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Electrostatic Discharge (ESD) Audits

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Electrostatic Discharge (ESD) Audits

Contents

1. General

1.1 Purpose of Electrostatic Discharge Audit

The purpose of an Electrostatic Discharge (ESD) Audit or survey is to alert telecommunications management of the ESD hazards in their facilities, so that immediate steps can be taken to prevent equipment upset or damage from ESD. Millions of dollars are lost each year because of electromagnetic interference (EMI) and or ESD upset or damage. This loss may be in the form of lost time, loss of connection, loss of data, shocks to personnel, or actual equipment hard failure. An ESD audit, as described in this document, will give each facility a comprehensive report of the strengths and weaknesses of their existing ESD control procedures, and recommend ways to improve them.

This document describes Bellcore's view of the procedures needed to complete ESD audits or surveys of equipment facilities, construction or assembly areas, installation and maintenance facilities, or storage facilities and the associated materials and handling in these areas. A facility is defined as any location where electronic systems comprised of electronic circuit boards are deployed, assembled, handled, packaged, scanned, stored, or utilized. Examples of these facilities are telecommunications central offices, customer premises, data centers, outside plant facilities including maintenance centers, Controlled Environment Vaults (CEVs), huts, or cabinets, and warehouses or storage areas of any size. Vehicles and containers used for transport, installation, and maintenance of systems and circuit board assemblies are also subject to ESD audits.

See for reference BR 010-170-005,[1] *Quality and Reliability - Electrostatic Discharge.* This practice describes the origin and nature of ESD and sets forth measures to minimize its probability.

Sections 2 through 16 contain all the tools and instructions to complete a facility ESD audit. Although this document is designed for telecommunication facilities, the scope covers an ESD audit of any location where electrostatic discharge sensitive (ESDS) electronic systems, assemblies, devices are manufactured, handled, transported, stored, or used. Appendix A is a sample work sheet that could be used to complete an audit or survey of a facility. Appendix B is a sample comprehensive checklist of required corrections that a facility should attain to realize ESD control compliance.

1.2 Description of Audit

This document provides the instructions for personnel to complete ESD audits of any facility where ESDS systems, circuit card assemblies (circuit packs), or devices are handled, transported, stored, or used.

The general attributes of an ESD audit are contained below, however users may modify any of these to suit their particular use. It is suggested that audits include the following areas of inspection:

1. General observations of the facility and personnel for ESD control procedures, tools, and habits.
2. That personnel have received training in the use of ESD controls and procedures in their specific work area.
3. Availability and knowledge of the use of ESD control items such as wrist straps and wrist strap testers that meet Bellcore generic requirements.
4. Availability and use of ESD workstations, meeting Bellcore generic requirements, where ESDS circuit card assemblies or devices are handled out of their protective packaging.
5. That all non-essential static generating materials are removed from the workplace and that static generators such as computer monitors are shielded.
6. The use of ESD floor covering, floor finishes, and footwear that meet Bellcore generic requirements.
7. That ESD packaging used in the handling, transport, storage of electrostatic discharge sensitive electronic devices, circuit card assemblies, and systems conforms to Bellcore generic requirements for these items.
8. That the facility has ESD warning signs arranged in strategic places to be observed by all personnel entering these static safe areas.
9. There is documentation of the condition of all ESD control items and procedures and that this documentation is current.
10. Periodic reports are made to management by site coordinators, auditors, and the ESD control team, of the status of current ESD control programs in facilities.

1.3 Application of Audit

This document applies to all facilities where ESDS devices, assembles, or systems that are handled, transported, stored, or used.

2. Wrist Strap Testers

2.1 Wrist Strap Tester and Calibration Tests

Verify that an approved wrist strap tester is in good working condition and passes the appropriate calibration tests. Use GR-1418-CORE,[2] *Generic Requirements for Wrist-Strap Testers* as a reference.

2.2 Wrist Strap Tester Serialized

Verify that the wrist strap tester has a test set identification number or equivalent attached.

2.3 Wrist Strap Tester Calibration Label

Verify that the wrist strap tester has a calibration label attached, indicating its calibration interval and date of next calibration along with the last calibration date.

