A White Paper:

Sealeze™ SSG515AT2D Static Dissipation Brush Performance in an Operational Environment

The following white paper was developed to document the performance of Sealeze SSD515AT2D static dissipation brush for reducing an electrostatic field in an industrial environment and application.

The application involved removing static charge from both sides of an insulative substrate (PETG film) on a "narrow web coater" in a manufacturing facility with 33% relative humidity at 18.6° C. The following chart summarizes voltage measurements taken with and without the static dissipation brushes.

Voltage Measurements of Substrate with and without Static Dissipation Brushes			
Front of Substrate		Back of Substrate	
Volts Without Brush	Volts with Brush	Volts Without Brush	Volts with Brush
10,240	3,380	10,240	4,000
0	0	-9,145	-810

A second test was conducted to determine the effect of using Sealeze SSD515AT2D static dissipation brush in conjunction with a bar ionization system. The following table shows the additional voltage reduction that was achieved using the Sealeze static dissipation brush.

Voltage Measurements of Substrate with and without Ionization and Static Dissipation Brushes					
Front of Substrate			Back of Substrate		
Volts Without Brush or Ionization	Volts with Ionization, only	Volts With Brush and Ionization	Volts Without Brush or Ionization	Volts with Ionization, only	Volts With Brush and Ionization
10,240	515	280	10,240	490	205
0	0	0	0	0	0

Summary of Results

The Sealeze static dissipation brush significantly reduced the static electric voltages generated on the PETG film during the manufacturing process. The voltage reduction was sufficient enough such that in many applications the use of costly ionization systems can be eliminated or reduced. The second test showed that Sealeze static dissipation brush can significantly increase the overall reduction in static charge when used in conjunction with ionization systems; thus, reducing or eliminating the need for additional or more powerful ionization equipment.

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White Paper: Sealeze™ SSG515AT2D Static Dissipation Brush Performance in an Operational Environment

The Sealeze™ SSG515AT2D 100% Thunderon® acrylic filament brush, chemically bonded with copper sulfide (0.0015" diameter), was evaluated on 30 November 2004 in an environment of 33% Relative Humidity at 18.6^{0}C on a "Narrow Web Coater" as pictured in **Figure 1** of this report. The purpose of the testing was to validate the reduction of an electrostatic field in a real world environment by facilitating the use of the Sealeze™ brush system on an insulative substrate. The PETG film was selected since this material represents a "worst case" scenario for evaluating charge removal on an insulator. Favorable charge removal results would be anticipated with the Sealeze™ brush system on corrugated linerboard or substrates that exhibit static dissipative characteristics. However, this paper is restricted to the evaluation of an insulative polymer film. The second portion of the report measured the beneficial results by utilizing the Sealeze™ brush in combination with ionization.

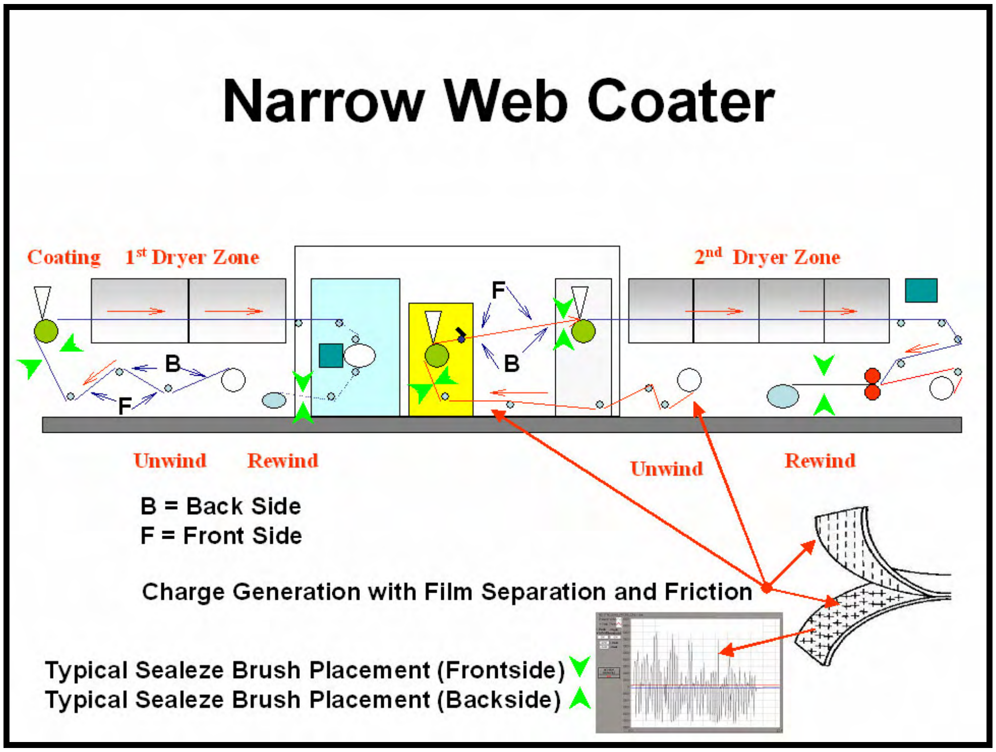

Figure 1

The reader should become familiar with the proper ESD (electrostatic discharge) terms so that one can gain a greater understanding of the specified resistance ranges to ANSI/ESD S20.20-1999 protocols. The ESD Materials Standard is ANSI/ESD S541-2003.

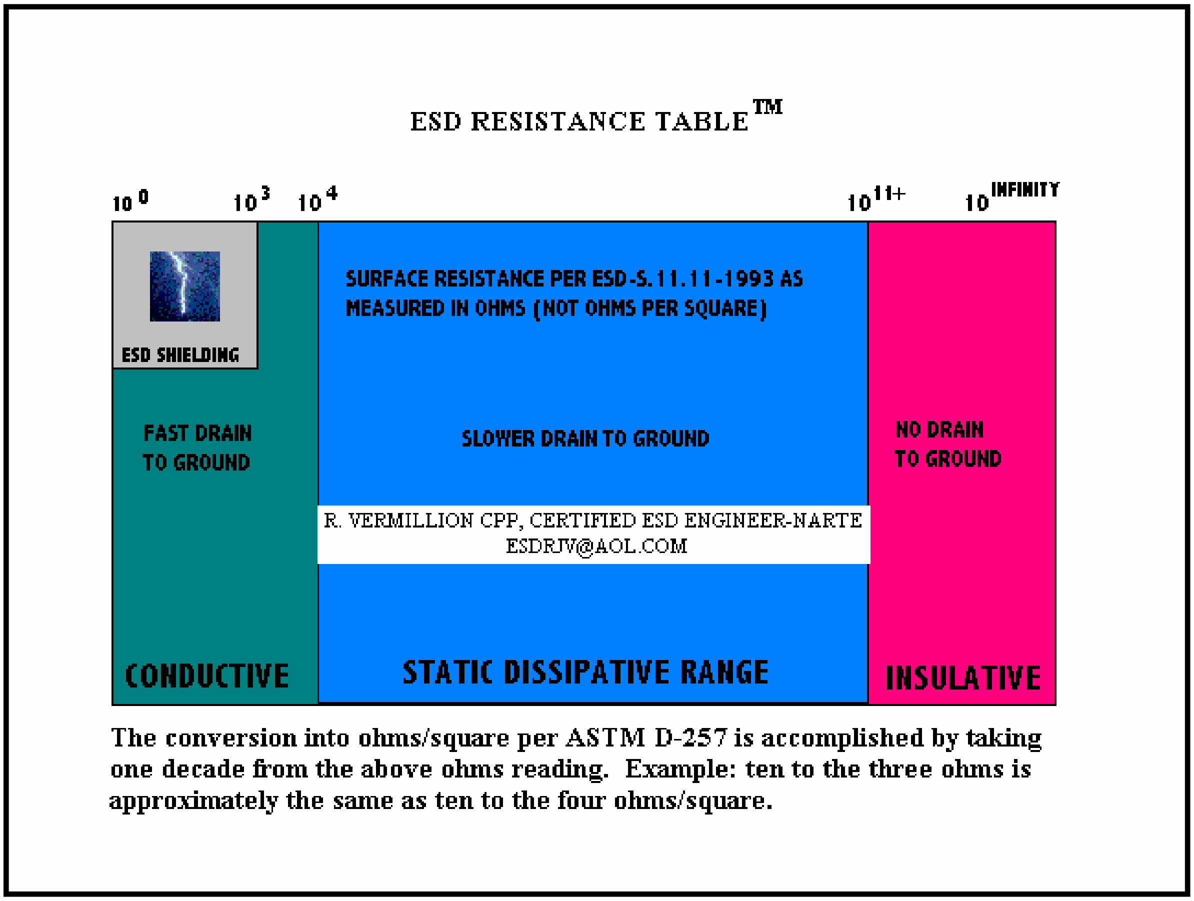

Figure 2

TERMS & DEFINITIONS

INSULATIVE MATERIAL: A property of the material that does not allow free charge movement with a surface resistance per ANSI/ESD STM11.11-2001 above 1.0 x 10^{11} ohms.

