STATIC CONTROL SPECIFICATION DEVELOPMENT FOR THE ELECTRONIC INDUSTRY

For the past few years, manufacturers and users of sophisticated electronics have struggled to understand the effects of static electricity on equipment and operations. Now that some understanding of static damage has been reached, management must analyze specific problems and select materials to solve these problems. Unfortunately, new confusion exists regarding formal guidelines, specifications, and standards which focus on static related materials and procedures. The following may eliminate some of this confusion.

During the last several years, many organizations anticipated this problem and began sorting out the various elements of electrostatic discharge, overstress standards and control methods. Though the job of clearly defining guidelines is far from complete, the effective manager should be cognizant of current specifications and their many sources. Without basic information, management can not make profitable decisions related to modern static control materials and procedures. Most important, without the efforts and vision of the following organizations, today's management would have few tools with which to make those decisions.

The Typical Problem. Anyone who has attempted to acquire static control materials faced a variety of product claims. Static controlled plastic bags were purchased based on the color, (such as pink, black, or blue) rather than on the performance of the product. As buyers became knowledgeable, they were faced with an array of products, all of which claimed to meet the MIL-B-81705B barrier packaging specification. Unfortunately, the situation became especially perplexing when tote boxes, cushioning foams, floor mats and so forth also claimed to meet a packaging standard. Further muddling the situation were test methods designed for other industries and environments that had little or no bearing on the electronic specialist's needs. Yet, a variety of products were offered and purchased because they met some standard, however confusing or irrelevant to intended use.

One tends to question the integrity of the venders in this situation, but they are not at fault. The electronic packaging specification (MIL-B-81705B) refers to a test method (FTS 101, Method 4046) originally designed with the medical industry in mind. The method went beyond defining how to test a material, and included some standards for material performance. The source of confusion becomes more apparent when one realizes that few standards for materials (other than bags) existed. When the method and the standard were combined, a variety of results and interpretations erupted as the demand for products grew. Making matters worse, customers expected venders to comply with the decay criteria as outlined in the packaging specification, whether or not the material was used for packaging.

To question the venders' integrity in this situation is unwarranted, as they have become major investors in promoting support for the development of electrostatic standards and guidelines. They participate on virtually every committee, task force, association endeavor, and in some cases are the only group testing and developing new methods for users' technology.

The Military Makes a Key Move. With the leadership and guidance of Mr. Toshio Oishi, in the late 70's Naval Sea Command developed the first comprehensive handbook (DOD-HNBK-263) and standard (DOD-STD-1686) for static control related to electronic manufacture. Mr. Oishi's group brought everyone's efforts together under one roof, so to speak. One has only to review these documents to see the scope of this very complex project. The work of literally hundreds of people, contributed in the forms of other specifications, interviews etc., made this project the broadest work in static control to date. What made matters especially interesting was the electronic manufacturers' response to these two documents.

During this period, the military was purchasing tons of electronic equipment for the defense system, a healthy percentage of which arrived on station DOA (dead on arrival) due to electrostatic damage. The contractors objected to the military's requirement that they change manufacturing factors of already expensive products by dealing with the variables of static.

The EIA Faces The Static Issue Head On. The Electronic Industries Association received many complaints from its membership regarding these new military guidelines and labeling requirements. In view of its members' complaints, the EIA was obliged to investigate these standards and take an appropriate position. Much to its credit, the EIA Committee for Packaging Electronic Products for Shipment (PEPS), chaired by a perceptive and patient gentleman, Mr. George Kahler of Western Electric, took an objective point of view.

Mr. Kahler sought input from those members who had practical experience with static control. RCA's then-Vice-President of Packaging, Mr. Joe O'Hanlon, was one of the first to speak up by relating significant cost savings with the proper use of static control technology. Others were asked to testify to their experience, including manufacturers, static control product suppliers and consultants.

Instead of objecting to the military's efforts to influence the private sector toward static control, they took a positive stand in supporting static control. The EIA's position was based on the fundamental logic that, if static control is, in fact, a positive contribution to quality, cost control and profits, the EIA has an obligation to advise its members accordingly.

The EIA Forms a Powerful Task Force. Subsequently, the EIA's PEPS Committee formed a static control task force, consisting of experienced industry practitioners, to recommend standards and advise the PEPS main committee.

