A Year in Review 2018-2019 Packaging Materials for Shipment of ESD Susceptible Items

David E. Swenson
Affinity Static Control Consulting, LLC
Round Rock, Texas

Packaging Materials an Issue Today?

- The principles involving packaging of electrostatic sensitive items have not changed very much since the mid 1970’s
- The advent of military specifications for packaging of electronics led the way for commercial development
- Packaging requirements have not changed significantly since the introduction of static discharge shielding materials.

Introduction

- ESD Association Standards Committee WG11 is responsible for Packaging Materials
- WG11 takes care of:
  - ANSI/ESD STM11.11 – Surface Resistance
  - ANSI/ESD STM11.12 – Volume Resistance
  - ANSI/ESD STM11.13 – Two-Point Probe
  - ANSI/ESD STM11.31 – Discharge Shielding - Bags
  - ESD ADV 11.2 – Triboelectric Testing of Materials
  - ANSI/ESD S11.4 – Bags
  - ANSI/ESD S541 – Packaging Materials

Current Status

- Most of the documents have just completed a mandatory 5-year review and were revised – mostly minor changes that do not affect the use of the established procedures or instrumentation.

ANSI/ESD S541 – Packaging Materials

- Some editorial changes were made, and the standard released in 2018 with the understanding that it would be re-opened after reaching a conclusion on two subjects:
  - Low Charging test procedures and specifications
  - Electric Field Shielding test procedures and specifications

Low Charging:

- Conceptually, a low charging material is something that does not develop a significant level of charge during processing or handling

Background:

- Most will (I hope) agree that it is a good idea to have low charge generating materials in intimate contact with electrostatic sensitive items.
- However, we have no accepted test method to evaluate low charging and therefore we cannot set any specifications. Charge generation and accumulation levels have been up to the end user to set in their processes

ANSI/ESD S541

- ANSI/ESD S541 offers guidance in evaluating the low charging property

7.1 – Low Charging Property

Materials with low charging properties have reduced amounts of charge accumulation when compared with standard packaging materials. Charge accumulation occurs when two materials are contacted and separated from each other (triboelectric charging). Charge magnitude and polarity are dependent on the materials involved, humidity, surface area, and other considerations. Mitigation of triboelectrification can be accomplished several ways.

- Increasing the amount of charge that flows back to the original material will reduce the total amount of charge either item retains. This can be accomplished by reducing the electrical resistance between the package and the contained device.
- Similar materials tend to charge less than dissimilar materials. Coating the package interior and the contained device with the same material may reduce charge accumulation.
- Reduction in the amount of relative motion between the package and contained ESDS item will reduce the amount of electrostatic charge caused by triboelectrification
- Some antistat coatings are not permanent and can degrade over time and while in-use.

ESD ADV11.2 – Triboelectric Charge Accumulation Testing - 1995

This Advisory is a compilation of demonstrations and techniques developed over the years to help judge the triboelectric phenomenon.

None of the demonstrations or techniques have been elevated to a true test method.

So, What to Do about Low Charging?

- Obviously, a method is needed to allow determination of the charge generation propensity of materials
- To do that, an agreement is needed on the actual contacting materials
  - One material is the packaging material of interest
  - The contacting material should relate to something in the process

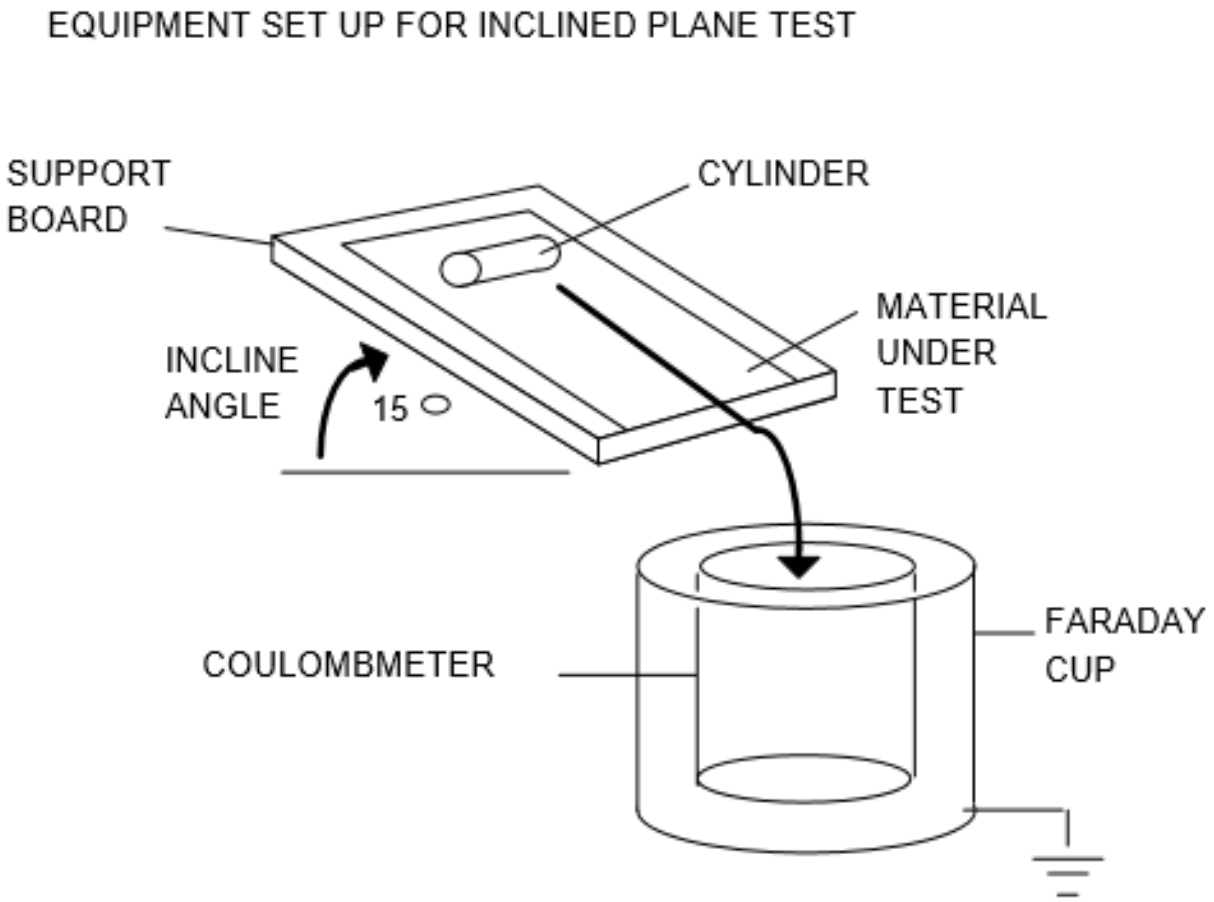
Triboelectric Series:

