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ESD Protection

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HOW TO SELECT THE RIGHT GLOVES FOR ESD PROTECTION IN YOUR CLEANROOM

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Abstract

In a cleanroom environment, the consequences of uncontrolled electrostatic discharge can be quite serious, ranging from potential damage to electronic components in semiconductors and medical devices to injuries to personnel from electrostatic shock and ignition of flammable gases, liquids or other materials. Static electricity can also attract contaminants or cause products to stick together in clean environments, such as pharmaceutical manufacturing. The cost of ESD-damaged electronic devices can be anywhere from a few cents to several hundred dollars.

For these reasons, it's essential to do what is necessary to mitigate potential ESD risks. Electrostatic Dissipative Cleanroom gloves provide protection against both product and process contamination. These gloves reduce the impact of the buildup and release of static electricity, these gloves are a critical line of defense to help reduce static electrical release to protect electrostatic-sensitive devices, electronics or semiconductors being handled by a technician. There are a lot of claims in the marketplace touting the benefits of cleanroom ESD gloves, making it difficult to determine the best glove for your environment. This white paper provides guidance for purchasers and users of cleanroom gloves used in manufacturing semiconductors, electronics, medical devices and pharmaceuticals to select the best gloves for the application including the best test methods for evaluating ESD glove performance under circumstances that represent real-world conditions.

IF YOU'VE EVER WALKED ACROSS A RUG OR CARPETING AND TOUCHED A METAL OBJECT TO RECEIVE A MILD SHOCK, YOU'VE EXPERIENCED AN ELECTROSTATIC DISCHARGE, OR ESD. IT'S AN UNCOMFORTABLE FEELING BUT GENERALLY NOTHING MORE.

However, in a cleanroom environment, the consequences of uncontrolled ESD can be quite serious. This can include damage to electronic components in semiconductors and medical devices, injuries to personnel from electrostatic shock, and ignition of flammable gases, liquids, or other materials. That's why it's essential to ensure that all personnel, tools, and equipment are grounded. This allows for any built-up static electrical charge to safely dissipate into the earth or ground, removing or reducing excess charge by transferring it directly between the object and earth. The cost of ESD-damaged electronic devices ranges from a few cents for a simple diode to several hundred dollars for complex circuit boards that combine different types of circuit technologies onto a single substrate, according to the ESD Association. When you add up the costs of repair and rework, shipping, labor and overhead, reducing losses from ESD becomes imperative.

All of this is more important than ever today with the renewed focus on global semiconductor production via the CHIPS and Science Act in the U.S. along with similar initiatives around the globe. With this expansion, there will likely be more facilities and more potential ESD risks, making it essential to understand ESD and institute safe practices to prevent damage during manufacturing.

Additionally, static electricity can impact cleanroom manufacturing in other industries. Static buildup and ESD can also attract contaminants causing them to stick to products that are being processed within clean environments, which can result in cross contamination or unwanted personnel exposure during pharmaceutical manufacturing.

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Two Main Pathways

ESD events occur when three steps happen in sequence – charge generation, charge accumulation, and rapid discharge – via two main pathways:

1. **Charged Device Model (CDM)** – *Discharge from an ESD-Sensitive Device.* When an electrical charge is transferred from one piece of equipment to another that contains a different voltage potential (e.g., negative vs. positive), an ESD event can occur.

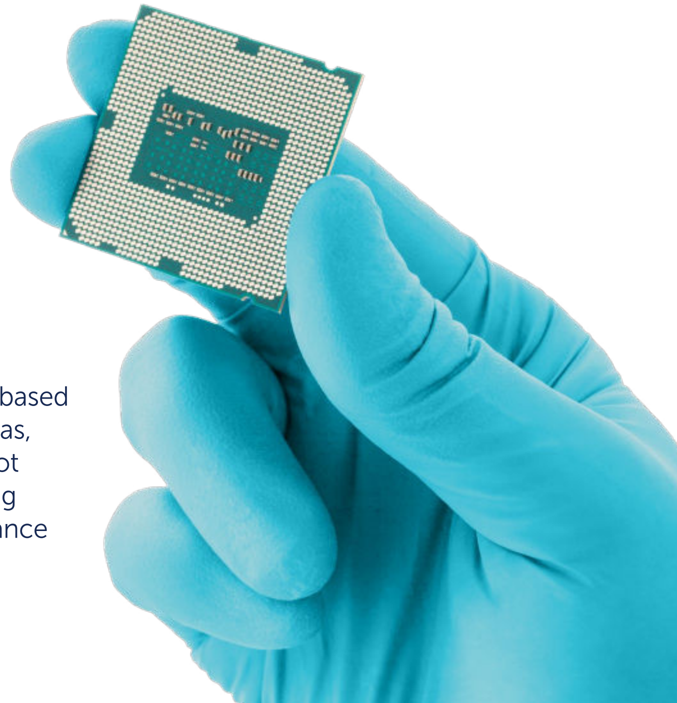
When the equipment is not effectively grounded, this may cause significant damage to the electronic device because the discharge from CDM is an extremely quick and uncontrolled voltage drop. Despite the quick movement of charge, this event occurs at a higher current than other "models," which can lead to even more damage.

