000 nC on the 2000 nC RANGE and 0.10 Volts applied to the capacitor will produce a reading of 10 nC on the 20nC RANGE. Additional points can be checked by using different voltage and/or capacitor values (must be a precision, low leakage type). Using the relationship

$$Q_{(nC)} = C_{(uf)}V_{(volts)}$$

any reading on the DPM can be obtained.

## 5.2 Ionizer Calibration

The ionizer supplied with the System has an ion output that is inherently balanced by design. As a result, there are no calibration adjustments. If the measurement of the ionizer output shows excessive imbalance, refer to the section in the Ionizer Instruction Manual for "Trouble Shooting Ion Output and Balance Problems".

## 6.0 MAINTENANCE

The Model 235 Inclined Plane Measurement Test System requires a minimum of maintenance. However, when servicing the individual components, normal care and safety precautions should be adhered to. If any piece of equipment must be returned to ETS for service or recalibration, a Return Material Authorization (RMA) must first be obtained. The equipment must be packed in adequate packaging to avoid shipping damage and incurring additional cost to repair.

### 6.1 Inclined Plane

The Inclined Plane should require no maintenance except for an occasional cleaning of the plane surface. The plane is aluminum with a black anodized finish. Abrasive compounds should never be used. Wipe the surface with a mild liquid household cleaner or isopropyl alcohol.

Return the inclined Plane to ETS for service if there are any mechanical malfunctions.

## 6.2 Nanocoulombmeter

The ETS Model 230 Nanocoulombmeter is designed with a low current circuit to ensure many hours of use from a single pair of 9 Volt Alkaline batteries. When the battery voltage drains down to 12 Volts the front panel BAT LO LED illuminates. At this time the batteries should be replaced to retain measurement accuracy. For additional information, please refer to the Model 230 Instructional Manual.

To change the batteries, remove the battery cover mounted on the rear panel. The batteries are connected to the instrument by a pair of standard 9 Volt battery clips. Both batteries should be replaced at the same time. Replace the battery cover.

If the instrument fails to operate properly it should be returned to ETS for repair and recalibration.

## 6.3 Ionizer

Refer to the ionizer manufacturer's instruction manual.

## 6.4 Ultrasonic Cleaner

Refer to the ultrasonic cleaner manufacturer's instructional manual.

# 7.0 SPECIFICATIONS

### Model 230:

**Ranges:** 20, 200, 2000nC  
**Resolution:** 0.01, 0.1, 1.0nC  
**Accuracy:** 2.0% full scale (max),  $\pm 1$  digit  
**Readout:** 3½-digit LCD, ½" (12mm) numeric  
**Drift:** <0.05nC/minute  
**Zero:** Front panel or optional foot switch.  
**Recorder output:** 0- $\pm 1.99$ V, BNC connector  
**Calibration output:** +1.00 Volts,  $\pm 1\%$   
**Power:** Battery, 2 ea, 9 Volt Alkaline, (20 hrs typical)  
AC power module: 95-260VAC, 50/50Hz  
**Operating environment:** 0-60% RH  
**Dimensions:** 7.5"Wx8.0"Dx1.75"H (191x203x45mm)  
**Weight:** 2 lbs.

### Faraday Cup & System

**Electrical connection:** Std. BNC  
**Model 231:** Inner cup dia.: 3.1" dia.x4"D (80x102mm)  
Overall dimensions: 4" dia.x6"H (102x152mm)  
**Model 235:** System includes the following:  
Model 236 Inclined Plane, 8 Sample Holders,  
Adj. Cup angle fixture, 36 ea. 1"x1" (25x25mm) Teflon  
& quartz cylinders, ionizer with foot switch, ultrasonic  
cleaner, plus accessories  
Calibration capacitor: 0.10  $\mu$ f,  $\pm 1\%$  (Low Leakage)  
**Options:** Small cylinders, 0.5"x1" (12.5x25mm)  
Static meter with charged plate detector

## 8.0 WARRANTY

Electro-Tech Systems, Inc. warrants its equipment, accessories and parts of its manufacture to be and remain free from defects in material and workmanship for a period of one (1) year from date of invoice and will, at the discretion of Seller, either replace or repair without charge, F.O.B. Glenside, similar equipment or a similar part to replace any equipment or part of its manufacture which, within the above stated time, is proved to have been defective at the time it was sold. All equipment claimed defective must be returned properly identified to the Seller (or presented to one of its agents for inspection). This warranty only applies to equipment operated in accordance with Seller's operating instructions.

Seller's warranty with respect to those parts of the equipment that are purchased from other manufacturers shall be subject only to that manufacturer's warranty.

The Seller's liability hereunder is expressly limited to repairing or replacing any parts of the equipment manufactured by the manufacturer and found to have been defective. The Seller shall not be liable for damage resulting or claimed to result from any cause whatsoever.

This warranty becomes null and void should the equipment, or any part thereof, be abused or modified by the customer or if used in any application other than that for which it was intended. This warranty to replace or repair is the only warranty, either expressed or implied or provided by law, and is in lieu of all other warranties and the Seller denies any other promise, guarantee, or warranty with respect to the equipment or accessories and, in particular, as to its or their suitability for the purposes of the buyer or its or their performance, either quantitatively or qualitatively or as to the products which it may produce and the buyer is expected to expressly waive rights to any warranty other than that stated herein.

ETS must be notified before any equipment is returned for repair. ETS will issue an RMA (Return Material Authorization) number for return of equipment.

Equipment should be shipped prepaid and insured in the original packaging. If the original packaging is not available, the equipment must be packed in a sufficiently large box (or boxes if applicable) of double wall construction with substantial packing around all sides. The RMA number, description of the problem along with the contact name and telephone number must be included in formal paperwork and enclosed with the instrument. Round trip freight and related charges are the owner's responsibility.

### **WARNING:**

**WOODEN CRATES MUST NOT BE USED. PACKAGING OF DELICATE INSTRUMENTS IN WOODEN CRATES SUBSTANTIALLY INCREASES THE CONTENT'S SUSCEPTIBILITY TO SHOCK DAMAGE. DO NOT PLACE INSTRUMENTS OR ACCESSORIES INSIDE OTHER INSTRUMENTS OR CHAMBERS. ELECTRO-TECH SYSTEMS, INC. WILL NOT ASSUME RESPONSIBILITY FOR ADDITIONAL COST OF REPAIR DUE TO DAMAGE INCURRED DURING SHIPMENT AS A RESULT OF POOR PACKAGING.**