- A loose ranking of materials arranged in such a way that the materials lower on the list tend to take electrons from the materials higher on the list
- There are as many “Triboelectric Series” as there are investigators who have developed the list
  - But there are commonalities – Quartz is always high on a list and PTFE is always at the bottom of a list

Test Demonstrations Using Quartz and PTFE

- A method called the Inclined Plane was investigated in the 1980's into the early 1990's
- In the procedure, cylinders of quartz and PTFE are rolled down a 15° ramp covered with the material of interest (example: film used to make bags)
- The cylinders are captured in a Faraday Cup to measure the charge
- The test is repeated many times to get a statistically relevant sample of charge generation for each cylinder type

Inclined Plane:



Data Collection:

APPENDX B. Inclined Plane Data							
MATERIAL #3 - EXPERIMENTAL BAG, PAPER							
	Spc#1	Spc#2	Spc#3	Spc#4	Spc#5	Spc#6	Averages
Teflon Cycle #1	-0.79	-0.62	-0.60	-0.75	-0.63	-0.70	-0.68
Teflon Cycle #2	-0.77	-0.70	-0.63	-0.55	-0.54	-0.66	-0.64
Teflon Cycle #3	-0.79	-0.59	-0.57	-0.65	-0.63	-0.58	-0.64
Teflon Cycle #4	-0.68	-0.77	-0.66	-0.45	-0.72	-0.68	-0.66
Teflon Cycle #5	-0.70	-0.69	-0.65	-0.62	-0.76	-0.77	-0.70
Teflon Cycle #6	-0.68	-0.68	-0.64	-0.55	-0.72	-0.51	-0.63
Quartz Cycle #1	0.68	0.66	0.42	0.70	0.46	0.34	0.54
Quartz Cycle #2	0.63	0.78	0.52	0.67	0.47	0.35	0.57
Quartz Cycle #3	0.76	0.68	0.45	0.72	0.57	0.49	0.61
Quartz Cycle #4	0.67	0.83	0.56	0.53	0.56	0.48	0.61
Quartz Cycle #5	0.58	0.76	0.53	0.46	0.54	0.53	0.57
Quartz Cycle #6	0.57	0.68	0.48	0.66	0.58	0.59	0.59

Data Summary PTFE:

Teflon Data Summary:	Spc#1	Spc#2	Spc#3	Spc#4	Spc#5	Spc#6	Averages
Ave Teflon nC	-0.74	-0.68	-0.63	-0.60	-0.67	-0.65	-0.66
Ave Teflon nC/in2	-0.23	-0.21	-0.20	-0.19	-0.21	-0.20	-0.21
Teflon Std. Dev.	0.05	0.06	0.03	0.10	0.08	0.09	0.08
Ave Teflon nC/cm2	-0.036	-0.033	-0.030	-0.029	-0.032	-0.032	-0.032
Actual Minimum nC	-0.79	-0.77	-0.66	-0.75	-0.76	-0.77	-0.79
Actual Maximum nC	-0.68	-0.59	-0.57	-0.45	-0.54	-0.51	-0.45

Task Team – Low Charging

- A Task Team has been established to further refine the Inclined Plane method
- The goal is to bring the procedure to at least the level of a Standard Practice so that specifications (within a range) can be established for the Low Charging property
- Status – gathering materials among 5-6 labs for Round Robin testing

Electric Field Shielding:

- EIA-541 – *Packaging of Electronic Products for Shipment* standard had a specification for Electric Field Shielding – mostly defined for rigid container materials
- 1000 ohm-cm/mm of thickness was set as the (approximately) equivalent shielding to metallized laminate discharge shielding bags
- In the creation of ANSI/ESD S541, that specification was dropped (not sure why – although the data that led to creation of the specification cannot be located)

