A Study of ESD Corrugated

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Abstract – Electrostatic Discharge (ESD) corrugated protective packaging is evolving to the point where new testing procedures need to be implemented in the evaluation process. This paper will serve as a general overview in outlining some test methods aimed at the qualification process for ESD corrugated and attempt to provide some understanding of what differentiates one ESD packaging product from another. In the course of this paper, we will explore mechanical, electrical and environmental considerations as we search for the "perfect package". This paper will address some basic design considerations in conjunction with testing procedures.

Introduction

For the ESD professional, the issue of appropriate packaging seems to persist, day in and day out. In the midst of process and technology improvement, ESD corrugated packaging is ripe with new technology and better ideas. Although initially, not particularly received by the ESD engineering community, ESD corrugated packaging has begun to foster acceptance and has received widespread use in recent history.

For total cost reasons, the use of ESD corrugated packaging offers several attractive features and benefits while offering physical strength and electrical performance over a long duration. In addition, the saving of labor and material by not having to use ESD bags has cleared the path for ESD paper technologies.

In the user community, expectations seem to vary widely for ESD protective properties. While some electrical equipment manufacturers prefer corrugated boxes that are essentially 'conductive', others have a strong preference for using 'dissipative' boxes exclusively. For the purpose of this paper, our ESD design goals included the usage of a buried shielding layer, a dissipative surface and low tribocharging.

This paper will explore mechanical, electrical and environmental considerations. Many coated and impregnated products have been manufactured to insure ESD protection, but may pose other hazards as conductive particle sloughing. A method known as the Sutherland Rub test will be reviewed as a tool in evaluating this problem. Air and spacing can contribute to the effectiveness of protective packaging. Various flute structures are available, including B, C, E or F flute. As B flute is the most widely used structure for ESD corrugated, this structure was generally used for testing performed in this paper.

Through the development of CDM safe technologies, static dissipative surfaces and advancements in paper technology have opened the door for improvements in ESD paper products. Static dissipative technologies, including coatings will be discussed along with their effectiveness for use in the electronics industry.

Recyclability will be discussed in depth and the various ESD corrugated technologies will be evaluated for characteristics such as repulpability. This paper will address some basic design considerations and testing procedures, including what happens to paper in low relative humidity.

I. Paper Definitions

Kraft is of German origin meaning strength, which designates pulp, paper or paperboard produced from wood fibers by the sulfate process. One type is cylinder Kraft containerboard, which is a multi-ply formation with predominate grain direction of fibers made from a natural light brown like Kraft pulp on a cylinder machine. This type of paper making technology is widely used. Corrugated is the correct term for "cardboard" box liner(s) and medium that has been bonded together by a corrugator. Fiberboard is a general term describing combined paperboard (corrugated or solid fiber) used to manufacture sheets or containers. It can take two or more paperboard liners and is adhered to a fluted corrugated medium to form corrugation or a makeup of two or more paperboard liners. Through lamination, solid fiber or a folding carton material will form boxes. Paperboard includes the broad classification of materials made of cellulose fibers, primary and recycled wood pulp, recycled paper stock, newsprint, packaging papers, solid and chipboard fibers that can be made into boxboard, chip board, solid fiber or fiberboard. Containerboard is the paperboard component (linerboard, corrugated materials and chipboard) used to manufacture corrugated and solid fiber. Medium is a paperboard material that has been formed into a wave shape or flute structure and is usually buried between one or more linerboards. Linerboard is the paperboard used for the flat outer facings of combined corrugated fiberboard or laminated as the outer facings of fiberboard.

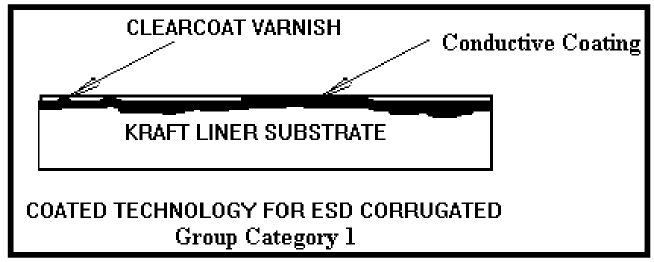
Edge Crush Test (ECT), TAPPI-811, Edgewise Compressive Strength of Corrugated Fiberboard (Short Column Test), was used for determining the compression strength of corrugated liner in lbs/inch. A special holder was employed to support precut corrugated specimens in a vertical position to be subjected to a top load. The Scott Bond test TAPPI UM-403 measures the amount of force required to pull apart the upper and lower surfaces (liners) of a specimen as adhered on both sides to a test fixture.