2. **Human Body Model (HBM)** – *Discharge to an ESD-Sensitive Device.* This generally occurs from static electricity that is transferred through human actions and/or friction from automated manufacturing equipment. It can be as simple as someone handling plastic packaging and accumulating a charge.

When the person carrying a charge touches an ESD sensitive object, an ESD event can occur resulting in uncontrolled electrical discharge directly to the sensitive item.

Any movement of equipment or people in a cleanroom can lead to the generation of friction or static. Although the charge that is generated can be relatively small and go unnoticed by the users, the damage can range from total failure to latent damage that will affect the integrity of a component or equipment over time. Different components can handle varying amounts of voltage before experiencing damage. As a result, components and devices are grouped under different sensitivity classes. For example, components that fall under the most sensitive class, Class 0, can only withstand voltages <250 volts for either HBM or CDM. These devices are highly susceptible to damage from smaller electronic discharge events. For example, lower current and even a minor static shock from a person could cause damage.

RESISTANCE IS A MEASUREMENT IN "OHMS (Ω)" WHEREAS RESISTIVITY IS REPORTED IN "OHMS-METER (Ω*M)".



In terms of measurement, one of the main ESD properties is resistance. This quantifies the level of opposition to the flow of current, indicating how easily a static charge can move through a material. Often, resistance and resistivity are used interchangeably by mistake.

Based on various test methods described below, resistance is measured based on the size and shape of the tested material i.e. cleanroom glove. Whereas, resistivity is a calculated property that is inherent to the material and is not representative of the size/shape of the cleanroom glove. When evaluating ESD performance of cleanroom gloves, it is important to consider resistance (versus resistivity) because ANSI guidance and other test method requirements classify in this way.

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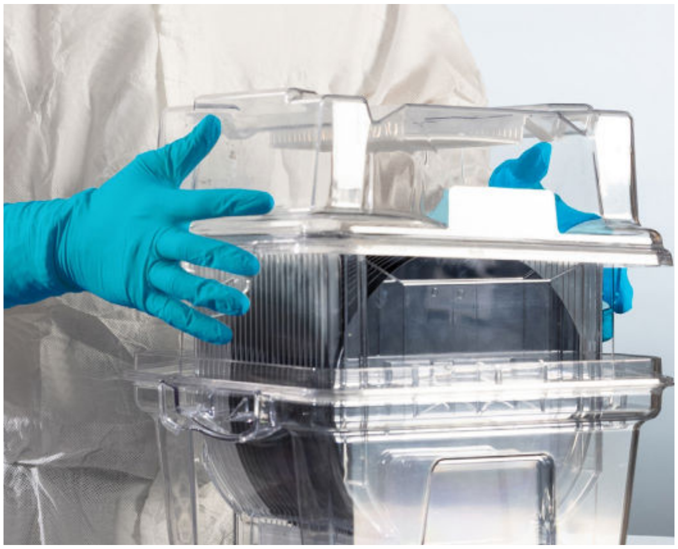
The Importance of Gloves for ESD Protection

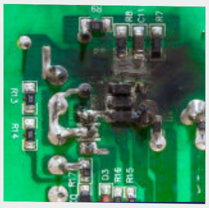


The primary goal of all cleanroom gloves is to provide protection against product and process contamination. Cleanroom gloves that protect against ESD are made with specialized materials that reduce the impact of the buildup and release of static electricity. They are a critical line of defense to help reduce static electrical release to protect electrostatic-sensitive devices, electronics or semiconductors being handled by a technician.