2.4 Wrist Strap Tester Calibration Interval

Verify that the wrist strap tester is calibrated on or before the expiration of the calibration due date.

3. ESD Protective Wrist Straps

3.1 ESD Protective Wrist Strap Assembly Resistance

Verify the integrity of the ESD protective wrist strap assembly and cord with a wrist strap tester that meets Bellcore generic requirements. The wrist strap assembly should be plugged directly into an ungrounded wrist strap tester. This ensures that the wrist strap assembly is tested, and not an alternate path to ground. Make sure that the person is wearing the wrist strap and has one hand placed on the test point.

Verify proper wrist strap assembly resistance, and verify that there are no intermittent failures. Stress the cord from side to side, up and down, and extend it to its full length; be careful that you do not apply undue force. A steady green light on the wrist strap tester indicates proper resistance. The recommended window is between 750 kilohms and 10 megohms ± 10%, from fingertip to meter.

NOTE The above testing is intended to reveal only electrical failures in the wrist strap assembly; failures due to improper use (or personnel improperly grounded) are addressed in Section 12, "Personnel Checks."

3.2 Intermittent Cord Verified with a VOM

In most cases, a wrist strap tester provides a solid indication of failure. If you are unable to receive a continuous faulty reading with a wrist strap tester, verify the failure with a volt-ohm-meter (VOM).

3.3 Wrist Strap Cuff Snap Condition

Verify that the wrist strap cuff snap is mechanically sound. Verify that the snap is attached to the wrist strap, and then pull the cord at the snap fastener. The wrist strap cuff snap should hold against forces encountered during normal use. (See GR-1422-CORE,[3] *Generic Requirements for ESD Controlling Wrist-Straps*, which specifies 1 to 5 pounds.)

3.4 Wrist Strap Cuff Condition

Verify that the wrist strap cuff shows no evidence of undue wear. Its elasticity should be such that the cuff fits the person's wrist snugly and does not break contact with the operator's skin. Verify that the metallic conductors in the cuff are active in the wrist strap

by grasping the cuff with the thumb and forefinger, away from the metal plate, and testing it. Repeat this test in a few locations on the cuff.

3.5 Wrist Strap Banana Plug Condition

Verify that the wrist strap banana plug's blades are not bent or dented and that the plating is not worn away to the base metal. The plug (or alternate clips) should hold in its socket against forces encountered during normal use. (See GR-1422-CORE, which specifies 1 to 5 pounds.)

4. The ESD Protective Workstation

The ESD Protective Workstation should conform to GR-1419-CORE,[4] *Generic Requirements for ESD Protective Workstations.* Items shall be surveyed and tested for conformance according to the ESD ADV53.1-1995,[5] *ESD Association Advisory for the Protection of Electrostatic Discharge Susceptible Items-ESD Protective Workstations.*

4.1 ESD Protective Workstation Wrist Strap Ground Point Present

Verify that ESD wrist strap ground receptacles are conveniently located wherever ESD-sensitive product is handled.

4.1.1 ESD Wrist Strap Ground Receptacle Properly Mounted

Verify that ESD ground receptacles are installed as described by ANSI EOS/ESD S6.1-1991,[6] *EOS/ESD Association Standard for the Protection of Electrostatic Sensitive Items-Grounding- Recommended Practice*, and BCC standards.

4.1.2 ESD Wrist Strap Ground Receptacle Condition

Verify that ESD ground receptacles show no visual evidence of damage. They should be solidly attached and satisfy their intended function.

4.1.3 ESD Wrist Strap Ground Receptacle Connected to Ground

Use a VOM to measure the resistance from the ESD ground receptacle to an available equipment ground. Verify that resistance is consistent with ANSI EOS/ESD S6.1-1991 (typically less than 1 ohm).

4.1.4 ESD Wrist Strap Ground Receptacle Labeled

Verify that a standard label such as **(CONNECT WRIST-STRAPS HERE)** is mounted at every work position in an area that is clearly identified with the ESD ground receptacle.

4.2 ESD Protective Workstation Common Point Ground (CPG)

4.2.1 ESD Workstation CPG Present and Labeled

Verify that the ESD Workstation CPG termination point is present and properly labeled.