Discussions about Field Shielding:

- Two distinct points of view about electric field shielding:
  - It is needed for boxes and containers other than bags
  - It is not needed since air gaps and separation distance reduce the need to define field shielding
- WG11 decided to establish a Task Team to investigate the property

Task Team – E-Field Shielding

- First step was to gather samples of relevant materials used to make boxes and containers (12” x 12” samples)
- The basic consideration for E-Field Shielding is the attenuation of signals from essentially 1 GHz to 10 GHz (MIL-PRF-81705 requirement) – Static Discharge Shielding bags - >10dB and MVB bags >25dB
- The USAF Materials Directorate Lab, Wright-Patterson AFB, Dayton, OH provided testing services (Thanks for all that)

Measurement System

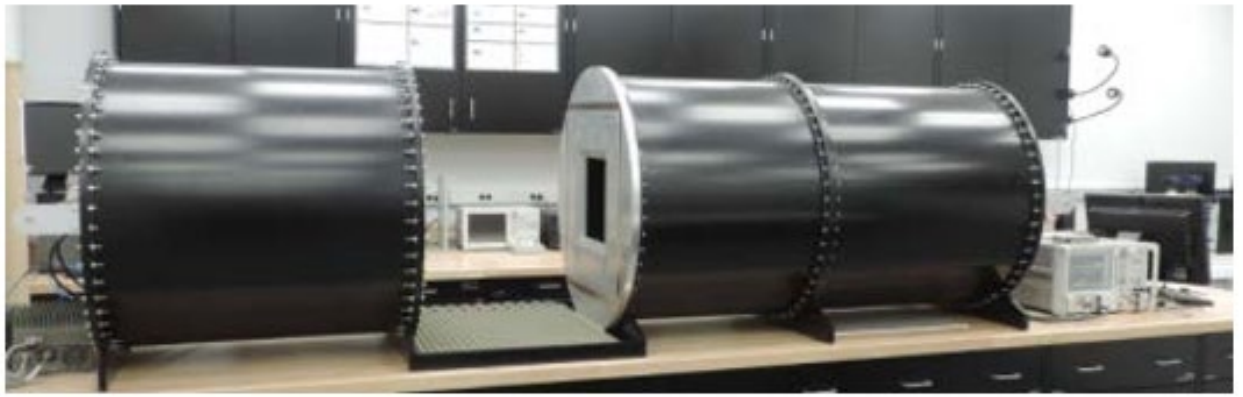
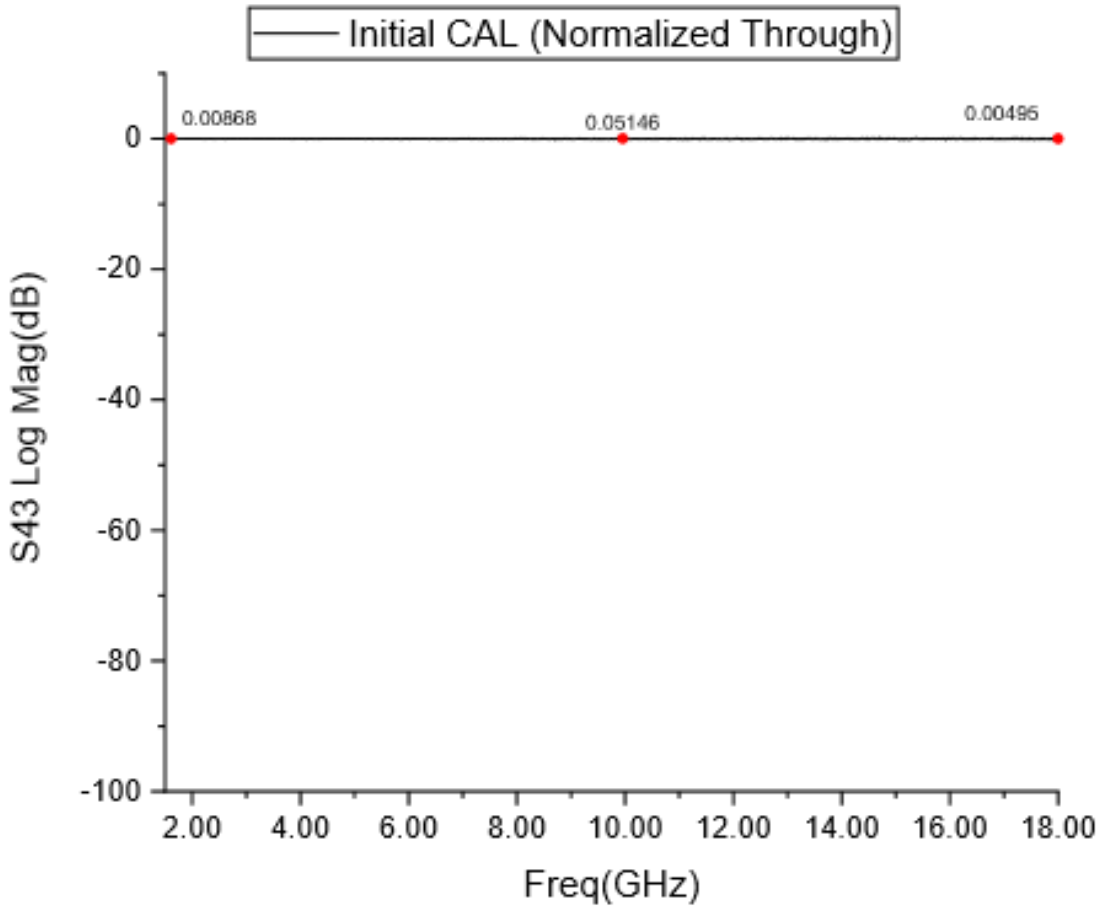
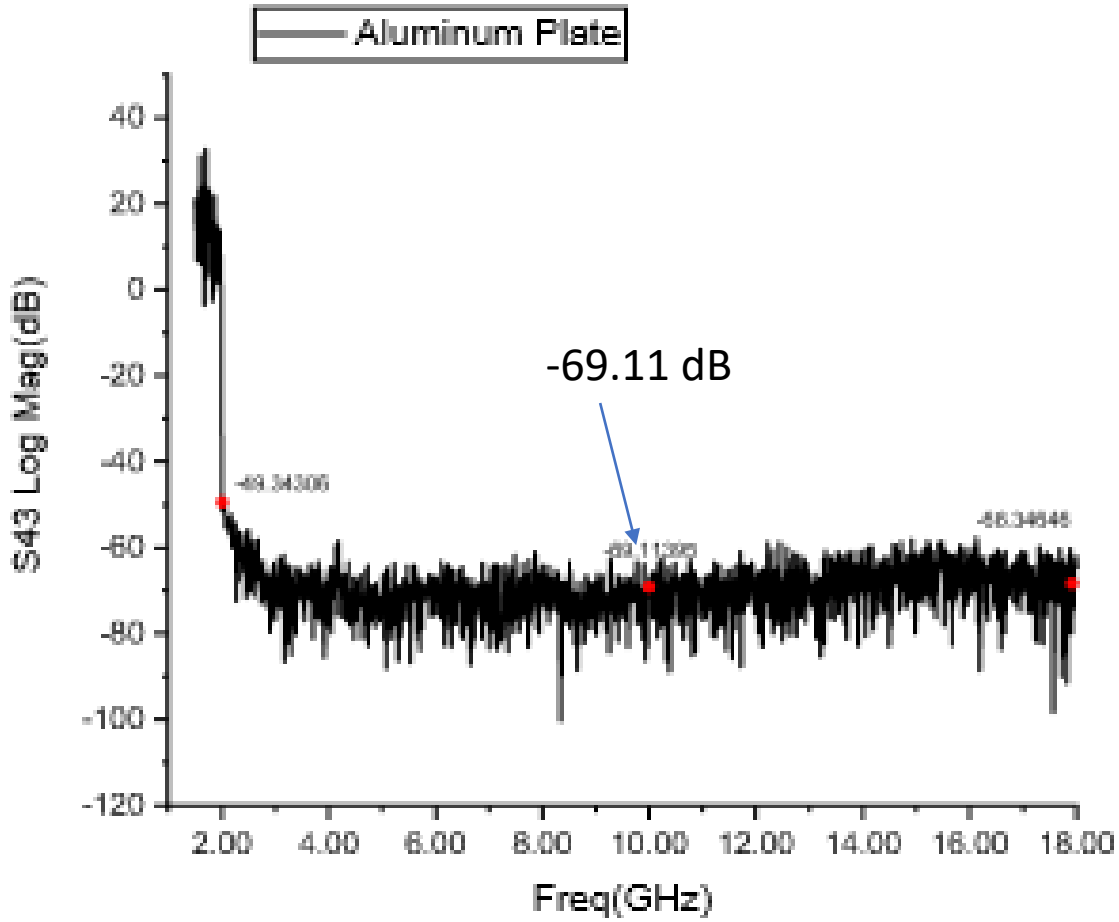


