WHITE PAPER

Packaging for ESD-Sensitive Components

A buyer's guide to resistivity grades, materials, design, and verification for static-controlled packaging

Published by

Kiva Container Corporation

Anaheim, California | Founded 1986 | ESD Since the 1990s

AS9100D | ISO 9001:2015 | Women-Owned

www.kivacontainer.com

Executive Summary

ESD packaging fails differently from regular packaging. The tote does not break. The component inside breaks, often days or weeks after the event, often without any visible damage at all. By the time the field returns come back, the lot number is gone, the operator who handled it has moved on, and the packaging has been disposed of. Most ESD damage is silent, latent, and untraceable.

This paper is for the packaging engineer or buyer specifying packaging for static-sensitive components: avionics, medical devices, automotive electronics, defense electronics, semiconductor handling, or any program where the part inside contains active silicon. It covers what ESD damage actually looks like, the resistivity scale that defines protection, the packaging types and materials that work in production, the common design mistakes that compromise ESD protection without anyone noticing, and the verification protocols that prove the spec is being met.

The short version: ESD packaging is not "anti-static." It is a defined material system with measurable surface and volume resistivity. If the program is not specifying resistivity in ohms and verifying it with a meter, the packaging is decorative.

1. What ESD Damage Actually Looks Like

Electrostatic discharge damages components in three patterns. Catastrophic failure is the obvious one. Latent failure is the dangerous one. Parametric drift is the silent one.

Catastrophic Failure

The component dies. The board fails functional test. The failure is traceable to the lot and the handling event. Quality flags it, the program absorbs the cost, and the corrective action targets the responsible step. This is the rare case and the easy one to manage. Catastrophic failures account for a minority of ESD-related field returns.

Latent Failure

The discharge weakens the component without killing it. The board passes test. The product ships. The component fails in the field, sometimes hours later, sometimes years later. The lot is gone, the handler is gone, the packaging is gone. The warranty claim shows up with no traceable cause and no clear corrective action.

Latent failures are where the cost concentrates. A single mis-handled batch of semiconductors can poison three months of field returns. The packaging program that prevents the event saves the company an order of magnitude more than it costs.

Parametric Drift

The component continues to function within spec but drifts toward the edge. Some pass, some fail, no clear pattern. The yield slowly degrades. The program never connects the yield problem back to packaging because the dots are too far apart in time. This is the most expensive ESD damage mode because it never resolves into a clear root cause.

> *The point of ESD packaging is not to prevent the discharge you see. It is to prevent the ones you do not see, which is most of them.*

2. The Resistivity Scale

ESD protection lives on a scale of surface resistivity, measured in ohms per square. The scale runs four orders of magnitude, and the difference between two adjacent categories is a factor of one thousand or more. "ESD packaging" without a resistivity number is meaningless.

Category	Surface resistivity (ohms / square)	What it does
Insulative	Above 1E12	Builds and holds charge. Standard polypropylene, polyethylene, untreated cardboard. The default state of most plastic until something is done to it.
Antistatic	1E9 to 1E12	Does not generate charge through tribocharging (friction). Does not drain charge well. Useful for parts that pass through ESD zones but should not be the primary protection grade for sensitive components.
Static-dissipative	1E5 to 1E9	Drains charge slowly enough to prevent discharge events without creating a hard short. The default ESD grade for board-level and component handling.
Conductive	Below 1E5	Drains charge immediately. Used for higher-sensitivity components, shielding applications, and bare die handling. More expensive per square foot than dissipative material.

The right grade depends on component sensitivity. For most board-level handling, static-dissipative is the spec. For bare die, sensitive RF components, and military-grade electronics, conductive is the spec. For non-electronic parts that just pass through ESD-controlled zones, antistatic is enough.

> *The most common spec mistake is using "antistatic" when the program actually needs "static-dissipative." Antistatic material does not drain charge. It only avoids generating new charge through friction. A component handed off in an antistatic-only tote can still be discharged by the operator, the bench, or the next handling step. Static-dissipative drains the charge. Antistatic prevents the generation. They are different protections for different problems.*

3. ESD Packaging Types

Four packaging types cover the majority of ESD applications. The decision among them comes down to geometry, cycle count, and the resistivity category the program requires.