4.2.2 ESD Workstation Grounding and Bonding

All workstations shall be tested to verify that the grounding system complies with ANSI EOS/ESD S6.1-1991, with a total resistance of less than 1 ohm from the CPG of the workstation to A-C Equipment Ground (ACEG) green wire or other building ground.

4.3 ESD Protective Workstation Electrostatic Performance

4.3.1 ESD Workstation Worksurface Resistance

Verify that all workstation worksurfaces meet static dissipative characteristics with a surface resistivity of $1x10^6$ to $1x10^{11}$ ohms per square using the test method in ANSI EOS/ESD S4.1-1990,[7] *EOS/ESD Association Standard for the Protection of Electrostatic Sensitive Items Worksurfaces-Resistive Characterization.*

4.3.2 ESD Workstation Worksurface Resistance to Ground

Verify that all workstation worksurfaces are bonded to ground by using ANSI EOS/ESD S4.1-1990 by making a measurement from the worksurface to the CPG that is in the range of $1x10^6$ to $1x10^{11}$ ohms per square.

4.3.3 ESD Workstation Grounding of Peripheral Equipment

Confirm that all peripheral equipment such as table mats, floor mats, drawers, shelves, keyboard or foot rests are connected to the workstation CPG. All video display monitors, glare screens, any electronic equipment, and all electric outlets are all grounded to the ACEG third wire (green) ground using ANSI EOS/ESD S6.1-1991 with a total resistance of less than 1 ohm.

4.4 ESD Protective Table Mats Present

Verify that ESD-related work surfaces are equipped with approved static-dissipative work surfaces which may be either soft ESD mats or hard ESD table tops. It is recommended that an ESD mat cover the entire work surface in order to minimize the possibility of human error when ESD-sensitive product is handled. Work surfaces may include benches where ESD-sensitive product is routinely handled. Conductive table mats should never be used. A table mat that is conductive should be discarded immediately and be replaced by a static dissipative one.

4.4.1 Table Mat Surface Resistivity

To verify a table mat's surface resistivity, place a surface resistance meter on the floor mat in several places. The preferred range is from 10^6 to 10^{11} ohms per square. All table mat failures must be reported, and prompt retesting or replacement made.

4.4.2 Table Mats Grounded

NOTE Table mats must be grounded and installed per EOS/ESD Association Standard-S6.1-1991.

The static dissipative table mat ground connector should be connected directly to equipment ground.

Perform the following three-step procedure to verify the integrity of a table mat's system.

NOTE To receive an accurate resistance-to-ground reading, you should not be grounded while performing this procedure.

1. First, inspect the table mat installation for proper grounding hardware, hardware location, and a solid connection to equipment ground. Verify that one end of the ground cord is solidly connected to the table mat, and the other end is solidly connected to the CPG.
2. Once you have performed a visual check, use the surface resistivity meter to make the measurement. Connect one terminal of the meter to the table mat and the other to the CPG. A passing condition is 10^6 to 10^{11} ohms per square.
3. Now test the resistance from the table mat's ground connector to the CPG. Use a VOM to confirm that the resistance is less than 1 ohms.

4.5 ESD Protective Floor Mats Present

Verify that static dissipative ESD floor mats, flooring, or floor finishes are present in areas where employees wear conductive footwear when working in a standing position. Floor mats should never be conductive. The floor mat ground connector should be connected directly to ground, (No resistance). Footwear should include a resistance to ground of approximately 1 megohm. BCC safety standards apply.

4.5.1 Floor Mat Surface Resistivity

To verify a floor mat's surface resistivity, place a surface resistance meter on the floor mat in several places. The preferred range is from 10^6 to 10^{11} ohms per square. All floor mat failures must be reported, and prompt retesting or replacement made.

4.5.2 Floor Mats Grounded

Use a VOM to verify that floor mats are in accordance with BCC electrical requirements and procedures. Generally, floor mats are connected directly to equipment ground.

Perform the following three step procedure to verify the integrity of a floor mat's system.

NOTE To receive an accurate resistance to ground reading, you should not be grounded while performing this procedure.