DISSIPATIVE: A property of the material, that allows for slower charge movement than conductive materials. ANSI/ESD STM11.11-2001 defines a range >1.0 x 10^{4} ohms to less than 1.0 x 10^{11} ohms.

CONDUCTIVE: A property of the material to allow free charge movement at low levels as measured per ANSI/ESD S541-2003 to less than 1.0 x10^{4} ohms.

STATIC SHIELDING (ELECTROSTATIC SHIELDING): An enclosed conductive container that utilizes a barrier to current flow with a shielding layer that has a surface resistance of less than 1.0 x 10^{3} ohms in conformance to ANSI/ESD S541-2003.

SURFACE RESISTANCE TESTS:

In 1993, the ESD Association adopted the test method ANSI/EOS/ESD S11.11-1993 [ANSI/ESD STM11.11-2001] to replace an older test method to test D-C conductance on insulators. Today's test method involves a concentric ring fixture that utilizes five measured pounds of weight on the specimen. This test is conducted on an insulative surface after preconditioning in the environmental chamber for 48 -72 hours. In **Figure 2,** the ANSI/ESD S541-2003 resistance classification is illustrated for the reader's reference. **Figure 3** illustrates the actual surface resistance of the PETG film as measured on an insulative test bed of a Plexiglas substrate. **Table 1** exhibits the findings.

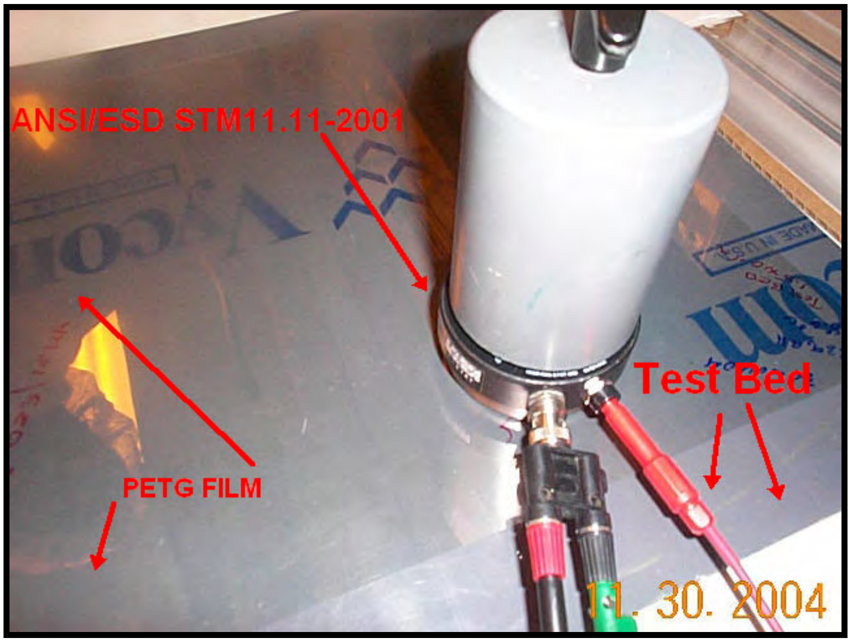

Figure 3

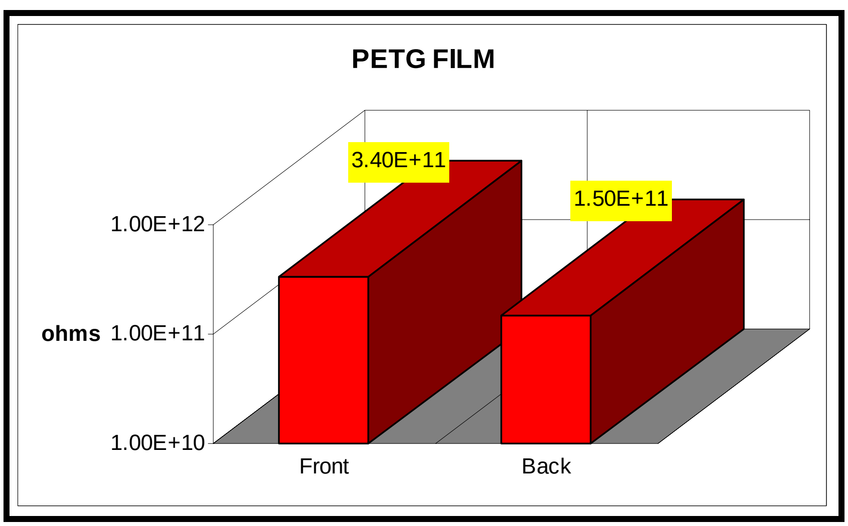

Table 1

TRIBOELECTRIC CHARGE GENERATION:

There is no established standard for charge removal on substrates for brushes. An insulative substrate charges to high electrostatic voltages that are caused from the friction or contact-separation between two bodies at different potentials. **Figure 4** portrays the electrostatic bonding of particulates on an insulative surface. Grounding the PETG film will not drain a charge since insulative materials will hold a charge for an indefinite period of time. Charge removal is facilitated by using a grounded electrostatic brush to minimize the occurrence of static electricity.

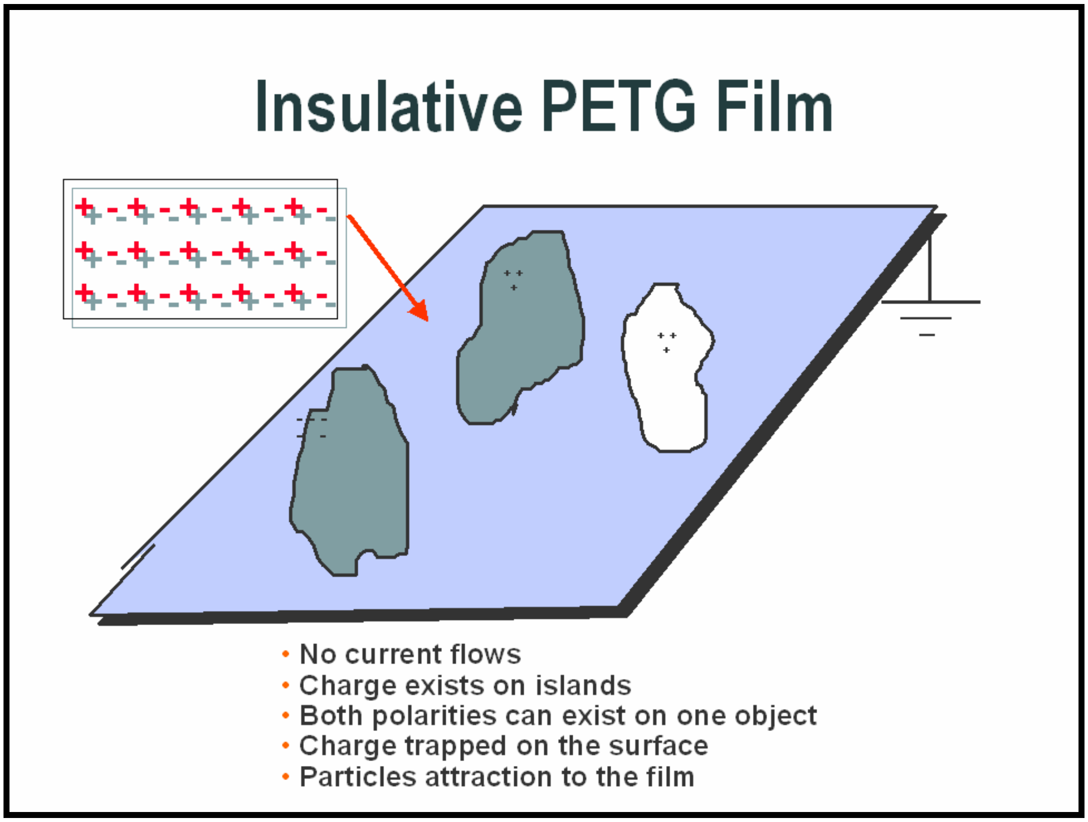

Figure 4

The reduction of static electricity can lower the potential of an electrostatic discharge (ESD) event that is an undesired nuisance to an operator working in close proximity to the charge generating insulative film. To put things in perspective, an individual walking across a carpet and making contact with a doorknob could generate voltages in excess of several thousand volts. A person will feel an ESD event when the voltage is approximately 3500 volts as seen in **Figure 5**.