Packaging type	Typical use	Construction at Kiva
Static-dissipative corrugated plastic totes and dunnage	Component and board handling, returnable totes, dividers, ESD shippers	Static-dissipative twin-wall polypropylene, 2mm to 10mm gauge, die-cut or sonic welded. Surface-treated or volume-loaded grades available.
ESD thermoformed trays and clamshells	Inline production handling, JEDEC trays, sensor cradles, surface-critical part dunnage	Static-dissipative ABS, polycarbonate, PETG, or PVC, 0.015 to 0.300 inch gauge, thermoformed on Kiva's sheet-fed lines.
Conductive corrugated and sheet	Bare die, high-sensitivity components, shielding applications, military electronics	Carbon-loaded volume-conductive material, available in corrugated and sheet form. Resistivity below 1E5 ohms.
Shielded bags and pouches	Moisture-sensitive devices, tape-and-reel, IC shipment	Not fabricated at Kiva (metallized film is a separate category). Most programs pair Kiva ESD totes with shielded inner bags.

Most reusable ESD programs combine two of these in a single shipment. The outer tote is static-dissipative corrugated plastic. The inner cradle is ESD thermoformed sheet sized to the component. For moisture-sensitive devices, a shielded bag goes inside the cradle. The whole stack ties back to the bench grounding path during handling.

4. Materials: Surface-Treated Versus Volume-Loaded

Static-dissipative and conductive properties exist in two forms. The difference matters more than most buyers realize.

Surface-Treated Material

The ESD-active additive is coated on the surface of the sheet. The treatment works well at first. Over time, the coating wears off through abrasion, washing, solvent contact, or simple aging. Programs that wash totes, run them through automated systems, or expose them to industrial chemicals will see the surface treatment degrade within months to a year, depending on conditions.

Surface-treated material is appropriate for medium-cycle programs in controlled environments and for cost-sensitive applications where the program can re-verify or replace material periodically. It is not appropriate for high-cycle programs without periodic re-testing.

Volume-Loaded Material

The ESD additive is distributed throughout the polymer during manufacturing. The resistivity properties persist for the life of the material. Volume-loaded sheet costs more per square foot than surface-treated, but it holds spec under washing, abrasion, and aging without degrading.

For high-cycle programs (hundreds of trips per part), automated handling environments, washed totes, and any application where the buyer wants to set the program and not chase verification, volume-loaded is the right material. The cost premium pays back through the program life.

> *Both grades need periodic verification regardless of which is specified. A surface-treated material that was never tested after receipt and a volume-loaded material that was tested once and assumed forever both fail the same way: they drift out of spec and nobody knows.*

5. Five Design Mistakes That Compromise ESD Protection

Five mistakes account for most of the ESD failures that trace back to packaging.

- Specifying "antistatic" when the program needs "static-dissipative." Different grades, different protection level. Spec the resistivity band in ohms, not the marketing word.
- Mixing ESD and non-ESD materials in the same handling step. An ESD tote with a standard polyethylene bag inside is not ESD protection. A dissipative tray on a non-grounded bench is not ESD protection. The pathway has to be continuous from packaging to bench to operator to ground.
- Forgetting the grounding path. ESD packaging drains charge to ground. If the rack, the bench, or the operator's wrist strap is not connected to ground, the charge has nowhere to go and the packaging is decorative.
- Relying on surface-treated material for high-cycle programs. Wash cycles, abrasion, and solvent contact degrade the treatment. Programs that wash totes routinely should spec volume-loaded material from the start.
- Not testing after spec. ESD properties drift over the life of the material. A program that tests at receipt and never again is making assumptions. Periodic verification with a resistivity meter is part of the ESD control program required by ANSI/ESD S20.20.

6. ESD Across Industries

The ESD materials are similar across industries. The combination requirements change. ESD almost always sits inside a stack of other specs, and that stack is what makes one program different from another.

Electronics Manufacturing

Standard ESD program. Static-dissipative totes for components, dunnage for boards, trays for finished assemblies. Wrist straps, mats, and packaging are all part of an ANSI/ESD S20.20 control program. The packaging vendor delivers material that meets the resistivity spec and supplies the documentation to prove it.

Aerospace Avionics

ESD plus AS9100D plus traceability. Material certs on every lot, conformity documentation with every shipment, lot trace through the program life. The combination raises the bar on documentation more than on materials. The materials are the same dissipative grades. The paper trail is what changes.

Automotive Electronics

ESD plus AIAG packaging standards. Returnable totes that survive automotive supply chain handling, fit the assembly line, and hold geometry through cycle counts in the thousands. The shift toward electric vehicles has multiplied the electronics content in every car, which has multiplied the demand for ESD-protected returnable packaging across Tier 1 and Tier 2 automotive suppliers.

Medical Devices

ESD plus cleanroom-compatible material plus, often, FDA grade. Static-dissipative sheet that meets cleanroom particulate shed and outgassing requirements. Material certifications that satisfy ISO 13485 customers even when the packaging vendor is operating under ISO 9001.

Defense Electronics

ESD plus MIL-PRF-81705 (military ESD packaging materials specification) plus MIL-STD-1686 (military ESD control program) plus ITAR-controlled drawing handling. The most stringent combination. US-based fabrication, single-facility production, and verified material certs all matter more here than anywhere else.