1. First, inspect the floor mat installation for proper grounding hardware, hardware location, and a solid connection to equipment ground. Verify that one end of the ground cord is solidly connected to the floor mat, and the other end is solidly connected to equipment ground.
2. Once you have performed a visual check, use the surface resistivity meter to make the measurement. Connect one terminal of the meter to the floor mat and the other to the CPG. A passing condition is 10^6 to 10^{11} ohms per square.
3. Now test the resistance from the floor mat's ground connector to equipment ground. Use a VOM to confirm that the resistance is less than 1 ohms.

5. ESD Protective Flooring

5.1 ESD Protective Flooring Present

Verify that static dissipative flooring or floor finishes are always present whenever specified. Flooring should be static dissipative and never conductive. See GR-1424-CORE,[8] *Generic Requirements for ESD-Protective Flooring* for floor covering requirements.

Verify that ESD floor mats, flooring, or floor finishes are present in areas where employees wear conductive footwear when working in a standing position. Footwear should include a resistance to ground of approximately 1 megohm. BCC safety standards apply, and no permanent flooring or floor mats should be installed which may present a potential shock hazard.

5.2 Flooring Grounded

Use a resistance-to-ground meter to verify that flooring is grounded according to ANSI/ EOS/ESD-S6.1-1991 and BCC electrical requirements and procedures.

Perform both a visual and an electrical check to verify that flooring resistance meets BCC standards. The preferred resistance to ground is less than or equal to 10 ohms.

5.3 Flooring Surface Resistivity

Use a surface-resistance meter to verify that flooring surface resistivity is 10^6 to 10^{11} ohms per square. EOS/ESD Association Standard for the ANSI EOS/ESD-S7.1-1994,[9] *Protection of Electrostatic Sensitive Items-Floor Materials-Resistive Characterization of Materials*, may be used as a method to measure flooring surface resistivity.

6. ESD Protective Floor Finishes

6.1 ESD Protective Floor Finish Present

Verify that static dissipative flooring or floor finishes are present. See GR-1423-CORE,[10] *Generic Requirements for ESD-Protective Floor Finishes* for floor finish requirements.

6.2 Floor Finish Appearance

Verify that the floor finish has the appearance of recent maintenance. It should appear continuous, be without voids, be clean, and meet BCC standards.

6.3 Floor Finish Maintenance

Verify that periodic maintenance of the floor finish is performed at regular intervals based on the history of performance or as prescribed by the manufacturer. Six months or less is recommended.

6.4 Floor Finish Surface Resistivity

To verify floor finish surface resistance, place a surface resistance meter on the floor in several places. Include high traffic areas. The surface resistivity should be in the range of 10^6 to 10^{11} ohms per square. Standard ANSI EOS/ESD-S7.1-1994 method may be used to characterize floor finishes.

6.5 Floor Finish Resistance to Ground

Use an appropriate resistance-to-ground instrument to verify the floor resistivity to a equipment ground. The range should be from 10^6 to 10^{11} ohms. Draft standard EOS/ESD-S7.1-1994 method may be used to characterize the floor finish resistance to ground.

7. ESD Protective Footwear

7.1 ESD Protective Footwear Assembly Resistance

Verify footwear resistance with an approved wrist strap tester (or a footwear tester).

NOTE For commercial footwear testers, follow manufacturer's instructions.

Plug the wrist strap tester directly into a footwear test plate, and verify that an operator is not grounded by any means other than the footwear. This verifies that the footwear assembly is tested, and not an alternate path to ground.

Verify proper continuity. The person wearing the footwear should stand with one foot placed on the test plate and the other isolated from both ground and the test plate. Typically, a green light on the wrist strap tester indicates proper continuity. The recommended window is between 750 kilohms and 10 megohms, same as for the wrist strap assembly resistance. Higher limits, but less than 35 megohms, may be specified locally based on sound technical analysis of the footwear as used in conjunction with the specified conductive-dissipative floor surface.

NOTE The above testing is intended to reveal only electrical failures in the footwear assembly; failures due to improper use (or personnel improperly grounded) are addressed in Section 12, "Personnel Checks."

7.2 Heel or Toe Grounding Tab Condition

Verify that the grounding tab or strap on the heel or toe, and also the boot straps, are mechanically sound. Verify that operators are properly wearing tabs and boot straps. Tabs should be worn inside the operator's footwear and extend the length of the operator's foot so that full body weight is placed on the tab.