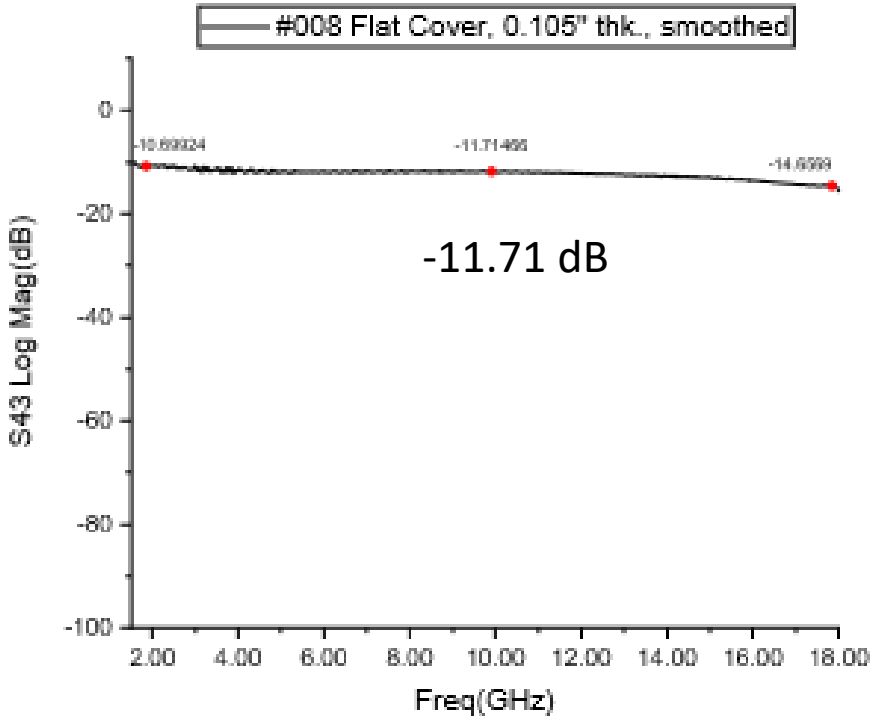
Table Top Focused Beam Materials Measurement System