II. Electrical Design Categories

Admittedly, the choice of design sets (or attributes) for corrugated packaging is rather arbitrary. In the research for this paper, it was noted that there must be at least a dozen or more approaches in industry use today, and not all methods were evaluated. From a definition standpoint, all designs evaluated were "non-homogenous" (i.e. "layered") arrangements. The following criteria was based upon the methods used to accomplish 'shielding' and 'surface' resistance:

II.a. Design Category 1"Conductive Ink Coating"

In this approach for shielding, the design uses conductive ink coated onto Kraft near the surface(s). The surface is designed to have a dissipative sealant, which also reduces sloughing, and tribocharging (Illustration 1).



Ilustration 1

Design Category 2 "Buried Metal"

In this approach, for shielding, the design uses a metal film which is buried close to the flutes and a polymer film which is dissipative on the surface (Illustration 2).

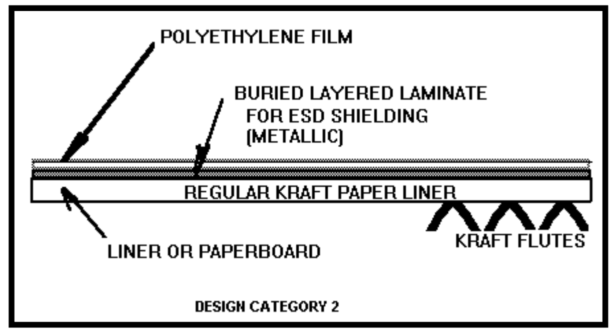


Illustration 2

Design Category 3 "Buried Conductive Ink"

In this approach, for shielding, the design uses a printed, conductive ink onto the liner in close proximity to the flutes, or the flutes themselves are conductive by virtue of carbon black impregnation. The dissipative surface is accomplished via dissipative ink printed onto the surface, with or without a dissipative varnish (Illustration 3).

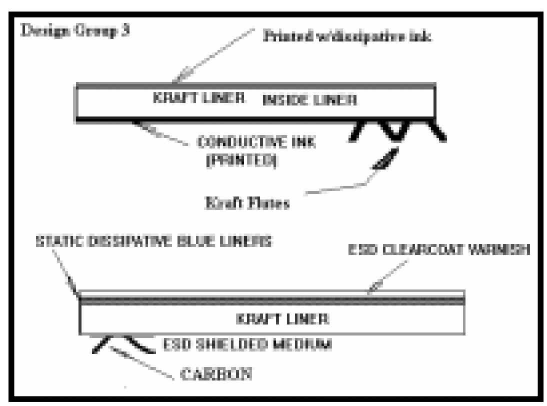


Illustration 3

Design Category 4 "Buried Carbon Black Impregnation"

In this approach, for shielding, the design uses a buried, carbon black to impregnate the inside liner layer, closer to the flutes than to the surface. The dissipative surface is accomplished by using progressively lighter amounts of carbon as the top surface is approached. Generally, a polymer coating is added.

Note: As a 'control', or reference, aluminum foil or plain Kraft corrugated material was employed for comparison purposes to all four-design categories (Illustration 4).

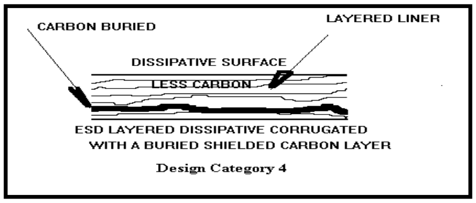


Illustration 4

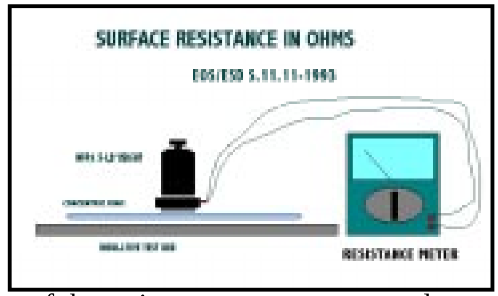
Although corrugated natural Kraft (corrugated or cardboard) boxes were found to be static dissipative at higher relative humidities, the Kraft paper was not electrically conductive enough to provide the desired static shielding. Kraft paper is hygroscopic (absorbs water), and the porosity of the surface can make paper become dry at low relative humidity [below 23% to 30% for bleached white and below 12% to 15% relative humidity for Kraft paper]; thus, the material's resistance tends toward the insulative range. It has a tendency not to drain a charge effectively, nor prevent a charge from being generated.