7.3 Footwear Condition

Verify that the underside of the footwear is clean and shows no evidence of undue wear.

8. ESD Protective Packaging Materials

8.1 ESD Protective Packaging Labels

Verify that all components and assemblies sensitive to electrostatic damage are packaged in containers with an industry-approved label attached to the outside. (See GR-1421-CORE,[11] *Generic Requirements for ESD-Protective Circuit Pack Containers* for packaging specifications and Bellcore Practice BR 010-170-005,[1] Figure 11-1 or 11-2 for the approved label.) See also ANSI ESD S11.31-1994,[12] *ESD Association Standard for Evaluating the Performance of Electrostatic Discharge Shielding Bags*, for test methods to qualify shielding type bags.

Labeling should be restricted to ESD-sensitive products only. Labeling should not be used for non sensitive products.

8.2 Characteristics of Packaging Materials

Verify that packaging for ESD-sensitive products is both static dissipative and low charging. You should be able to readily identify it visually, either by label or characteristic. Use a surface-resistance meter or an electrostatic locator to measure the characteristics. Verify that the characteristics are in the approved range, 10^6 to 10^{11} ohms per square.

9. ESD Protective Transport Media

9.1 ESD Protective Transport Characteristics

Various totes, carrying boxes, and trays may be used to transport ESD sensitive product from one location to another on site.

Use an electrostatic locator and surface-resistance meter to verify that transport containers are in accordance with the manufacturers specifications and Bellcore generic requirements. See GR-1421-CORE.

Verify that transport media, when required, can be grounded and are both low charging static dissipative. For example, a tote would be considered grounded when resting on a dissipative work surface or attached to a ground cord.

9.2 Transport Media Lining

Verify that non conductive transport media are lined with low charging static dissipative cushioning materials to prevent direct contact with static generating materials. The preferred surface resistivity is from 10^6 to 10^{11} ohms per square. Some materials used in transport media may generate such high electrostatic fields (for example, 1000 volts) that transport media may have to be replaced, regardless of a work area's ESD classification. If highly conductive material is a process requirement and no alternate methods exist, then a documented engineering risk assessment is recommended to determine the product ESD sensitivity as well as the charge and electrostatic potentials present. See TR-NWT-000870,[13] *Electrostatic Discharge Control in the Manufacture of Telecommunications Equipment*, Table 6-1.

9.3 Transport Media Condition

Verify that transport media such as bags and various wraps conform to GR-1421-CORE for static dissipative and low charging properties. The preferred surface resistivity is from 10^6 to 10^{11} ohms per square.

Perform a visual check for holes and tears, then judge the transport media as either usable or worn out.

On-site transport procedures are known as handling operations; off-site transport procedures (shipped outside) follow additional requirements and are known as packaging operations. The procedures described herein are handling operations.

9.4 Carts

Verify that carts can be grounded and are static dissipative.

Verify that all carts are equipped with drag chains wherever dissipative flooring, floor finishes, or mats are present. It is recommended that 12 to 18 inches of chain be in contact with the floor as long as BCC safety standards are met.

It is also recommended that the carts be identified with ESD certification stickers that identify the carts as inspected for compliance to ESD standards.

Verify also that carts are equipped with banana jacks (or equivalent) for grounding, and verify that the carts' work surfaces are static dissipative and comply with BCC standards.

Verify that there is less than 1 ohm resistance between the drag chain and the banana jack on all metal portions of a cart. Verify that static dissipative work surfaces have been properly installed and grounded to the banana jacks on the carts.

NOTE Drag chains are not a substitute for ground cords. If a dissipative surface is used, verify that it is properly grounded to the banana jack per BCC standards.

Verify that carts are designed so that there is no direct contact between the conductive materials of the carts and the ESD-sensitive product. However, approved transport media that contains ESD-sensitive product may be placed on the conductive surfaces of carts.

9.5 Stationary Transport Mechanisms

Verify that all stationary transport mechanisms in warehouse areas, such as conveyors, slides, and other seldom moved mechanisms in ESD-sensitive areas are safe for ESD-sensitive products. Ask the engineering coordinator/consultant to evaluate complex transport mechanisms.