Open Aperture

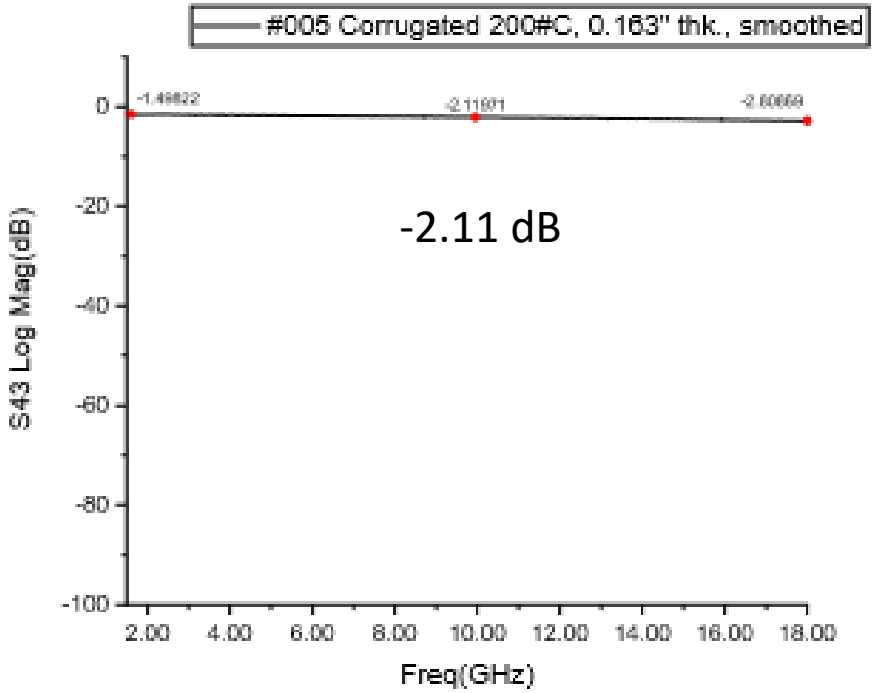


Metal Plate


Aluminum Plate
S43 Log Mag (dB)
40
20
0
-20
-40
-60
-80
-100
-120
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
18.00
Freq(GHz)
-69.11 dB