III. Electrical Testing

III.a. Surface Resistance Versus Relative Humidity (RH)

Fundamental to electrical measurement is resistance. The first effort to characterize the various designs was to measure surface resistance. At 1.0×10^{11} ohms some conventional corrugated materials begin to become insulative and hold static charges for several seconds or more. Resistance tends to vary with relative humidity. Untreated corrugated surfaces exhibit an increasing electrical resistance at lower relative humidities. A dissipative surface resistance reading is generally desirable for ESD packaging materials. Low relative humidity may portend shipping and handling problems for non-ESD treated corrugated surfaces material. The ESD Association defines volume resistivity as "the ratio of the DC voltage per unit thickness to the amount of current per unit area passing through a material. Volume resistivity is generally given in ohm-centimeters." Volume resistivity may be an effective measurement tool in evaluating homogeneous liners. Since non-homogeneous corrugated ESD was under consideration, no volume resistance measurements were taken. The four corrugated designs were measured on the front and back of the sample for surface resistance (Illustration 5).

Illustration 5



The average of the resistance measurements, along with the min and max readings, is illustrated on the Excel spreadsheets and Tables I - IV.

Over the course of several days, the ESD corrugated specimens were evaluated per ESD S-11.11-1993 guidelines at three conditions: 46% RH ("ambient"), 23% RH, and 9% RH. Table 1/Fig. 1 shows the specimens as measured for ambient conditions. All four design categories fell within the static dissipative range and below 1.0×10^9 ohms; Design Category 1 was much lower and close to the lower limit of the dissipative range. At approximately 23% RH, Table II/Fig. 2 shows, relatively, resistance moving higher. At approximately 9% RH, per Table III/ Fig.3, Kraft and Design Category 2 exceeded the 1.0×10^{11} ohms range, which is the upper limit of the dissipative range. Hence, for RH values lower than 9%-15%, untreated Kraft and Design Category 2 may begin to lose some effectiveness. Table IV/Fig. 4 shows the combined averages of the surface resistance readings versus varying RH%. A conclusion was reached for this set of tests, indicating that all designs were generally dissipative over the range 20% - 46% RH. Paper is hygroscopic, which helps to explain the relationship between relative humidity and surface resistance. A rough "Rule of thumb" for Kraft seemed to emerge, suggesting that as the RH% was cut in half, the resistance tended to increase by an order of magnitude.

Another concern is CDM safety. Surface resistance is a common approach for judging CDM safety, also. Surface resistance readings, which are too conductive, represent a potential threat from too rapid a discharge. Some organizations claim that a Resistance to Ground (RTG) value of greater than 5.0×10^7 ohms is desired for CDM Safety[1].

III.b. Static Decay

This test measures decay time of a charged, isolated object to 10 percent of its original value. Federal Test Method

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[1] ***ESD from A to Z,*** Second Edition, Kolyer & Watson, Chapman & Hall, 1996, Paper No. 17, Pages 286-292.

Standard No. 101, Test Method Number 4046, specifies that the charged object at +/- 5000 volts should drain the voltage to +/- 500 volts in less than 2 seconds. A modification is to use +/-1000 volts to drain to +/-100 volts in less than 2.0 seconds. This type of testing may have difficulty with materials of complex construction and is most often used with homogeneous materials. This test relates to a material' ability to dissipate induced voltages with proper grounding, i.e. charge relaxation.

There is opinion within the ESD industry that this test does not always typify real world events. ESD corrugated that has thin layers or a conductive surface acts differently from homogeneous or layered products. However, this test was performed for completeness. An ETS 406 Static Decay Chamber was used to employ the test from +/-5000 volts to +/-500 volts. Table V/Fig. 5 shows that the Kraft corrugated exceeding a desired decay time of 2.0 seconds. Most of the Design Categories, with the exception of Group 3, had decay times of less than .1 second.

III.c. Static Shielding

The first effort to characterize the various designs for shielding effectiveness was to measure surface resistance of the conductive layer. A calibrated PSK SPC/SQC Prostat 801 meter with a concentric ring unit and shielded cables in an atmospheric ETS controlled chamber was used to perform this test following EOS/ESD S-11.11-1993 guidelines.

The shielding layers of barriers were measured for Surface Resistance at 43.5% RH. As shown in Table 6/Fig. 6, Design Category 2 provided the lowest resistance readings. Design Group 1's conductivity readings were measured in the low static dissipative range. Samples from Design Group 3 had to be physically altered as the shielding layer was buried; however, conductive readings were achieved as illustrated in Table 6/ Fig. 6.