Though this group had highly diverse attitudes toward methods of control, they were motivated by the common goal of developing an objective commercial standard. Ultimately, they produced the EIA's Interim Specification No. 5 for the PEPS Committee's review and consideration. In January 1983, IS-5 was published and issued to the industry for comment, almost three years after the EIA's initial meetings.

The Military Expands Their Commitment. After initial joint meetings with the EIA Task Force and approximately nine federal organizations, a joint working group was formed by the military under the leadership of Mr. Jack Holmes, Director of DARCOM, at the Army's Tobyhanna facility. The intent of the

Military Working Group is to define standardized static control guidelines to meet military/government needs, and work with the EIA Task Force for further development of compatible commercial standards.

During the first exploratory joint meeting, update status of Federal Test Standard 101, Method 4046, and MIL-B-81705B was explained by their sponsors, Mr. Dennis Agnew (Naval Air Development Center) and Mr. Thomas Major (Naval Air Engineering Center). Work on these two important documents has since been in process. The encouraging testimony of these and all the other attending agency representatives demonstrated the military's continuing concern regarding static damage.

The EOS/ESD Association Joins the Effort. The Electrostatic Overstress/Electrostatic Discharge Association is a group dedicated to dealing with electrostatic problems and related solutions in the electronics industrv. An outgrowth of the EOS/ESD Symposium sponsored by the Illinois Institute of Technology Research Institute (IITRI) and the Reliability Analysis Center (RAC) at Rome, New York, the new Association began its efforts toward standards development in 1982.

The EOS/ESD Association Standards Committee consists of over fifty electronic and static industry specialists. In their review of the military and EIA Efforts, most specification work was found to be directed primarily to packaging materials. Consequently, the greatest needs of the industry in areas of static control devices, production aids, instruments, and ionization was yet to be considered. These became focus subjects for the Association's standards work, and initial drafts of wrist strap, table top material evaluation, and other specification guidelines have already been developed and circulated for comment.

Other Organization Efforts. In addition to the above, the IEEE has formed an Electrostatic Instrumentation Standards Committee. First proposals were drafted in 1982.

The Electrostatic Society of America has acted as a general forum for all types of electrostatic development for several years. In addition, several international chapters (most notably in England) have sponsored annual symposia for the dissemination of electrostatic technology at the highest professional levels.

A major attack on static related defects in the clean room environment has been launched by the Institute of Environmental Sciences. The focus on clean room static control technology is one of the more complex and critical areas of development. Combining the expertise of the leaders in the IES Working Group (RP-10) with that of environmental static control expert, Sharon Kaminskas (Director of Static Control and Clean Room Materials, Biggam Enterprises), the 209B specification revision regarding this sensitive area is almost completed. It is due for presentation and review by the GSA in early 1984.

The Current Focus of EIA's Interim Standard No. 5. The major area of concern by the Electronics Industries Association has been static controlled packaging materials, in constant use and close proximity to sensitive devices. Current commercial specifications, such as IS-5, do not presume to define mechanical performance requirements because the technology of packaging is well established within most organizations. It is the electrostatic performance of various materials which is vital to the industry today.

Key electrostatic elements to packaging material design and selection were defined as follows:

1. Designation of electrostatic function in terms of surface conductivity and static decay properties;
2. Methods of electrostatic material testing;
3. Protective characteristics related to types of shielding performance; and
4. Contaminating factors such as corrosion, sloughing and chemical transfer.

The EIA Task Force on Static Controlled Materials has struggled with these primary elements for over two years in an effort to provide both manufacturers and users of materials with concise, objective criteria. The essence of EIA's Interim Standard No. 5 is based on this work.

Designation of Electrostatic Function. Most experts agree that materials with a surface resistivity in excess of the 1×10^{14} ohms/square is considered insulative; that is, electrons do not pass easily across the surface. As static is generally considered a surface phenomenon, a static controlled material's surface resistivity should be below 1×10^{14} ohms/square. This allows the movement of electrons to either "bleed off" electrons, as in the case of a negatively charged material, or supply electrons to neutralize a positive charge.