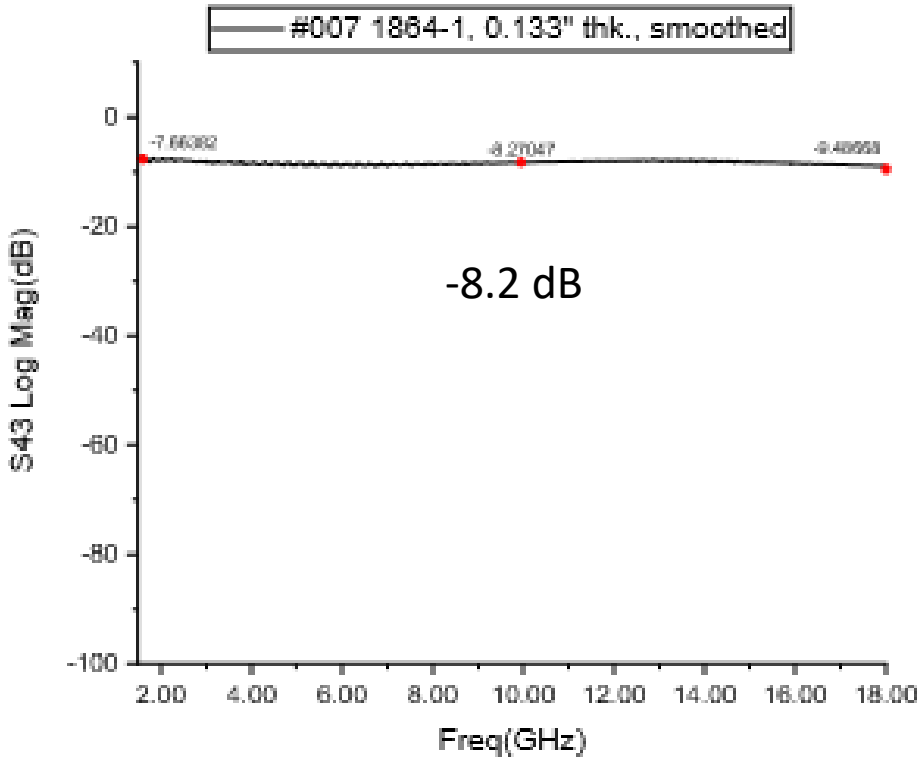


-11.71 dB

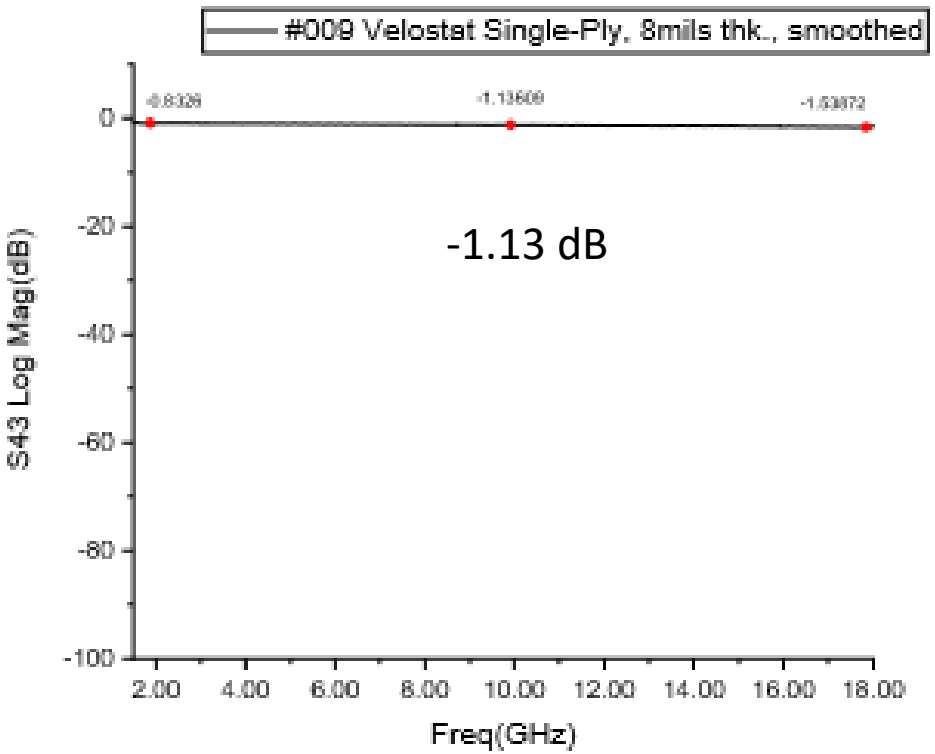


-2.11 dB

Conductive Plastic 0.105” thick and Corrugate 0.163” thick



-8.2 dB

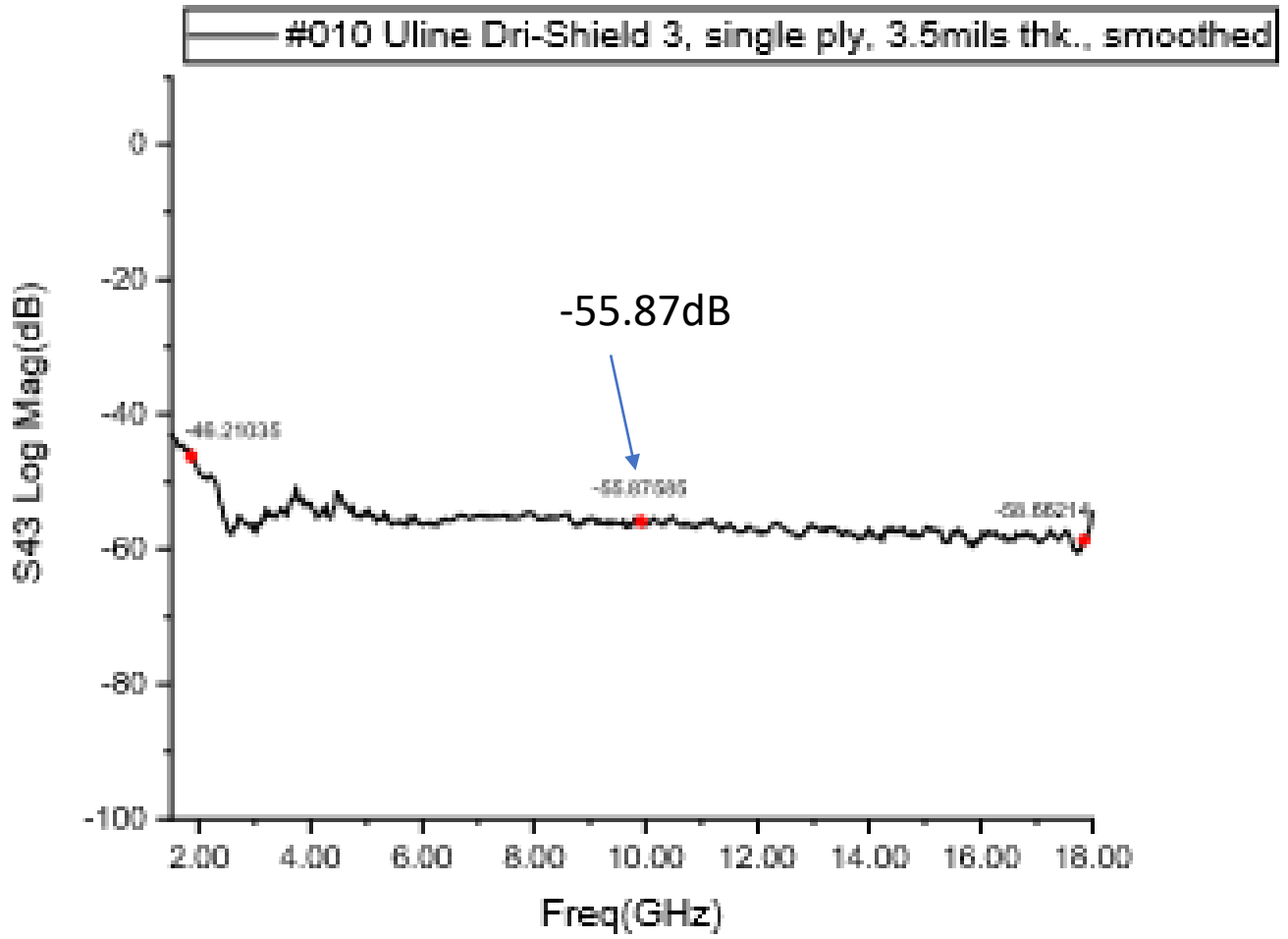


-1.13 dB

Carbon Filled Plastic Sheet and Bag material

0.133 inch 0.008 inch

Metallized Moisture Barrier Film



Additional Samples:

- At the time of preparing this slide set, more samples were being prepared for attenuation testing

Task Team Evaluation:

- When all the data is collected, the analysis will involve comparing the attenuation factor to surface and volume resistance and sample thickness
- The goal will be to develop the correlation between electrical resistance, thickness and attenuation

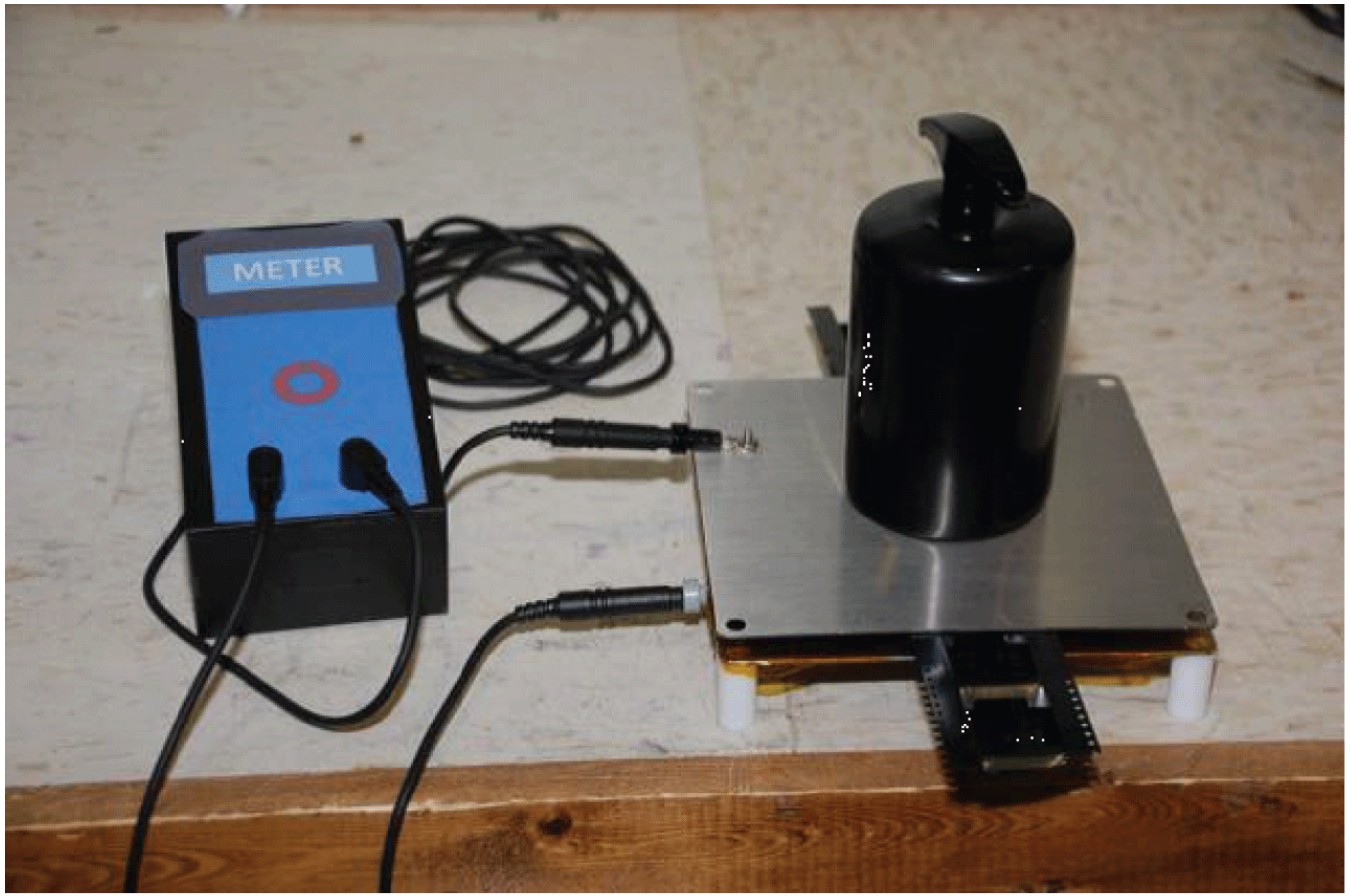
Revision of ANSI/ESD S541

- The current release of S541 is good for 4+ years
- When the Task Teams have completed their work, WG11 will consider adding updated information to S541 for the properties of Low Charging and E-field shielding