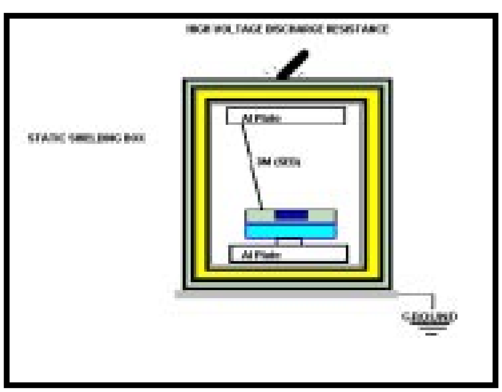


Illustration 6

Static discharges could damage ESD sensitive items through the wall of corrugated packaging. The High Voltage Discharge Test employed a Zero Static Simulator and Rockwell International's Modified Capacitive Probe that housed a 3M Static Event Detector (SED). The SED, configured into a modified capacitive sensor, was placed inside a fully enclosed ESD box (see Illustration 6).

This battery powered 3M Event Detector is approximately a 1" square reusable device to detect low level electrostatic discharge events. It is housed in a plastic case with a clear window on top with a metal back plate. In addition, it has a high impedance detection circuit, a reference antenna and a LCD display. When placed in a modified capacitive sensor, the SED can sense the rapid change in potential during an ESD event. The difference in potential between the antenna and the back plate triggers the LCD, which will change from clear to red, or blue in color. This indicates that an ESD event has happened. An ESD simulator set between 100-5,000 volts touches the package. At the same voltage, blunt tools will throw a longer and more pronounced arc as compared to sharp points. Table 7/ Fig. 7 illustrates the results of a High Voltage Discharge test on the product specimens. Each sample was of B-flute construction and cut on the same CAD/CAM cutting table to insure that the boxes were of equal size. The style of the box was a rolled end lock front construction with dust flaps. In ESD box designs, ESD corrugated performance can be compromised by a poor design. Slots or gaps in a design should be minimized as much as possible to insure effective static shielding. The ESD liner should face inside the box when a kraft outside surface is desired (Kraft will become insulative in low relative humidities). In designing a box, one should utilize roll-over dividers for in-plant handlers in order to maximize the use of partitions or dividers. It has been observed that this style of design can prolong the divider's life by tenfold. In addition, a modified "pizza" box design known as a RELF (Rolled End Lock Front) with dust flaps insures maximum closure in comparison to a RSC (Regular Slotted Container). This RELF design was used for the discharge tests.

The design goal was to pass at minimum 1 kV or greater at 50% RH. Design Group 1 failed the high voltage discharge test at 1KV, but passed at 675-volt discharge. The conductivity measurements for surface resistance found the specimens to have a surface resistance value of greater than 1.0×10^3 ohms which appears to account for the poor shielding of this design type. By comparison, the Kraft box, i.e. the control, only passed a 250-volt discharge (no shielding barrier). Design Group 4 passed at 3.25 kV.

If the box passed at the 5000-volt level, an additional test was created: The sample was subjected up to a 10,000-volt discharge via charging up a 200pf capacitor and discharging it onto the specimen. At this point, only Design Group 2 and

3 were remaining. Design Group 3 passed at 8.3 kV generating transformer but failed at 10 kV.

Finally, a 1-7/8" x 6" discharge plate was placed on top of the box and was employed to observe whether the specimen survived the additional 10,000-volt discharge to the metal plate. Only Design Group 2 was able to protect the 3M 100-volt SED unit under this condition.

Some organizations require another method, which measures energy. The proposed ESD corrugated test (11.32) should be somewhat like ESD S.11.31-1994 (for static shielding bags). ESD S.11.31 is defined as an electrostatic discharge measurement method. The method employs a capacitive sensor inside the package. A 1KV discharge to the outer package is conducted; the fixture then measures the current across a resistor connected to the fixture's upper and lower sensing plates.

The current and resistance are used to calculate energy seen inside the package during the discharge event. This test should be effective in measuring energy per specified relative humidities of either 12% or 50%. Corrugated specimens for either test procedure should be of the same size and flute construction to keep consistency.

Table 8/Fig. 8, only for Groups 1 and 3, and from another party, shows Design Group 3's performance of 6.7 nJ to perhaps have some correlation to the previous test above which the group was shown to shield a 8290 volt discharge. The performance of the Design Group 3 allowed 131 nJ to be measured in the test above, which provided only 675 volts of shielding. As the shielding capability increases, one would expect to see higher withstood voltages and lower energies within the box. A design goal for this test is to have energy below 50 n-jls [see ESD DS 20.20]. A comparison of three tests, Resistance of the conductive layer, HVDT, and CPT (11.32) is shown, below:

	Surf. Res	HVDT	CPT (11.32)
Group 1	6E4	675	131 nJ
Group 3	3E2	8300	6.7 nJ

Illustration 7

Group 1 would seem to have too high a surface resistance for the shielding layer to withstand 1KV, HVDT, or have CPT < 50nJ.