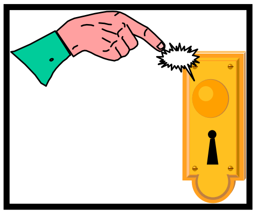

Figure 5

Military Handbook 263 (**Figure 6**) illustrates the variances in voltages that are produced at low and high humidities.

Charging at Low and High Relative Humidities

VOLTAGES FROM CHARGING

ACTIONS	20% RH	80% RH
WALKING ACROSS VINYL FLOOR	12KV	250 V
WALKING ACROSS SYNTHETIC CARPET	35KV	1.5KV
ARISING FROM FOAM CUSHION	18KV	1.5KV
PICKING UP POLY BAG	20KV	600V
SLIDING STYRENE BOX ON CARPET	18KV	1.5KV
REMOVING MYLAR TAPE FROM PC BOARDS	12KV	1.5KV
SHRINKING FILM ON PC BOARDS	16KV	3KV
TRIGGERING VACUUM SOLDER REMOVER	8KV	1KV
AEROSOL CIRCUIT FREEZER SPRAY	15KV	5KV

Military Handbook 263

Figure 5

CHARGE GENERATION EVALUATION:

A specialized non contact voltage probe system (**Figure 6**) that is computer interfaced was utilized to record and capture the voltages generated from the PETG film on the narrow web coater. The non contact probe was positioned above the PETG film on the Front Side and Back Side of the film by an operator wearing a grounded wrist strap (**Figure 7**).

Figure 6

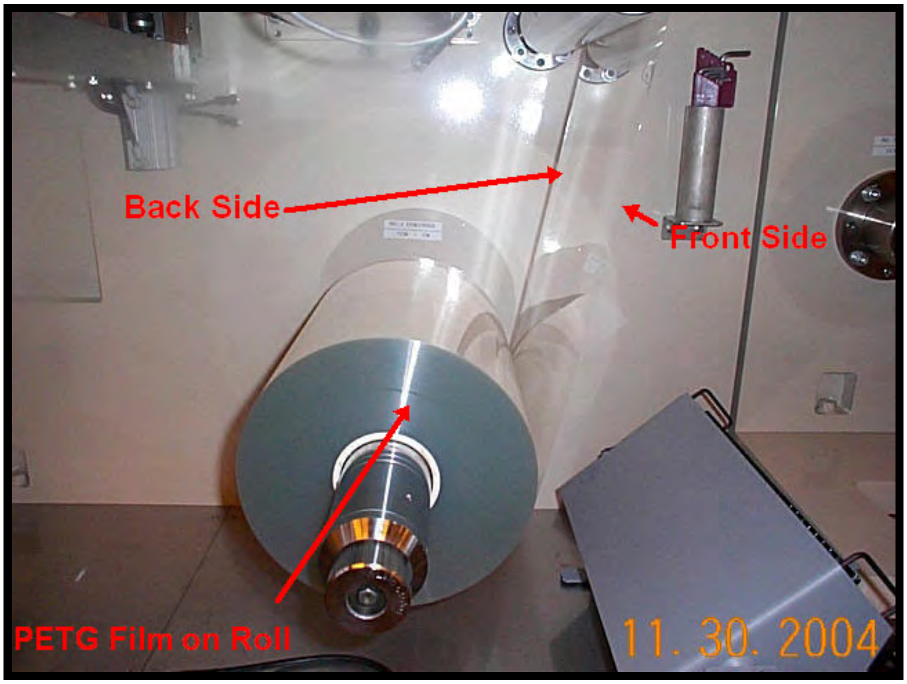

Figure 7

It should be noted that the non contact voltage probe used in this test series does not rely upon being positioned at a fixed distance from the object being measured. The non contact voltage probe in this report was designed to minimize voltage fluctuations during the measurement process. A traditional field meter must be positioned at a fixed distance and represents an average of the voltage measured over an unspecified area. **Figures 8** and **9** illustrate the non contact probe's position in proximity to the PETG film (as placed before the Sealeze™ brush). The 542 probe measures the triboelectrification (charge by friction) of the film **before and after** passing through the Sealeze™ brushes.

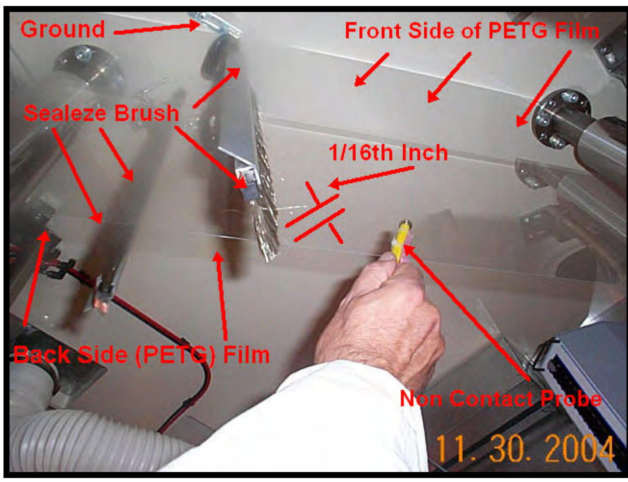

Figure 8

Figure 9

The results of the film for the Back and Front Side are illustrated in **Figures 10** and **11** of this report. The time duration for each measurement series was 3 minutes.

Note: The term "Pre" in the recording charts constitutes measurements made prior to the PETG film passing under or over the brush before neutralization.