7. Testing and Verification

ESD packaging requires verification, not just specification. The verification protocols come from ANSI/ESD S20.20 and the related ESD Association test methods. The basics are:

- Surface resistivity measured with a two-point probe, expressed in ohms per square. The primary test for dissipative and conductive materials.
- Volume resistivity measured through the material thickness, expressed in ohm-meters. Used for volume-loaded materials and for any program that needs to verify properties below the surface.

- Charge decay time measured from an applied voltage to a defined fraction (typically 10 percent), expressed in seconds. Confirms that the material is actively draining charge, not just measuring as low-resistivity.
- Walking test for floor and table materials, measuring the voltage generated by a person walking on the surface.

The program sets the verification cadence based on the material type, the cycle count, and the operating environment. Volume-loaded materials need less frequent re-test than surface-treated. High-cycle programs need more frequent re-test. Programs with washing, solvent exposure, or abrasive handling need re-test after the relevant process step.

> *Documentation belongs in the ESD control program. AS9100D and ISO 9001 customers will expect it during supplier audits. Customers running formal ANSI/ESD S20.20 compliance will require it. Packaging that arrives with material certs but no in-service re-test plan is not a complete program.*

8. What to Send a Vendor for an ESD RFQ

ESD adds three to four lines to a standard packaging RFQ. The most important is the resistivity spec by number, not by name.

1	**Resistivity grade.** Antistatic, static-dissipative (1E5 to 1E9 ohms), or conductive (below 1E5 ohms). Spec by resistivity, not by marketing term.
2	**Surface-treated or volume-loaded.** Surface-treated for medium-cycle programs. Volume-loaded for high-cycle, washed, or abrasive environments.
3	**Part drawing or 3D file.** STEP or IGES preferred. Include the contact surface and any grounding-tab locations.
4	**Geometry.** Tote, dunnage, divider, tray, clamshell, or assembled enclosure. The geometry drives material and process.
5	**Volume and cycle count.** Annual usage and expected program life. Cycle count drives material selection between surface-treated and volume-loaded.
6	**Combination requirements.** Cleanroom class, FDA grade, AS9100D documentation, AIAG standards, MIL-PRF-81705. ESD almost always sits inside a stack of other requirements.
7	**Verification requirements.** Surface resistivity testing at receipt, periodic re-test cadence, documentation format. Per ANSI/ESD S20.20 if applicable.
8	**Identification and marking.** ESD warning markings, lot trace, color coding (typically pink for dissipative, black for conductive).
9	**Hardware and grounding.** Grounding tabs, conductive snaps, integrated grounding paths if

	the packaging is part of a bench-to-ground continuity path.
10	**Lead time target.** First-article date and production ramp. ESD material grades have their own stocking realities.

> *If the buyer is not sure which resistivity grade the part needs, send the part spec or the customer flow-down. A capable vendor can recommend the grade based on the component sensitivity and the handling environment. Do not let the spec default to "ESD" without a number.*

About Kiva Container Corporation

Kiva Container Corporation is a custom thermoforming and corrugated plastic shop in Anaheim, California. Founded in 1986. ESD and conductive materials in production since the 1990s. AS9100D and ISO 9001:2015 certified. Women-owned. All design, tooling, and production in-house at a single facility.

ESD CAPABILITIES

- Static-dissipative corrugated polypropylene, 2mm to 10mm gauge, in surface-treated and volume-loaded grades
- ESD thermoformed sheet in ABS, polycarbonate, PETG, and PVC, gauge 0.015 to 0.300 inch
- Conductive corrugated and sheet for high-sensitivity programs
- Pioneer flatbed die-cutter (78 by 150 inch) and Gerber M3000 turbo router (75 by 120 inch) for ESD totes and dividers
- 4 sheet-fed thermoformers (max 46 by 54 inch) for ESD trays, cradles, and clamshells
- Sonic welding, proprietary flat welding, and wire bending for ESD tote assembly and high-cycle reinforcement
- In-house screen and digital printing for ESD warning markings, lot trace, and color coding
- Material certs and lot traceability as part of the AS9100D and ISO 9001:2015 quality system
- 30 plus years of ESD program experience across aerospace, medical, electronics, automotive, and defense

Most ESD customers are buyers and packaging engineers running programs that already have a control plan and need a vendor who understands the spec stack: ESD plus AS9100D plus cleanroom plus AIAG plus MIL standards. The combination is where the engineering work happens.

> *Have an ESD program coming up? Send the part drawing, the resistivity requirement (ohms per square), and any customer-specific quality clauses. We will recommend the right grade and the right construction before we quote, and we will tell you if the program needs something we do not run.*