III.d. Triboelectric Charging

This test is erratic and difficult to reproduce. One method is rubbing two objects together and reading a generated voltage. Another technique for triboelectric tests of corrugated sheets has not provided consistent readings for ESD corrugated. The said method employs 1 inch diameter quartz and Teflon cylinders released on an 17 inch long elevated incline at 15 degrees on the affixed ESD corrugated material. Unlike thin-filmed materials, corrugated has a more porous surface. A microscope illustrates the porous and wavy nature of corrugated. NASA has demonstrated an effective method that charges a specimen from a rotating Teflon wheel and measures the discharge time in seconds, (see NASA Illustration 8).

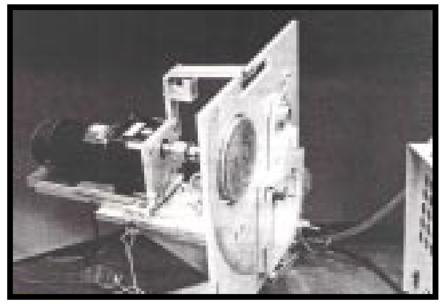


Illustration 8

Dr. Ray Gompf of NASA's Kennedy Space Center took several specimens and conducted testing. At 45% RH, all the samples generated a peak voltage of less than 100 volts. However, at 12% RH at 76 F, Kraft corrugated generated a peak voltage of 14,410 volts. A white and Kraft specimen generated 16,790 volts and 12,870 volts respectively. To compare tribocharging data from the inclined plane to the NASA method, another corrugated product had several samples tested in accordance with H-P's Workmanship Specifications, Appendix P, 5951-1589. The ESD corrugated specimens were found to have an average of -0.17nC/sq.in, for Teflon, and -0.19nC/sq.in., for Quartz. NASA's findings at 12% RH showed a peak voltage of about 20 volts for the same ESD corrugated technology. In review of the static decay measurements and surface resistance measurements, it would appear that Kraft corrugated could pose a potential hazard at low relative humidity.

IV. Mechanical Testing

IV.a. Reducible Sulfur Levels

Reducible sulfur of less than 8 parts per million (per TAPPI 406 om-94) is considered safe for electronic corrugated. This method involves the reduction of various forms of sulfur to hydrogen sulfide and the development of a dark spot for lead sulfide on the filter paper impregnated with lead acetate. The intensity of the spot is compared with spots developed from standards and is proportional to the concentration. Sulfur combines in the pulping process of paper making to break down the wood fibers. Sulfur can be a contamination to sensitive electronic components. Overall, recycled liners have low levels of sulfur as compared to virgin fiber. This test was not performed for the said samples but consideration to sulfur content should be considered.

IV.b. Rubbing Abrasion Resistance

The Taber Abrasion Test (ASTM D4060) consists of a 1000-gram wheel (CS-17) that rotates at 70 revolutions per minute over a sample. This test wears holes through the corrugated paper sample until conductive particle erosion takes place. ASTM D 5264-92 or Sutherland Rub Test mounts specimen on top of rubber pad over the Sutherland base, with the receptor cut to fit the 2-LB or the 4-LB weight. The receptor is mounted to the weight. The test duration is determined by the number of the samples to be rubbed. The number of strokes desired is preset on the Sutherland timer. The weight is mounted on the Sutherland and the machine is turned on. In this paper, 50 strokes with a 4-LB weight was used. Sloughing of conductive particles could bridge the gap between circuit lines and short out a board. Group 2 performance was outstanding, Group 4 performed very well Group 3 was acceptable as the surface was free of carbon, and Group 1 had good rub resistance (see Illustration 9). However, one coat of varnish would prove ineffective.

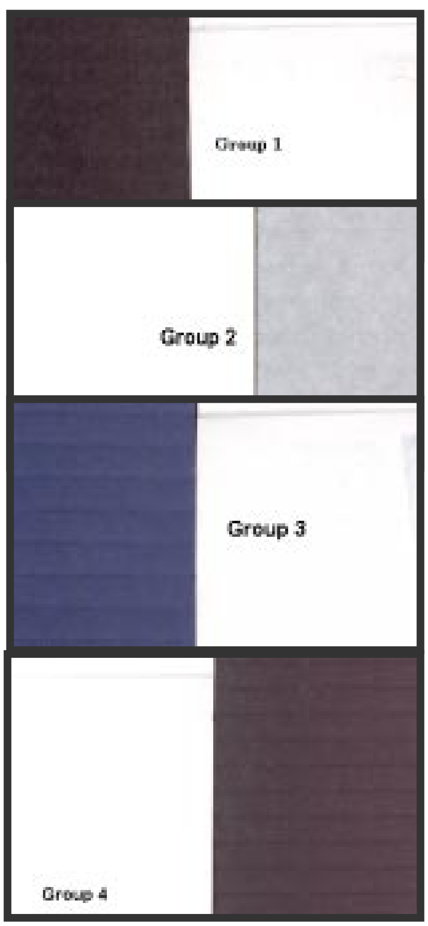


Illustration 9

IV.c. Other Performance Considerations (Mech.) “Internal Bond of the Linerboard, Adhesion, Basis Weight & Edge Crush Test”