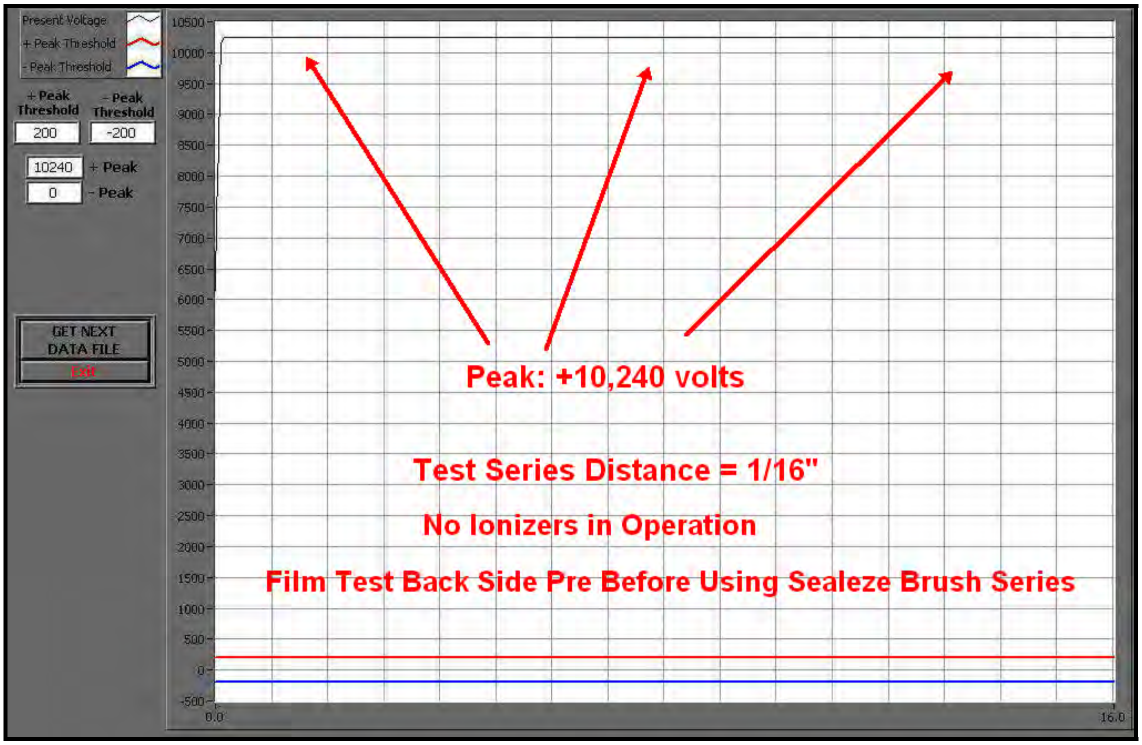

Figure 10

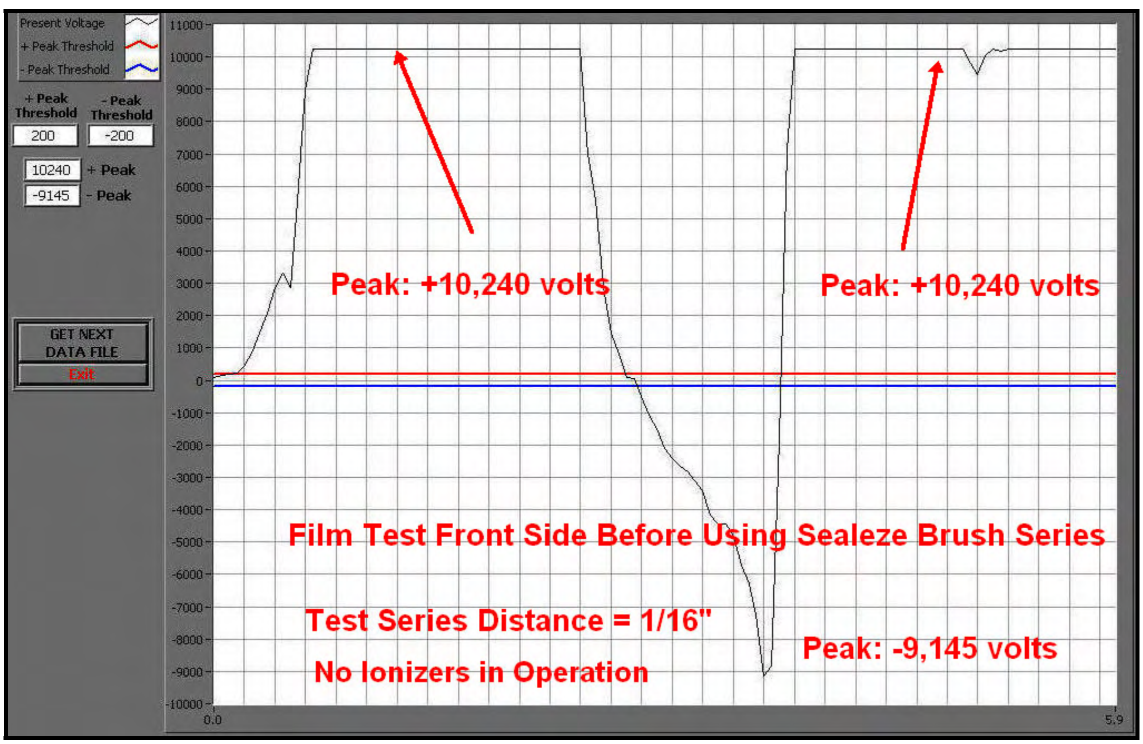

Figure 12

The first test series was conducted by positioning one of the Sealeze™ brushes over the Front Side of the PETG film and below the Back Side of the substrate at a distance of approximately 1/16th of an inch. **Figure 13** is an illustration of the brush positioning.

Figure 13

A resistance to ground measurement from the brush filaments to ground was measured at a favorable 1.5 E+06 ohms. For personnel safety, a 1.0E+06 ohms resistance value is targeted by many electronic organizations.

The brush was placed in close proximity to PETG film at a known distance to facilitate removal of voltages generated by separation of the film from the base roll and passage through stainless steel rollers (**Figure 14**) positioned throughout the web coater.

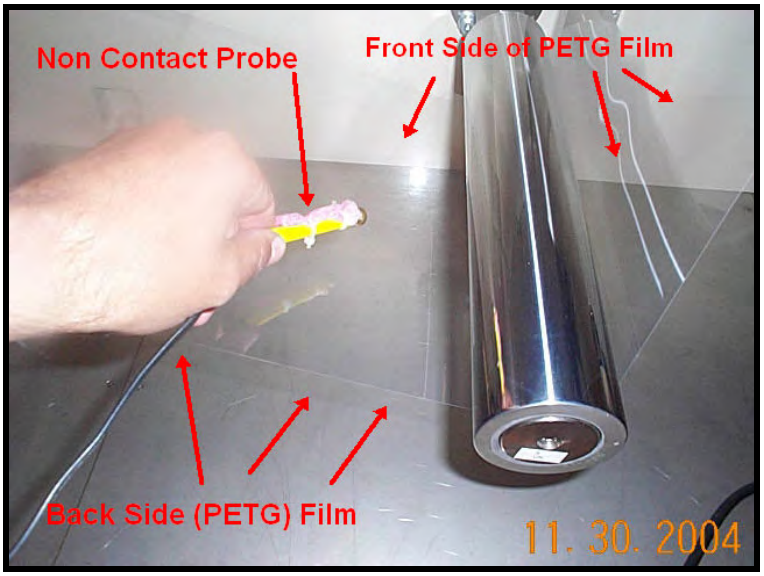

Figure 14

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Figure 15 represents the positioning of the non contact voltage probe after the Sealeze™ brush position for the first test series.

Figure 15

Figures 16 and **17** illustrate the findings for the Sealeze™ brush in removing charge from the PETG film during a 3 minute voltage measurement recording process.

Note: The term "Post" in the recording charts constitutes measurements made on the PETG film after passing through the brush during the neutralization process.