There are several reasons why gloves are needed in these environments:

- People are a source and conductor of static electricity.
- Electrostatic discharge is different from normal current or electricity and must be addressed differently as a result.
- People are also a source of contamination. Gloves help protect against the risks posed by cleanroom personnel.
- Gloves act as a system with the user's hands, wrist straps, and other protective apparel to dissipate any charge buildup when someone is working with their hands.
- Different types of materials respond to electrostatic discharge in different ways, and consideration of the ESD-sensitive application in parallel with materials within the process is critical.

ESD protection with cleanroom gloves occurs in one three ways:



Conductive. Conductive materials have a low electrical resistance, allowing electrons to flow easily across the surface or through these materials. The ease of movement allows charges to go to the ground or to another conductive object that the material contacts. The higher current flow through conductive material facilitates more rapid and potentially disruptive discharge to the ground and may increase the probability of an electrostatic discharge rather than prevent it.

Dissipative. This is our recommendation for ESD protection for cleanroom gloves. After a charge build-up occurs, dissipative materials have better control during release and allow the charges to flow to the ground in a more controlled, direct manner than with conductive or insulative materials. It is safer compared to conductive responses because it facilitates a slower and direct discharge to ground at a lower current level.

Insulative. Insulative materials have a high electrical resistance, which means they prevent or limit the flow of electrons across their surface or through these materials. However, insulative materials tend to be more difficult to ground. Therefore, they present challenges during ESD events as static charges cannot move to ground quickly and can remain in place on these materials or where the charge was generated for a longer time, posing an extended ESD risk.

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For most cleanroom applications, it is recommended that cleanroom gloves should be “dissipative” and evaluated to a resistance level of <1x101^{1} Ω. This guidance is based on ANSI/ESD S541 (see table below). In some instances where applications consist of highly ESD-sensitive devices (Class 0 at +/- 250 volts), it may be appropriate to pursue cleanroom gloves with an even lower resistance performance level i.e. 1x10^{9} Ω.

Figure 3: Resistance Classifications

Designation		Resistance (ohms)	Exponent Format
Conductive **$< 1 \times 10^4$**		10 100 1,000	10^1 10^2 10^3
Dissipative **$\geq 1 \times 10^4$ to $< 1 \times 10^{11}$**		10,000 100,000 1,000,000 10,000,000 100,000,000 1,000,000,000 10,000,000,000	10^4 10^5 10^6 10^7 10^8 10^9 10^{10}
Insulative **$\geq 1 \times 10^{11}$**		100,000,000,000	10^{11}

Even with this information, determining which glove to buy or use in your process can be a challenge. A key step in selecting Electrostatic Dissipative cleanroom gloves is to evaluate how they are tested, how they perform in these tests, and how these results align with the sensitivity of the ESD-sensitive devices in your process.

Which test method is best for you?

There are several different standards that recommend varying test methods to evaluate the ESD performance of cleanroom gloves. The following are some of the most commonly used:

ANSI/ESD STM 15.1

For the Protection of Electrostatic Discharge Susceptible Items - Methods for Resistance Testing of Gloves and Finger Cots

ANSI ESD ASSOCIATION

EN 1149

Protective Clothing - Electrostatic Properties

EN 1149

EN 16350

Protective Gloves - Electrostatic Properties

EN 16350

These standards differ in scope, requirements/limits, test methodology, and environmental conditions. It is important to consider the test type and results when evaluating compatibility of cleanroom gloves with the sensitivity of your process. Depending on the test method, the performance may be quantified based on different properties, such as surface resistance, volume resistance, in-use resistance, charge decay, and/or voltage generation, which may lead to different considerations for your process and risk assessments.

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Industry-Accepted Test Methods for ESD Properties and Performance