ESD corrugated liners can be coated, layered, impregnated, laminated or consist of coated liners with homogeneous ESD mediums. The focus on understanding ESD corrugated packaging should not be restricted to electrical characteristics only! Some packaging engineers may be only concerned with conventional corrugated properties. ESD considerations need to be satisfied along with corrugated requirements. Good electrical values are not enough. In a proper manufacturing environment, the top sheets of a given liner bond with the base sheets. In the TAPPI T 459 om-93 or the Surface Strength of Paper (wax pick test) method, "...calibrated sealing waxes with increasing adhesive power are pulled from the surface of the liner. The highest number of wax in the series which does not disturb the surface of the paper is the numerical rating of the pick." Internal bond strength of paperboard (z- direction tensile) TAPPI 541 om-89 consists of applying two sided pressure-sensitive tape to both sides of the liner. The specimen is then placed between two platens and compressed in a uniform manner over the entire liner surface area. Equal tension is applied over the entire test area in a perpendicular direction to the plane of the sample (z-direction) to cause separation. This test is intended for paperboard which has internal fiber bond strength lower than the adhesive bond strength of the tape to the specimen or test platens. UM 403 (Scott Bond), UM 404 are other methods under TAPPI for bond.3 Good internal bond promotes better glue joints in ESD corrugated products, less edge cracking or score cracking and a reduction in quality problems. Some methods are shown in Table 9.

	Group 1	Group 1	Group 2	Group 3	Group 3	Group 4
ECT	50.35 Good	52.46 Good	56.29 Good	**33.00 Low**	46.27 Good	58.48 Good
Scott Bond 42# Liner Target 85	**60**/86 Very Low Scott Bond	**111/117 Good Bond**	123/**69** Side 2 Low	154/**82** Side 2 Slightly Low	**78/78** Internal Bond is Slightly Low	**75**/100 Low Scott Bond on Side 1
Basis Weight	121.43 42-26-42	125.88 42-30-42	133.59 42-36-42	111.09 33-33-33	124.34 42-26-42	146.81 54-26-54

Table 9

IV.d. Testing Comments

ESD Corrugated materials need to be tested on a level playing field. The size needs to be the same for evaluating performance characteristics of different commercial ESD corrugated materials. Measuring two boxes of the same material can produce various results if one box is made of C-Flute and the other is of a B-Flute construction. The additional air gap or space provided by C-Flute could improve static shielding (see Table 10). Using a liner which weighs 42 pounds per thousand square feet (basis weight is measured in pounds per thousand square feet MSF) may speed up the drain to ground value, while a 69 pound per MSF liner would slow down the drain time.) Slots or gaps in ESD corrugated containers should be minimized. Different materials need to be conditioned in the same environment for at least 48 hours. During the testing process measurements need to be taken in the same location. Relative humidities and temperatures need to be the same for materials being evaluated.

TYPE OF FLUTE IN CORRUGATED	FLUTES PER LENGTH (FT)	HEIGHT OF FLUTES (inch)
A	33+/-3	0.184
B	47+/-3	0.097
C	39+/-3	0.142
E	90+/-4	0.062
F	96+/-4	0.045

Table 10 FLUTE SIZING TO CONSIDER AIR GAP ON SHIELDING
Not including thickness of facings from the fiber box handbook, p. 109 (1992)

V. Environmental-Recyclability

The ability to recycle corrugated to be repulped into paper has diminished the use of the old foil laminated products. It is no longer acceptable in Tier Level 1 countries in Europe to receive easily disposed of at a recycling center. In this test, a large non-ESD Papermill who has several recycling centers employed a method of cutting ESD corrugated specimens into pieces where they were mixed with hot water in a high speed disintegrater (blender) and mixed for a five minute duration. This resulted in 1-1/2% solids and water. The mixture was poured through a screen to simulate the Fourdrinier or Cylinder making paper process and allowed to dry for evaluation. A paper technologist can determine from the hand sheets the acceptability of used paper for repulping. Note that as product is repeatedly recycled, the concern arises over shorter and shorter fiber lengths, which results in decreased mechanical strength. From strong, corrugated boxes, the recycling path often leads to weak, cereal type boxes and ultimately to paper products.