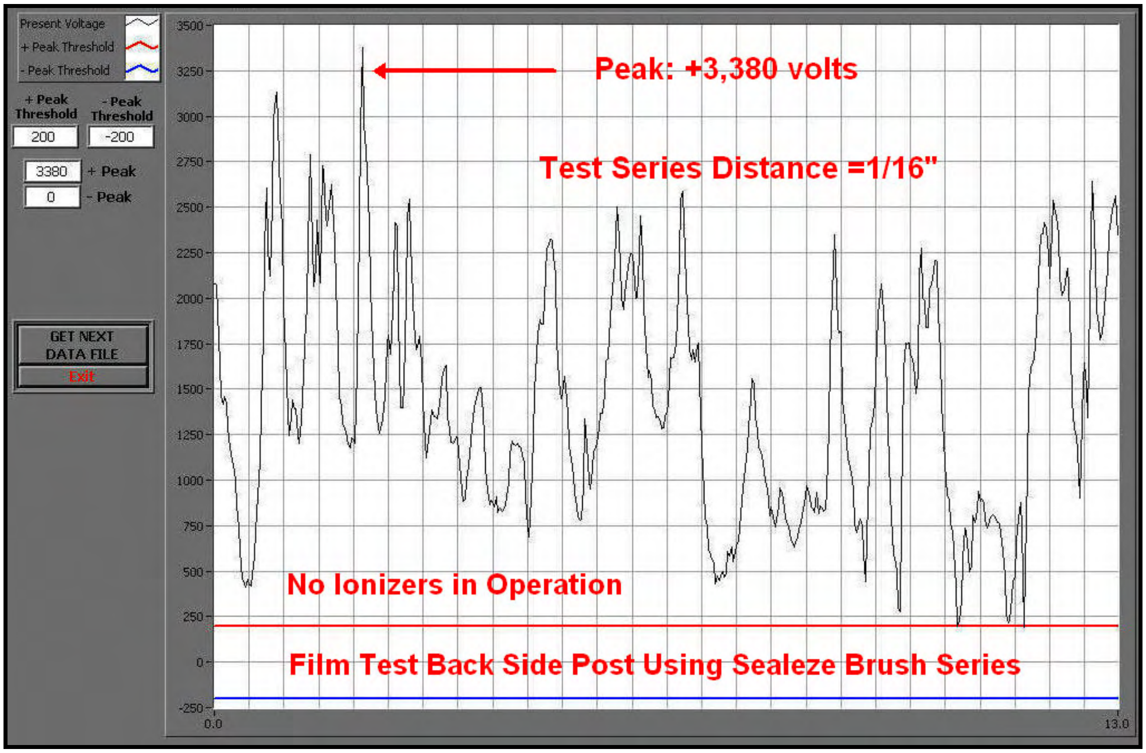

Figure 16

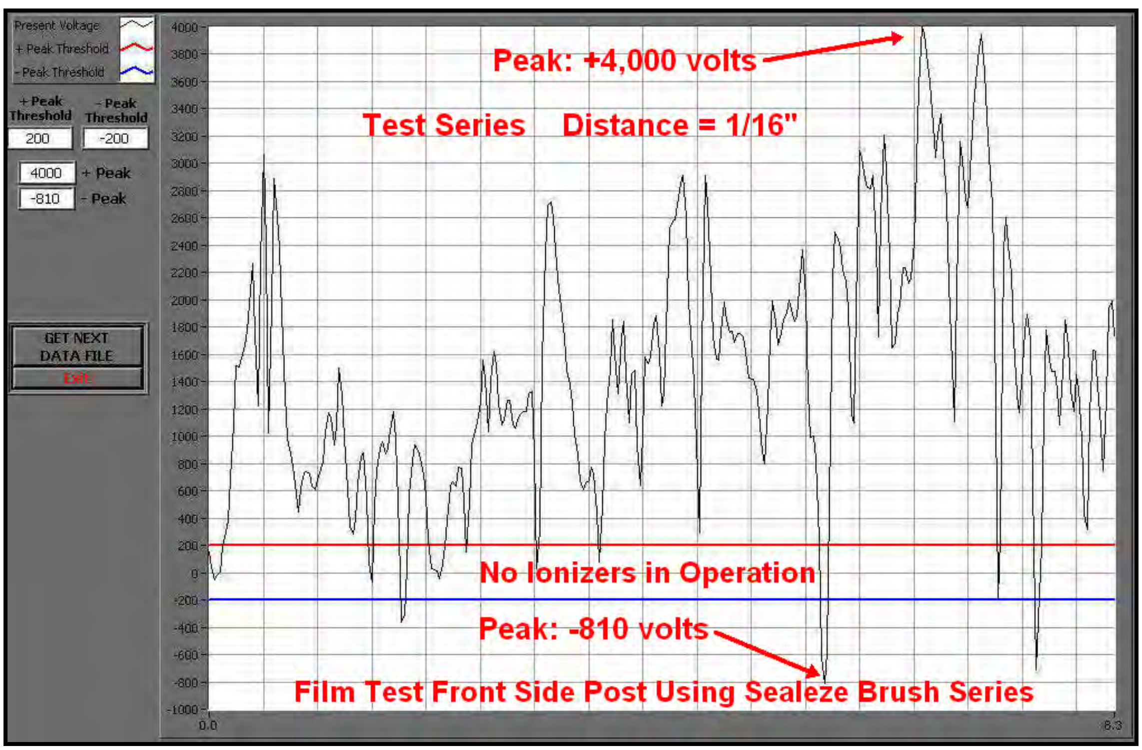

Figure 17

Table 4 33% RH Performance of Substrate with and without Static Control Brushes

Voltage Before Brush Back Side	Back Side w/Brush	Voltage Before Brush Back Side	Front Side w/Brush
+10,240	+3,380	+10,240	+4,000
0	0	-9,145	-810

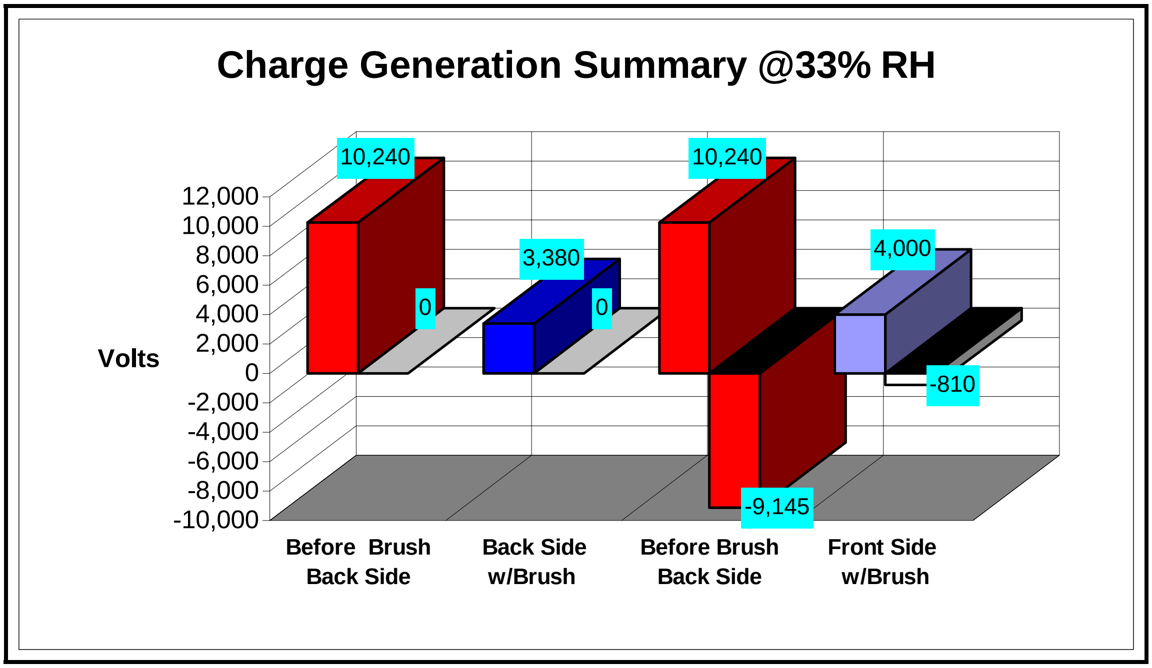

Table 5

In summary, the Sealeze™ brush was effective in removing charge from the film as a stand alone unit. The 2nd phase of this white paper evaluates the Sealeze™ brush when utilized in combination with commercially available ionizer bars.

SEALEZE™ BRUSH IN COMBINATION WITH IONIZATION:

The purpose of this exercise is to verify the improvement in ionization effectiveness when a Sealeze™ brush is used in combination with ionization. The objective is removal of the majority of charges so that the neutralization process facilitated by ionization is improved. In factory environments, ionization emitter points must be maintained on a regular basis; otherwise, dirt build up or erosion will diminish performance. When an ionizer is poorly maintained, the unit does not produce an efficient flow of positive and negative ions (**Figure 18**). Consequently, in a factory environment, charge neutralization effectiveness is sacrificed. However, as long as the Sealeze™ neutralizing brush is grounded, the unit should continue to reduce charge generation with monthly or quarterly cleaning. Because a Sealeze™ brush does not draw current, the cost of operation is negligible. Likewise, in comparison to Alpha Particle ionization requiring a Polonium **(**Po210) Element (annual renewal replacement fees), the Sealeze™ unit constitutes an inexpensive alternative. Ionization, in combination with a Sealeze™, brush appears to be effective in reducing charge(s) to a minimum in an industrial setting. The PETG measurement duration for the Sealeze™ brush – ionization charge removal recording exercise was 3 minutes.

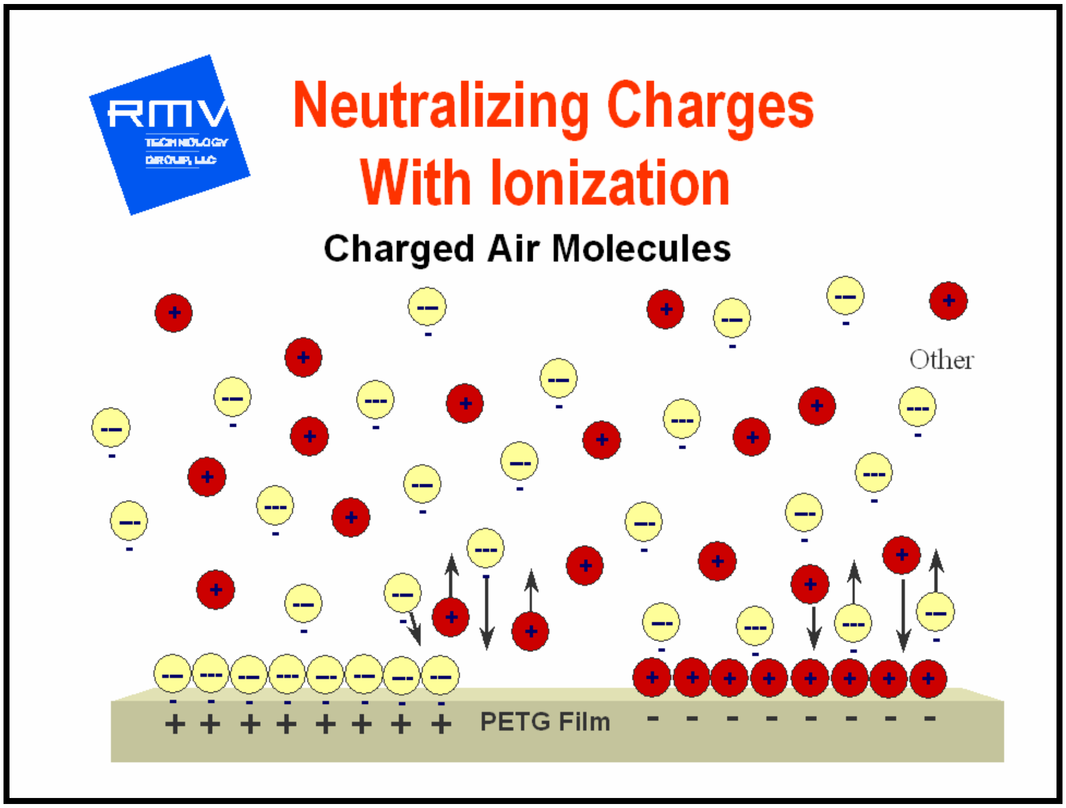

Figure 18

Note: If the process of ion production is hindered through poor maintenance, an ample supply of ions will not be present for effective charge neutralization.

Figures 19 and **20** below illustrate the usage of **a** non contact voltage probe in proximity to the film ahead of the brush and ionizer. The computer interfaced non contact voltage probe measurement captures the voltage generated by the PETG film traveling through the web.

Figure 19 **Figure 20**

Note: The term “Pre” in the recording charts constitutes measurements made prior to the PETG film passing under or above the brush or ionization before neutralization.