At this point, several questions must be considered, such as:

1. How fast should a material supply or eliminate excess electrons? Too fast will cause hazardous arcs and subsequent RFI damage, says one school of thought. Too slow will allow charge build up and reduce potential electrostatic shielding effectiveness, says another.
2. What is to be considered an "antistatic" material as opposed to a "conductive" material? Should a separate category of "dissipative" materials be maintained? How should these functions be defined?
3. As surface resistivity and static decay was always thought to be directly linear and proportional, which should be used for the criteria of material designation?

EIA Task Force reasoning for material designation was based on these factors. First, the relationship between surface resistivity measurements and static decay analysis had to be clarified. Second, a safe range of resistivity had to be defined based on desirable material attributes. Third, within the "range", specific characteristics of performance needed identification.

Defining The Range of Performance. Reason dictated that any material which could safely be called "Static Controlled" would have two traits: it would not be insulative in nature and provide a reasonable margin of safety in that respect; and, it would dissipate a measureable charge in a reasonable amount of time. The upper limit of 1×10^{13} ohms/square satisfied the first requirement. The two second decay criteria imposed by MIL-B-81705B is indicative of a material (with some capacitance) to completely dissipate a charge, and also infers that, should a static charge be generated on its surface, it would not reach hazardous levels, due to its resistivity. Thus, the two-second maximum decay time became the second characteristic of a static controlled material.

The performance ranges of static controlled materials subsequently became:

1. less than 1×10^{13} ohms/square surface resistivity; and
2. less than 2.0 seconds decay from 5,000 volts to under 50 volts.

Characteristics of Static Controlled Materials. Materials below 1×10^{13} ohms/square share two features to varying degrees:

1. Conductivity - the ability to pass electrons across its surface, and attenuate an electrostatic field;
2. Antistaticity - the ability to minimize charge generation in a triboelectric situation.

Specifically, all materials in this range could dissipate a charge and prevent charge generation in some respect.

At less than 1×10^5 ohms/square, materials had sufficient conductivity when properly constructed, to act as a Faraday cage and fully attenuate an electrostatic field. Therefore, materials with a surface resistivity less than 1×10^5 ohms/square were designated, "conductive."

Chemically compounded materials above 1×10^6 ohms/square demonstrate an ability to minimize charge generation in a friction/separation situation. This range was designated "antistatic." The entire range is "static dissipative." To avoid confusion, that designation has been eliminated as an identification of a special performance range.

Methods of Electrostatic Testing. To avoid confusion and standardize evaluation procedures, the Task Force isolated a few specific methods for material testing. The attitude that any given test is the best way to measure material performance was avoided. Rather, the Task Force sought to define various tools which would clarify material performance. Finally, the conditions for testing were standardized.

The same criteria for test conditions is applied to all electrostatic analysis. Prior to testing, materials must be conditioned at less than 15% relative humidity and 70° F (23° C plus or minus 3°), for over 24 hours. All tests must be performed in the conditioning environment. A material cannot be conditioned in one environment, then be removed to another for testing.

Federal Test Standards 101C, Method 4046.1., was selected for static decay testing. It should be noted that the IS-5 standard requires that a 5,000 volt induced charge decay to technical zero (less than 50 volts) using the FTS101C method. Some nonelectronic industry specifications require decay measurement to "10% of the initial charging voltage" when using the FTS101C method. Decay to 10% is not appropriate for electronic industry materials. There is good reason for this restriction. A material may decay to less than 500 volts, say 450 volts, but not below that point. Consequently, devices sensitive to low voltages may be damaged by these "10%" materials.

Surface resistivity will be measured using ASTM D-257, or equivalent. In the past, the ASTM method was used under ambient conditions then compared to decay analysis conducted at low relative humidity. This is not an acceptable practice; surface resistivity must be measured at less than 15% Rh in order to have value in electrostatic analysis and comparison to other test data.

Charge generation testing developed by a Task Force Member shows significant promise in many types of material evaluation. Originally, the member pursued charge generation measurements to evaluate magazines used to package Dual In-line Packages (DIPs). His work demonstrated that a device sliding through a magazine generated a potentially harmful charge on the device leads and package. When the charged device comes in contact with a grounded surface/object, it discharges and may cause device failure. IS-5 requires that magazines be tested utilizing charge generation measurement techniques. The charge generation test is performed under the same environmental conditions as decay and surface resistivity in order to obtain consistent test results.