In examining the hand sheets (See Illustration 10), it appears that the ESD corrugated technologies are repulpable but not necessarily acceptable to all recycling centers. ESD corrugated should be acceptable to recycling centers that can bury the pulp in corrugated medium, tarpaper makers, gypsum board (drywall) and construction or colored paper. A cylinder machine makes liner that is built up in layers.

Illustration 10

This may prove a favorable center for recycling more difficult to ESD paper by hiding the product within the liner. If recycling paper is selling for $175.00per ton it would be economical to repulp versus a reduced rate of $45.00 per ton. Outthrows for box board cuttings or corrugated containers are materials that are undesirable and they shall not exceed 1% of prohibitive materials or 2%-5% of the entire batch to be recycled.

It is apparent that the acceptability of corrugated for recycling is on a case by case basis. Both carbon and metal are undesired. In addition, specialty liners that make paper drinking cups do not accept recycled content that would be favorable to a mill that makes liner for corrugated boxes.

CONCLUSION

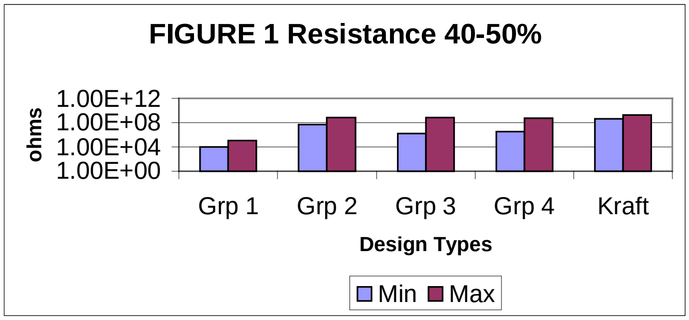
Most of the designs that were evaluated performed satisfactorily in all three testing phases. However, it was observed that a relationship exists between static shielding effectiveness and the conductivity of the shielding barrier. The metalized corrugated in Group 2 had the best static shielding. Group 3 results were excellent, followed by good results for Group 4. Group 1's performance appeared to be a potential concern since the conductivity average (Table VI) of 5.8 x 10^4 ohms represent close proximity to a 1.0 x 10^5 (low static shielding barrier) ohms reading. After experiments, two coats of ESD ink were needed to achieve a conductivity of less or equal to 1.0 x 10^3 ohms. Dissipative varnish is necessary to prevent rub off of the conductive ink coating (see Illustration 11). Future electrical testing methods, e.g. 11.32, are anticipated to aid in determining the effectiveness of design approaches.

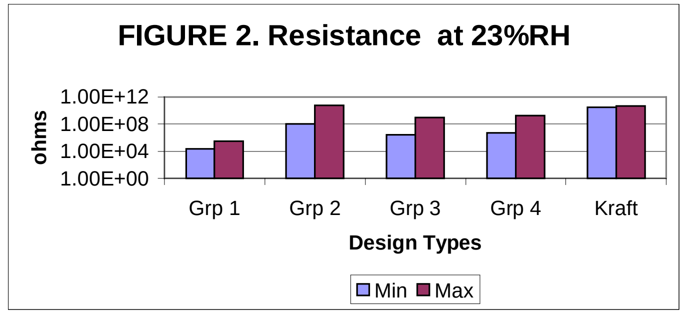
Illustration 11

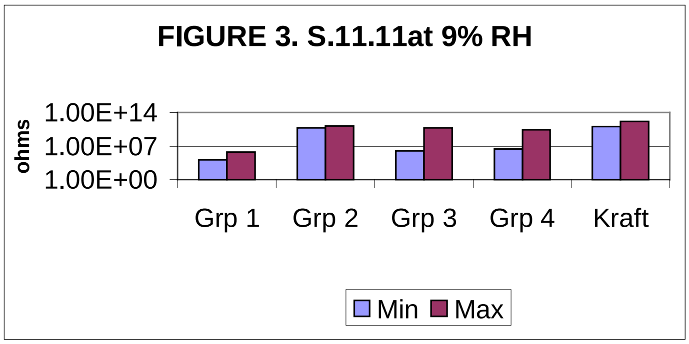
As the technology for coatings continues to improve, it is anticipated that more exciting, new stronger lighter weight ESD corrugated alternatives will be available in the future, and available for export. One novel method coats the liner before it is manufactured into corrugated sheets to improve coverage and maximize strength. If sheets are coated, the flute structure can be compromised or crushed during coating. This method could represent up to a 15%-20% loss of compression strength. Environmental awareness is on the rise and will continue to receive increasing focus. Packaging materials in particular are gaining more and more attention around the world, as evidenced by "take back" requirements and the like.

