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CONSIDERATION FOR DEVELOPING *ESD GARMENT SPECIFICATIONS*

Author:
G. Baumgartner
ESD West Consulting

Electrostatic Discharge Association
7900 Turin Road, Bldg 3
Rome, NY 13440

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Introduction

Concerns about effective ESD garments are best addressed by starting with an understanding of electrostatic measurements and how they relate to ESD protection. Basic ESD measurements are simple, but for yarns, fabrics, or garments, measurements become difficult and complicated. An ESD Association Technical Report (TR), TR-1 *"CAN STATIC ELECTRICITY BE MEASURED?"* by Niels Jonassen [1] discusses ESD measurements at length and at a fairly high technical level. The principals stated in TR-1 are basic to understanding electrostatic measurements, and what measurements are, or are not, valid. From studying these basic principals, garment measurements can be understood. Only proper test methods will provide the information that can determine effective ESD protection.

There are many test methods applied to garments, some are applicable others are not. Some of the test methods being used today are valid measurement standards however, they were designed for other specific materials. Some test methods do provide useful information to assure device protection. Others use in-house test methods that may or may not be effective. So far, these test methods have not been demonstrated to be directly related to the protection of ESD sensitive devices.

After careful analysis, some presently proposed measurements may be discarded as improper, impractical, or meaningless. Still, there will be those that will argue about the validity and usefulness of a particular measurement because they believe that their measurement or test method will determine ESD protection. Disagreement is inevitable, as the variables of numerous protection configurations, device requirements, and static charge sources are open-ended. Only when scientifically valid models are proposed can people agree on the facts and calculations to show what is useful for determining ESD protection.

The device's sensitivity must be considered and related to the requirements before ESD protections can be evaluated. What must be considered is the type of sensitivity of various device technologies and the possible way that devices can be damaged by common clothing, ordinary garments, or ESD garments. Only then can the requirements be evaluated to assure ESD protection.

To start the analysis of garment requirements, a list of "features" is discussed and defined. This will prevent confusion with the actual terms used to describe garment protection attributes. Then, the measurement methods can be discussed and evaluated. Also, measurement methods that could theoretically be made are analyzed and their problems discussed.

The Appendix has helpful and supporting information. The Appendix also has a definition of an ideal garment. The definitions show the contradictions of the listed requirements that are assumed to be needed for ESD protection of devices.

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A Discussion of ESD Protection Properties

It is necessary to list and define the "features" that are provided by ESD protective garments. A discussion of "features" or properties will clarify the protection elements, real or imagined. Some features listed may not be possible to evaluate, or test in any meaningful way. Some features are, for all practical purposes, improbable or impossible to measure, as they are not based on any engineering formula that can be used to calculate ESD protection. (The term "feature" is used in a broad sense to cover characteristics, properties, parameters, and attributes; all the terms that are sometimes used, but never clearly defined and often misused by technical as well as non-technical people.)

Here is a list of garment "features", real and maybe not so real:

1. ESD Awareness
2. Surface Resistance (Conduction)
3. Dissipation of Charge (Static Decay)
4. Shielding Types
5. Induced Electrostatic Voltage Suppression
6. Anti-Static Property (Non-Tribocharging or Low-Charge Generating)

See Appendix for Ideal ESD Garment Definition

Feature 1.

ESD Awareness

ESD awareness is a "feature" that can be attributed to ESD garments. A garment, when it is identifiable as an ESD garment, promotes awareness. The effectiveness of ESD protection is not an issue for this valuable awareness feature. This feature is enhanced by garments being clearly identifiable as ESD garments because of color or visible conductive lines or grids.

Feature 2.

Surface Resistance (Conduction)*

The garment surface is mostly a relatively good insulator, except for the dissipative or conductive yarn woven into the fabric. The yarn conductivity spreads the charge or conducts the charge to ground, thus reducing the electrostatic field strength at the location where a charge has been generated. Resistance, to some extent, is involved with and related to all other issues even affecting tribocharging.

The charge may be on the surface of the garment or below it on the clothing of the person. Moisture given off of the person wearing the garment generally reduces the charge. Clothing items such as nylon-down jackets are the exception. Insulative yarns with conductive cores can reduce the electrostatic field strength by spreading the charge over a large surface, regardless of where the charge is located, even if these yarns have a high surface resistance (See Appendix Fig. 1).

When the dissipative or conductive fibers provide a path to a grounded person or a direct path to ground, the assumption is that charge has been removed from the garment. Charge may have only been removed from the conductive yarn and the insulative surface near the conductive yarn. Charge will avalanche on the surface of an insulator as an abrupt change in charge density cannot exist on any surface. This is known as the breakdown potential (charge avalanche) of an insulative surface. Therefore, there will always be some electrostatic field measurable on the surface of an ESD garment. (See Appendix Fig. 2.) The conductive yarn connections in the garment weave or knit are important in the dissipation of charge. (Conductive, in this usage, includes the dissipative resistance range of yarns as well as the conductive range.) The connections affect the resistance values measured across seams, and from sleeve to sleeve. The connections are also a factor in the measurement of the garment surface resistance. The resistance of the yarn can be different in the x and y directions of the fabric. The connections can affect the resistance when measured in different directions on the garment fabric using a square electrode. When there is a directional factor to the fabric, the square electrode measurement value will differ from the circular electrode value. This resistance variation caused by conductive yarn direction goes unnoticed when circular electrodes are used.

The pattern of the conductive fiber for woven or knit fabrics, can affect the resistance measurement for a given yarn resistance or resistivity. Also, the resistance in the X and Y direction have been found to be quite different for woven fabrics, presumably due to the different amount of stretching that occurs during the weaving process. Also, the difference in applied voltages will cause variations in the measured values, as will the distance between electrodes. The change in distance between electrodes can have a linear resistance change or a non-linear affect on the measured resistance if the conductivity varies with the voltage gradient. A voltage gradient is the change in voltage per unit length between the electrodes. The voltage gradient changes for a fixed voltage as the electrode separation distance is changed or the gradient can change for a fixed electrode distance if the applied voltage is changed.

As previously stated the weave or knit is an import factor in the measured resistance. The resistive connection between conductive fibers needs to be examined. (See Appendix Fig. 2 & 3). The resistive connections are complicated and vary for the different fiber patterns. Models can only be developed knowing the resistance of the conductive yarn configurations and their resistive connections, as there is nothing else in the garment to produce ESD protection.
**Conductive or conductivity, as often used in this paper, describes material in the conductive range or may be used to define any material in the conductive, dissipative, or insulative (as in very low conductivity) resistivity range of resistance.*