One should note that charge generation measurement is based on evaluating the effect of two materials rubbing together. As one material strips electrons from the other, the electrons accumulate on the host material in the form of a "charge". The charge is measured in nanocoulombs. While this technique is currently recommended for DIP magazines and small items, it can be used for other material testing as well.

The final acceptable levels for charge generation on magazines and other products is being evaluated by the Task Force. However, the method of testing has been accepted.

These three methods of testing form the heart of IS-5's test recommendations; however, other evaluation factors are included for consideration, such as volume resistivity per ASTM 991. Another test is under consideration. This proposal concerns evaluating the effectiveness of an inaccessible electrostatic shield. (See *ITEM '83* for detailed descriptions of this test.) Though several features of this evaluation method are still being explored, the potential value of the new work is significant to professional analysts.

Shielding. The initial shielding concern of the Task Force was the common DC field given off by a charged material. As previously mentioned, the Task Force generally agrees that a conductive material having surface resistivity less than 1×10^5 ohms/square will act as an electrostatic shield, and IS-5 takes that point of view.

However, shielding requirements related to RFI and EMI have not been broached at this time. The Task Force will probably be dealing with these subjects in the near future, and will invite specialists in these areas to make contributions.

Corrosion. To avoid secondary problems of contamination and corrosion, other evaluation factors have been incorporated in IS-5. As a general statement, Federal Test Standard 101, Method 3005 is used as a corrosion test criteria. In addition, obvious particle contamination or sloughing is objectionable in electronic packaging materials.

These areas are being investigated by several other organizations, including other subcommittees of the EIA. Further definition will be provided in IS-5 as work in this area progresses.

The Relationship Between Resistivity & Decay. Surface Resistivity is a direct contact measurement of a material's capability to allow electron flow across a square unit of surface, whereas, static decay is a noncontact evaluation of the combined effect of surface resistivity and the material's capacitance. Static decay time is based on how fast a field emanating from the material will collapse when a charged sample is grounded. It is indicative of the material's primary construction attributes, not a physical measurement of mechanical factors. A specific material has an electrical relationship between surface resistivity and decay time, but other materials with identical resistivity cannot share that exact relationship, due to differences in construction which affect capacitance.

Types of Materials Covered By IS-5. The following types of packaging materials are currently included in the IS-5 guideline:

- Magazines (DIP Tubes, slides, rails, etc.);
- Bags, Pouches and Sheets (Non-cushioning);
- Flexible Cushioning Materials - Foam, Open Cellular, Closed Cellular, and others in Sheet, Roll, Pouch or Bag Form;
- Chipboard Cartons, Corrugated Boxes, and other similar nonflexible containers other than magazines;
- Loose fill, Molded, or Irregularly Shaped Materials;
- Rigid Foams and Other Similar Materials (All types); and
- Shunting Foams.

Each material group expands as more input is received by the PEPS committee. As Mr. Kahler, Chairman of the PEPS Committee and Task Force has frequently said, "...the standard will be an ongoing, ever-changing guideline to reflect the needs of those who use it."

One Problem. The static control industry has always faced problems of user awareness, understanding of electrostatics and its impact on electronics. The EIA PEPS Committee tends to share that problem to some degree. Few of the hundreds of companies who are affected by static and static control specifications participate in these very important decisions. In fact, the bulk of those attending these meetings are venders of static controlled materials. The common cry from attendees is "What does the industry need to solve problems?"

When more, interested corporations become involved, this question will be answered by a growing number of very qualified people.

Author's Comment. It should be noted that the EIA Standards are intended as guidelines, and not specific requirements for the industry as a whole. There is no federal agency that demands use of IS-5 in any given application. However, one will find that this document tends to form a compendium of static control attitudes and criteria which exists in many federal specifications. Several EIA member organizations may base their commercial material specifications on this document. In addition, IS-5 is currently limited to packaging materials because the EIA's PEPS Committee charter is oriented specifically to these materials. Other devices and methods of static control are necessary in order to inhibit static related losses in the electronic environment.

Finally, there are hundreds of men and women who have made major contributions to the growing arsenal of static control weapons. They are unique, creative individuals who tend to share their knowledge. Though space does not permit listing their names and accomplishments, their work is sincerely appreciated by others.

This article was prepared for ITEM '84 *by Stephen A. Halperin of Stephen Halperin & Associates, Elmhurst, IL.*