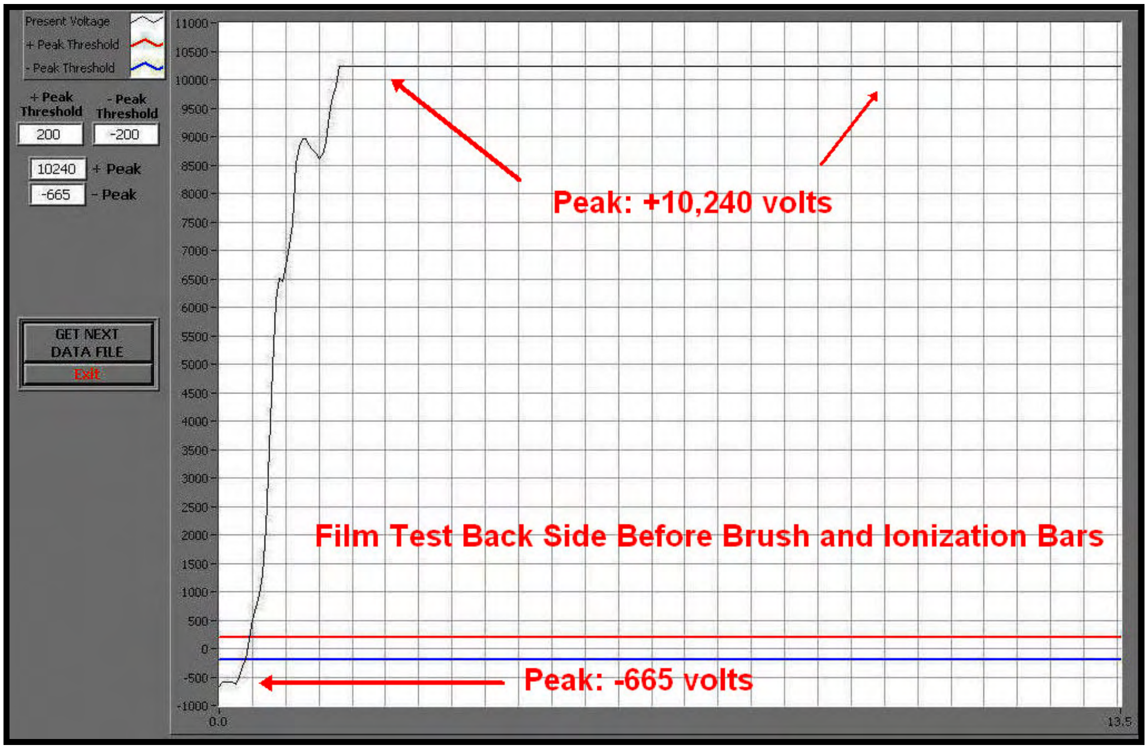

Figure 21

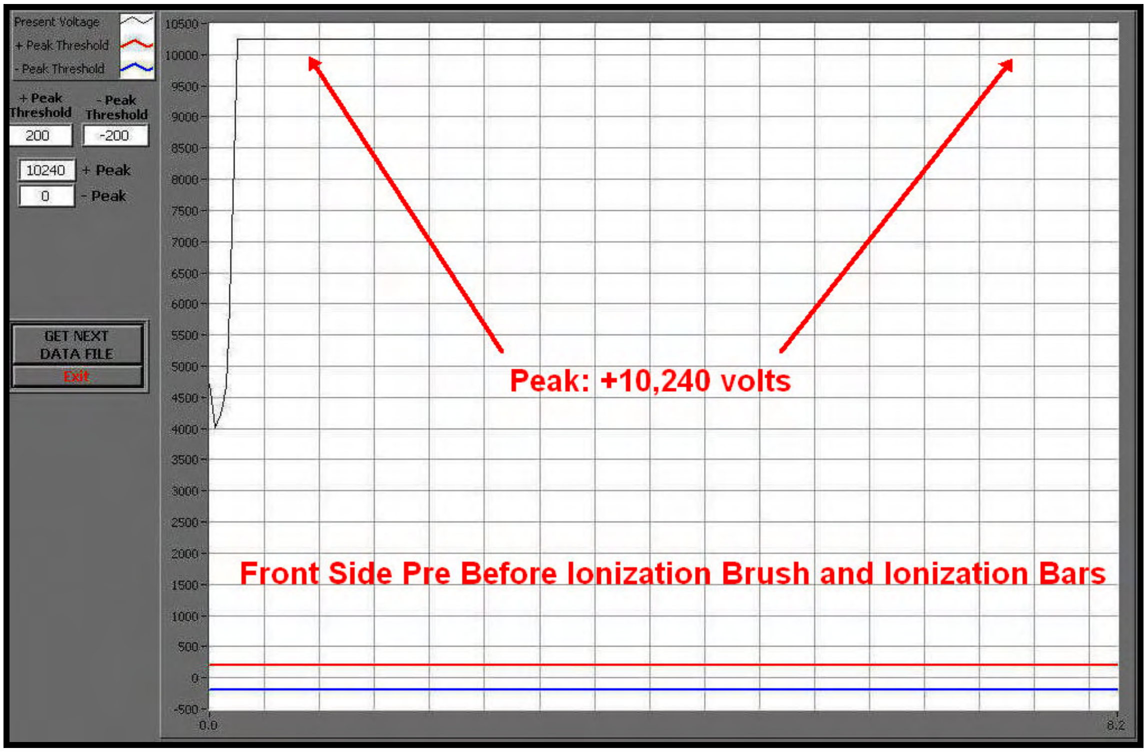

Figure 22

Figures 21 and **22** display the charge generated on the PETG film for a test period duration of 3 minutes while the web coater is in operation. The non contact voltage measurement recorded voltages produced on the PETG film before entering the Sealeze™ brush and ionizer for charge neutralization. A better illustration of the Sealeze™ brush placement ahead of the brass colored ionization bars are found in **Figures 23** and **24**. The alligator clip was connected to the filaments of the Sealeze™ brush to provide a temporary path to ground; the brush placement before the ionization bars was not a permanent set up. The alligator clips were removed to determine the ionizer bar's charge removal effectiveness as stand alone units (Results: **Figures 25** and **26**). Thereafter, the alligator clip was connected so that the Sealeze™ brush was working in conjunction with the ionization bars (Results: **Figures 27** and **28**).

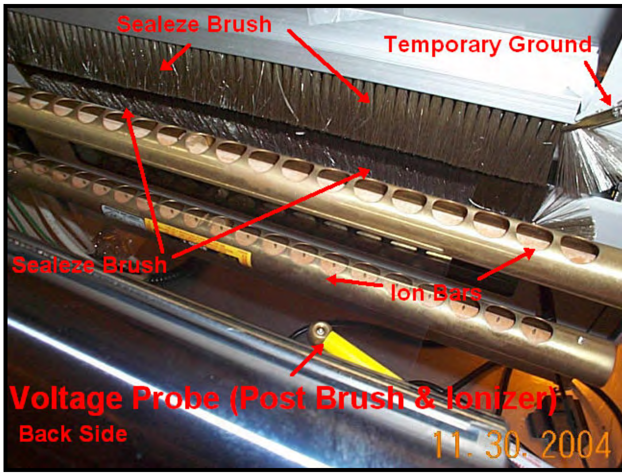

Figure 23

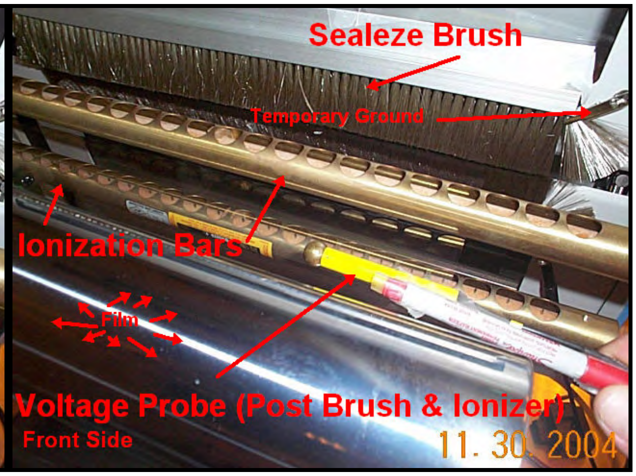

Figure 24

Note: The term "Post" in the recording charts constitutes measurements made after the PETG film passed through the brush or ionization neutralization process.