Other Work Regarding Packaging:

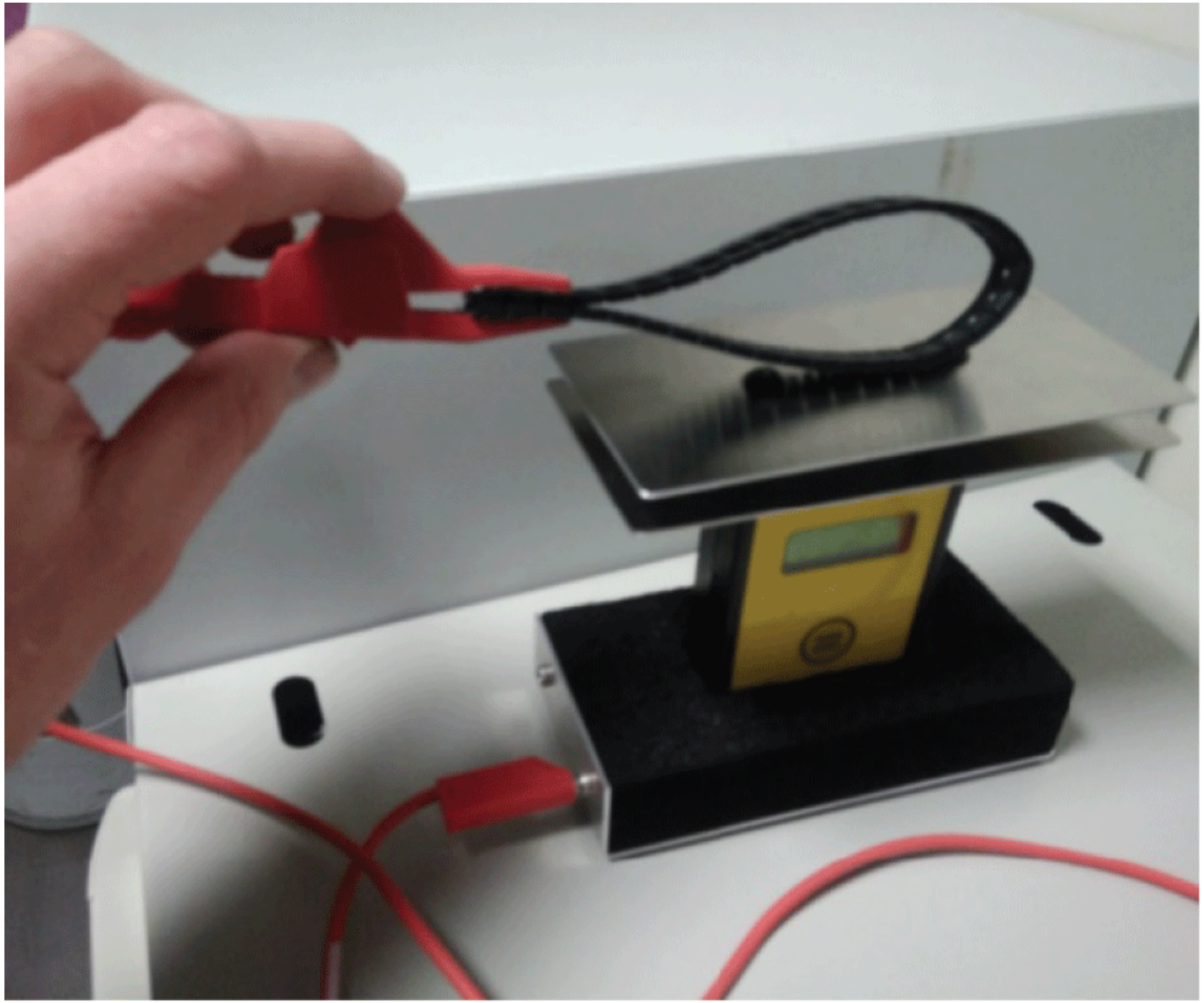
- IEC61340-5-5 was released in 2018 – dealing with packaging used for small profile parts
- Document provides information about measuring packaging materials that cannot be measured accurately by existing test methods

Parallel Plate Method for Pocket Tape



IEC

Discharge Method



IEC

IEC61340-5-5

- Tape and reel, some trays, blister packs and other profiles of packaging materials cannot be measured for surface or volume resistance using existing test methods
- Two-Point probe is too large to make measurements inside small pockets
- Guidance is provided in the document for determining the suitability of packaging materials

ANSI/ESD S11.4 - Bags

- Document revised and released in 2019
- Minor changes only

Summary:

- Packaging materials have evolved over the years
- Major developments occurred in the 1970’s and 1980’s
- Test methods have evolved since the 1990’s
- The advent of IEC Electrostatics TC101 has helped to harmonize global standards for packaging materials
- After all these centuries (millennia?), low charging is still an issue regarding test methods and specifications
- Electric field shielding is a controversial subject that needs resolution
- Maybe all will be resolved by 2020 (?)