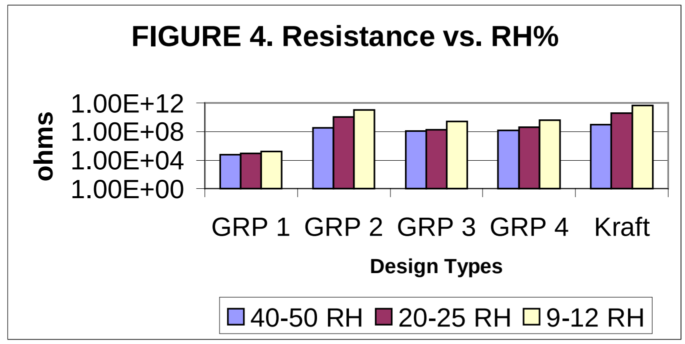
Future studies should review more samples from more design types with a focus on new coating methods. The use of thermoforming in conjunction with corrugated materials should likewise receive attention. More testing should be performed at lower humidities.

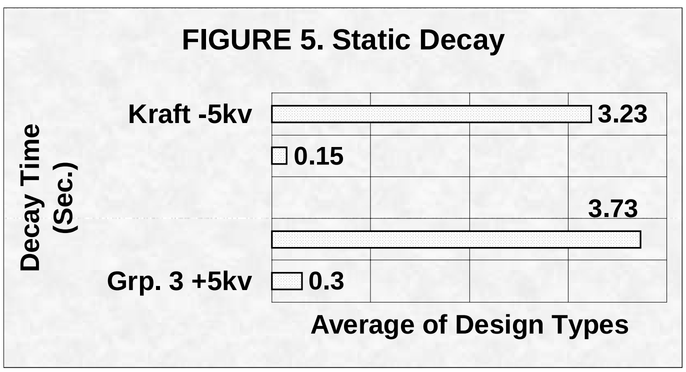
The ESD engineer should play a key role in the design and manufacturing of effective ESD corrugated packaging. He should also be aware of the various technologies available in the market today, plus be able to determine what course of action to take for his organization. Lastly, he should understand what precautions to take to avoid potential problems and to optimize ESD protective packaging efforts.

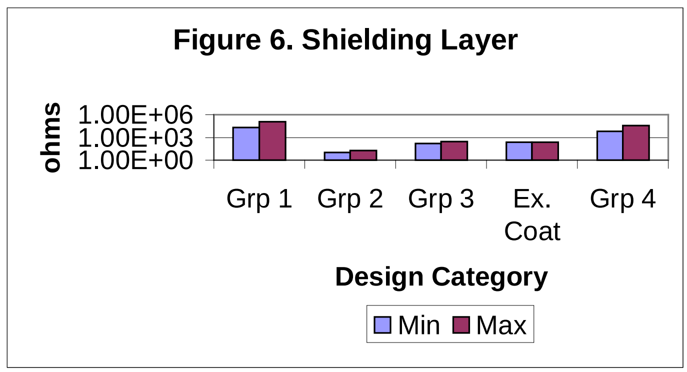


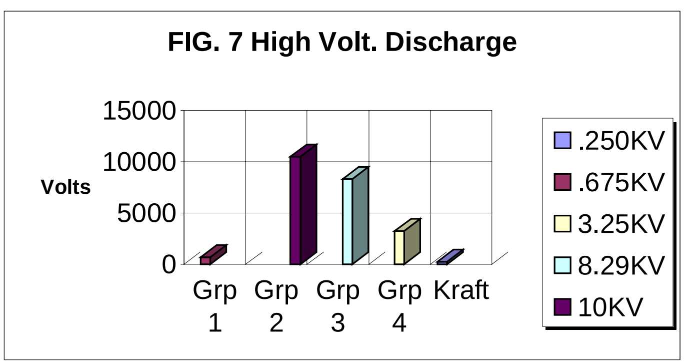


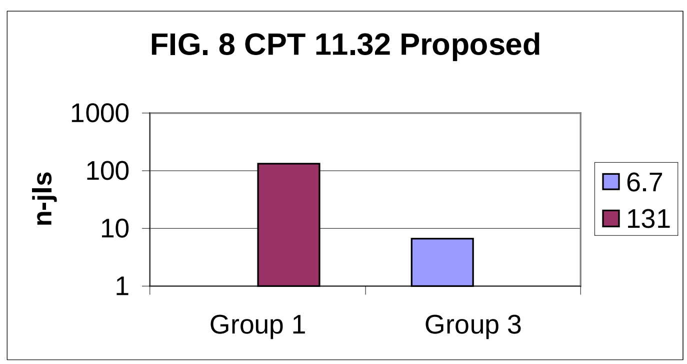












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