	ANSI/ESD STM15.1	EN 1149	EN 16350
Scope	Test procedures for measuring the intrinsic electrical resistance of gloves, as well as their electrical resistance together with personnel as a system. The system test provides data that is relevant to the user's specific environment and application.	Test method for materials intended to be used in the manufacturing of electrostatic dissipative protective clothing (or gloves) to avoid incendiary discharge	Provides requirements for protective gloves that are worn in areas where flammable or explosive areas exist; Electrostatic dissipative protective gloves to minimize explosion risks
Test Conditions	Low Humidity Environment - Relative Humidity: 12% Moderate Humidity Environment - Relative Humidity: 50%	Relative Humidity: 25%	Relative Humidity: 25%
Precondition	48 Hours	24 Hours	48 Hours
Intrinsic (Preliminary) Tests	ANSI/ESD STM 11.11 - Surface Resistance Measurement ANSI/ESD STM 11.12 - Volume Resistance Measurement	N/A	N/A
Main Test	In-Use Testing using CAFE Fixture (ANSI/ESD STM15.1) Users wear grounding wrist strap	Options: EN 1149-1 - Surface Resistance Measurement EN 1149-2 - Vertical (Volume) Resistance Measurement EN 1149-3 - Charge Decay	EN 1149-2 - Vertical (Volume) Resistance Measurement
Requirement	N/A; Industry experts refer to ANSI/ESD S541	Per EN 1149-5, an electrostatic dissipative material shall meet at least one of the following requirements: 1. Half Decay Time (t50) < 4 seconds 2. Shielding Factor (S) < 0.2 3. Surface Resistance ≤ 2.5 x 109 Ω	Electrostatic dissipative protective gloves Vertical Resistance: <1,0 x 108 Ω

Note (based on ANSI/ESD STM15.1 Annex B guidance): Many styles of gloves rely on moisture to provide the electrical connection to the person. These types of gloves are known to have a measurement greater than 1.0 x 1011 ohms during the intrinsic resistance tests, but when testing as a system, the resistance reading will be less than 1.0 x 109 ohms. Therefore, the intrinsic resistance test does not always provide correct information for how the gloves will perform as part of a system. Nitrile gloves, for example, rely on the hydration that occurs once placed on the hand/finger of the operator.

Cleanroom glove ESD testing solely based surface and/or volume resistance does not take into account the key influence of the user, in terms of the skin/glove interaction and the usage of a grounded wrist strap. Although surface and/or volume resistance testing may be useful for comparison's sake, in-use ESD testing as described in ANSI/ESD STM15.1 is necessary to fully characterize ESD performance of cleanroom gloves to simulate real-life application performance.

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Other Considerations

Humidity and temperature conditions should be considered when evaluating electrostatic dissipative cleanroom gloves and their ESD test data. Environmental conditions (temperature, humidity, etc.) are specified by test methods/standards during the conditioning and testing of the gloves. During testing and normal in-use, these factors have implications for how static charge is dissipated through the system.

Test methods are developed to evaluate ESD performance at "worst-case" conditions, such as at low humidity, where discharge occurs at higher voltages and the dissipation of charge is slowest. For example, a routine task like moving a polybag on the workbench can generate ten times more charge, in terms of voltage, in a low humidity environment (10-25% RH) vs. standard humidity (>50% RH). Although standard cleanroom manufacturing processes may operate at standard conditions (23ºC and 50% RH), testing at conditions specified by test standards can account for fluctuations and environmental control equipment failures. Glove manufacturers and suppliers should provide test data and test conditions to provide a full picture of the ESD performance of cleanroom gloves.

Another important factor to consider is the balance of cleanliness (particulate count, ionic content, and other non-volatile residue) with the ESD performance of cleanroom gloves. The cleanliness, specifically ionic content, and charge dissipation properties of cleanroom gloves tend to be inversely related. Ionic content residue on the cleanroom glove surface can act as conductive particles. When a charge buildup occurs on the cleanroom glove surface, the ionic content can facilitate charge dissipation across the glove surface to the ground. Therefore, "cleaner" gloves with less ionic content can have lower ESD protection.

Conclusion

There are a lot of claims in the marketplace touting the benefits of ESD protective cleanroom gloves, making it difficult to determine the best glove for your environment. To cut through the clutter, consider the sensitivity of your devices and partner with a vendor or manufacturer who takes these things into consideration so you can select the best gloves for your application. Overall, gloves that have resistance levels <1x1011 Ω are considered dissipative, but for more sensitive devices, there are situations where resistance levels <1x109 Ω would be more suitable.

Last, it's important to keep in mind that ESD presents a danger even at small levels. The goal of cleanroom gloves is to minimize contamination and help dissipate charge buildup. Remember that gloves work as a system with hands, wrist straps, apparel, and environmental conditions, such as humidity. That's why it's essential to ensure the appropriate test methods are followed and take into account the necessary considerations based on your application. All of this must be factored into the cleanroom glove selection process to mitigate ESD levels large and small. By choosing wisely, you can help protect your products and process.

For more information or samples, contact your distributor or visit: **www.purezerogloves.com**

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