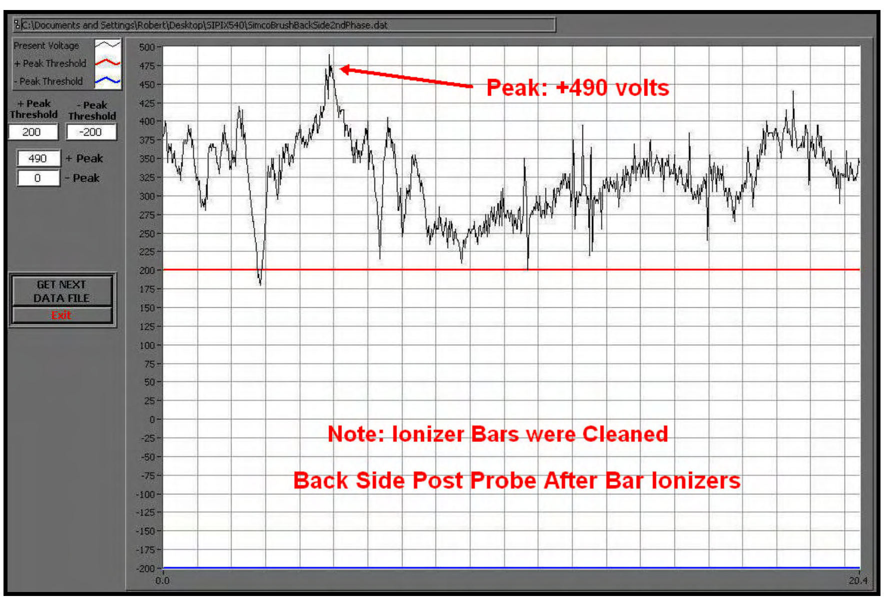

Figure 25

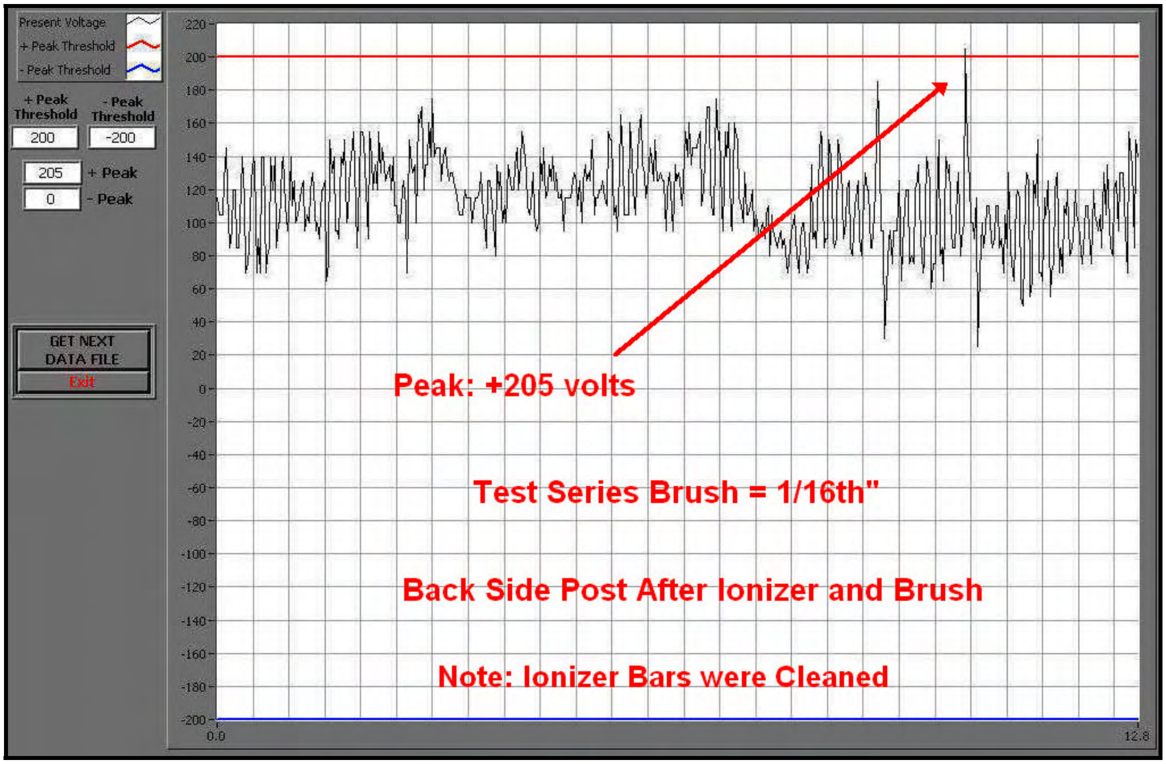

Figure 26

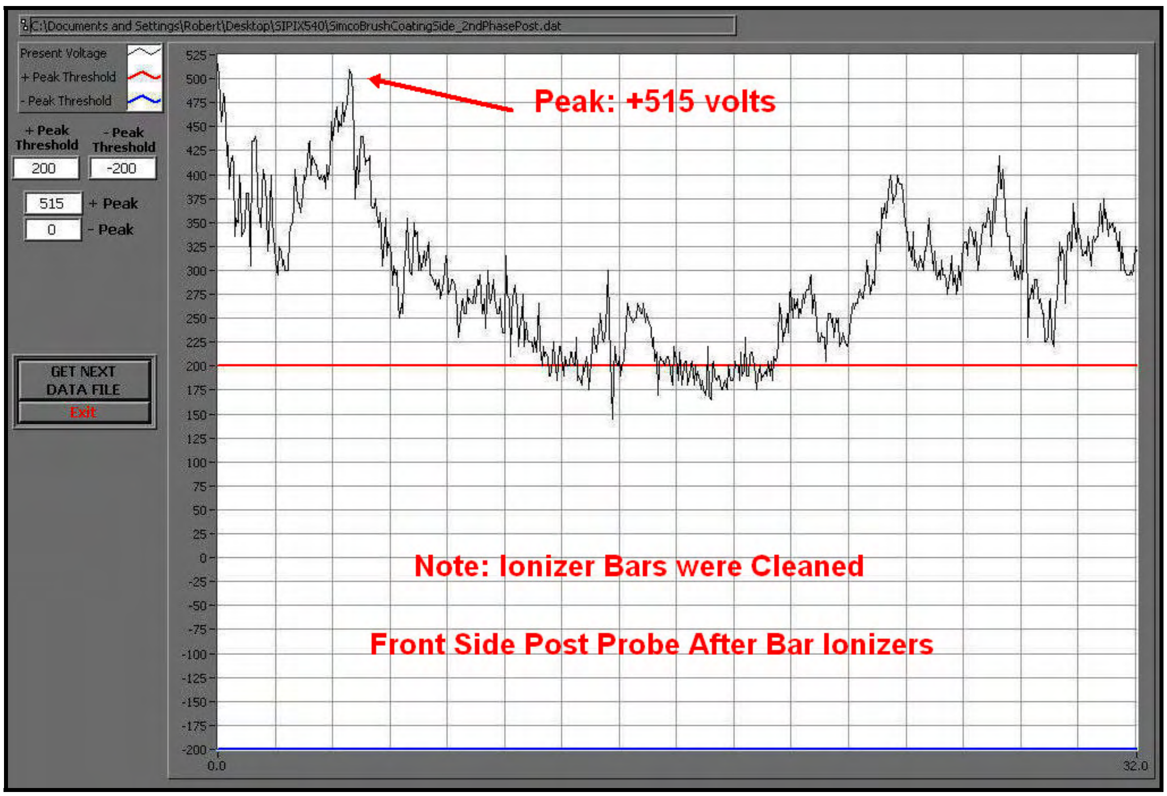

Figure 27

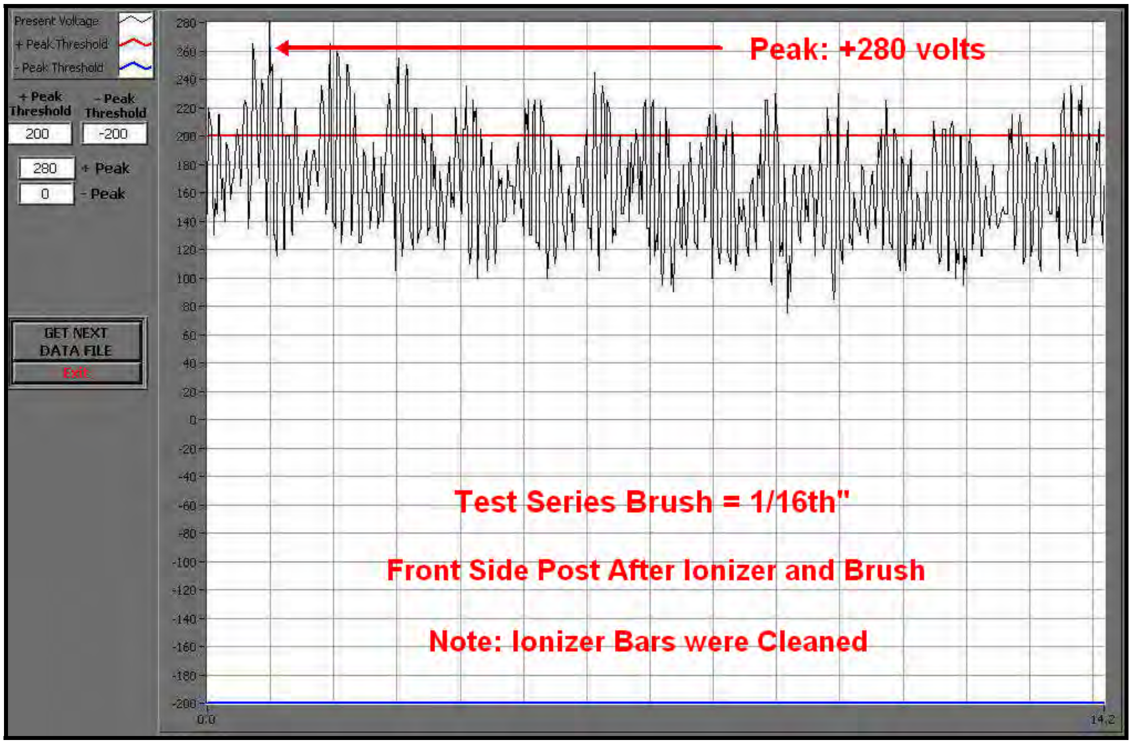

Figure 28

A summary of the charge reduction performance for the Back and Front Side of the PETG film is represented in **Tables 4** and **5**.

Table 4 33% RH Performance with and without Static Control Brushes + Ionizers

Voltage Before Brush + Ionizer Back Side	Probe After Ionizer without Brush	After Back Side w/Brush + Ionizer	Voltage Before Brush + Ionizer Front Side	Probe After Ionizer without Brush	After Front Side w/Brush + Ionizer
10,240	490	205	10,240	515	280
-665	0	0	0	0	0

A more detailed illustration of the ionizer bar's performance as a stand alone unit in comparison to the Sealeze™ brush and ionization performance can be viewed in **Table 6**. The charge reduction from the Back Side from 490 volts to 205 volts and from 515 volts to 280 volts on the Front Side is significant. In this white paper, the brush did not make direct contact with the PETG film. However, in a vacuum hood ionization system, one brush could be placed in front of an ionization bar while another brush is placed after the ionization unit. A Sealeze™ brush making minimal contact with a suitable substrate would be capable of physically dislodging particulates after the ionization neutralization process. Physical contact with the use of a brush or close proximity to the ionizer alone may not dislodge a charge particle. For instance, charging a 4" silicon wafer to 1000 volts attracts a one (1) micron size particle. Thus, the bonding force of charged microns is approximately 830,000 pounds per square inch.[1]

[1] Presentation on 12 March 2002 by Arnie Steinman, MSEE, at *ESDISCOVERY2002 Singapore*. The electrostatic attraction between charged objects and particles can be quite strong compared to gravitational, aerodynamic or adhesion forces.

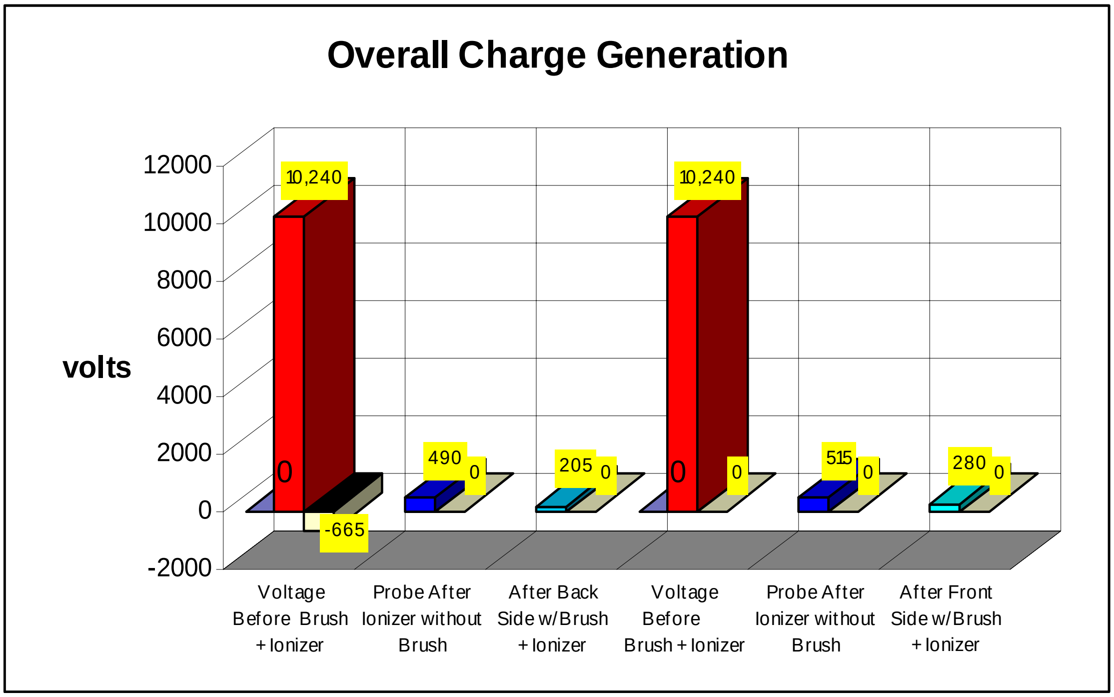

Table 5

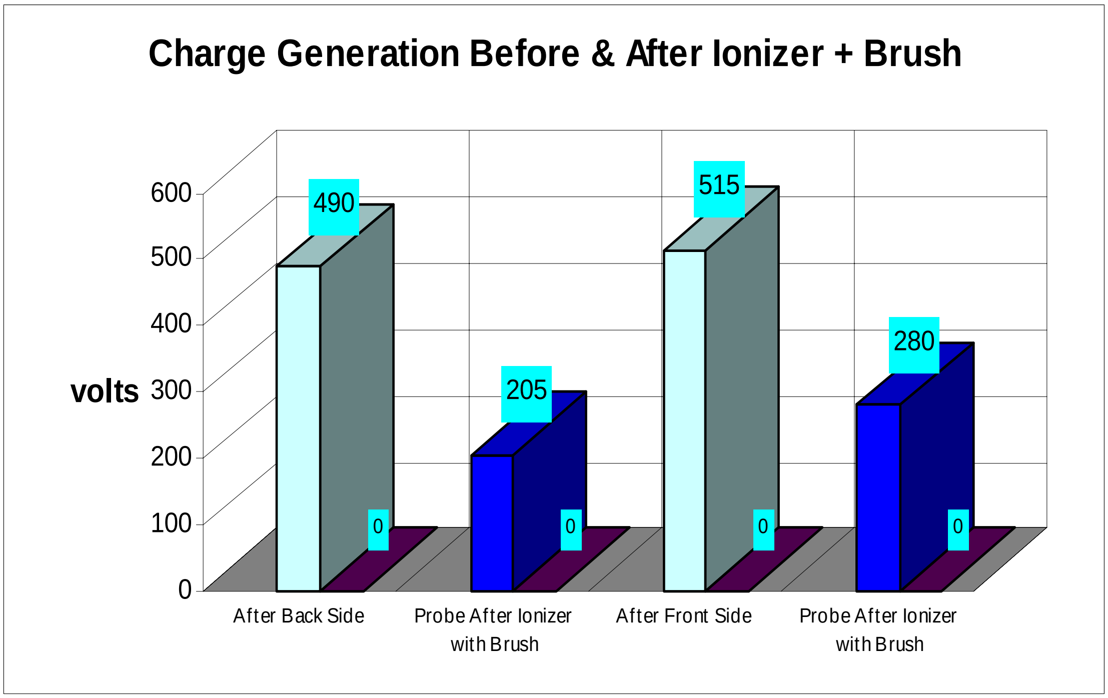

Table 6

In conclusion, the Sealeze™ brush in a real world environment at a low 33% relative humidity environment removed large electrostatic fields in significant numbers to be considered an alternative means of removing charges from insulative substrates. The Sealeze™ brush systems require a reliable grounding source. In addition, performance may improve in areas of higher relative humidity or with substrates that have some electrical conductivity. Below 30% RH, the performance may be less significant since moisture pick up by charge generating substrates would be minimized. When the Sealeze™ brush is combined with ionization, a more effective charge reduction process appears to be in place, that improved the performance of the older ionizer bar's ability to reduce charges to lower levels. In initial usage, a new ionization system may have better neutralization characteristics, but without continuous emitter cleaning maintenance, the performance will diminish. A well grounded Sealeze™ brush requires minimal attention so that expected long term performance will be consistent where the brush does not make direct contact with the substrate. In both cases, organizations using Sealeze™ brushes and/or ionization are encouraged to monitor the electrostatic charge performance on a regular basis.

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