Use a static locator to verify the electrostatic potentials on the conveyors, slides, and other stationary transport mechanisms that transport ESD-sensitive products.

10. ESD Protective Storage Media

10.1 ESD Protective Storage Media Characteristics and Lining

Verify that storage media for all components, assemblies, and circuit card assemblies are made of low charging, static dissipative materials when required. Static-safe media's surface resistivity should range from 10^6 to 10^{11} ohms per square and meet all the requirements of the work surface.

10.2 Storage Media and Fixture Grounding

Verify that storage media are grounded when loading and unloading sensitive product. Storage media includes storage cabinets, shelving, racks, bins, and boxes. Metallic storage media should be grounded to prevent a shock hazard.

10.3 Sensitive Components and Assemblies Properly Stored

Verify that ESD sensitive components and assemblies are stored on approved surfaces or inside approved containers. It is recommended that an ESD mat cover the entire work surface in order to minimize the possibility of placing sensitive product (or the sensitive product's containers) on an ungrounded surface.

Approved surfaces include table mats, hard table tops, and grounded transport media such as totes and carts that adhere to requirements.

Surfaces unapproved for direct contact with sensitive items include bare metal, painted metal surfaces, treated or untreated wooden surfaces, paper, plastics, test cables, and glass surfaces.

For example, an approved storage for circuit packs is a static dissipative container, with a surface resistivity of 10^6 to 10^{11} ohms per square. An example of unapproved storage would be unprotected circuit packs stacked one on top of the other on a work surface or inside a tote, thereby allowing conductor-to-conductor contact.

11. Static-Generating Materials

11.1 Unnecessary Static-Generating Materials on Work Surface

Verify that no unnecessary static-generating materials are placed on bench tops with sensitive product present or on any work surface where they may come into contact with an ESD-sensitive product. Examples of unnecessary plastics are Styrofoam trays, coffee cups, Styrofoam product containers, and an empty cellular-block Styrofoam that once held non-ESD-sensitive components. Use an electrostatic locator to determine if suspect material is capable of developing a charge.

11.2 Static Generating Materials in Contact with Product

Verify that static generating materials do not come into contact with ESD-sensitive product. Some static generating materials are unavoidable; however, these materials should be kept as far away as possible from ESD sensitive product and no closer than 3 feet.

One example of a necessary static-generating tool is a CRT terminal. A CRT terminal screen is a significant ESD risk. All circuit card assemblies and components should be kept at least 3 feet away form CRT terminals.

11.3 Purchases of New Handling Materials

Verify that all new handling materials are ESD safe. New handling materials made of insulative static-generating materials should not be purchased.

11.4 Supplies

Verify that supplies such as wipes, various containers, visual aid covers, and other such purchases are ESD safe and that they continue to retain their ESD safe characteristics.

11.5 Static Generating Materials in Area

Verify that no static generating materials are present in ESD work areas. Note any static-generating materials that you find. Any unsafe materials that are absolutely required for work should be kept at least one meter (three feet) away from static sensitive items.

Personal effects made of static-generating materials are included in this definition, e.g., purses, radios, etc. However, these materials are allowed if they are enclosed in an ESD-protective container and isolated from the sensitive product.

12. Personnel Checks

12.1 Proper Use of ESD Protective Wrist Straps

Verify that all personnel are properly wearing wrist straps in accordance with the manufacturer's recommendations when handling ESD-sensitive products.

NOTE This personnel check refers to those employees who handle ESD-sensitive products while in either a seated or standing position.

12.2 Proper Use of ESD Protective Footwear

Verify that all personnel are properly wearing conductive footwear in accordance with the manufacturer's recommendations when handling ESD-sensitive products. Conductive footwear must be worn in conjunction with approved, properly installed static dissipative flooring, floor finishes, or floor mats.

NOTE This personnel check refers to those employees who handle ESD-sensitive products while in a standing position only. Footwear is not an approved grounding method when the operator is seated.

12.3 Personnel Grounded

Verify that anyone handling ESD-sensitive products is wearing ESD protection (i.e., wrist straps or conductive footwear) and is properly connected to ground.

An employee who is wearing conductive footwear when working in a seated position and is not wearing a wrist strap is not grounded. Another ungrounded condition would be an employee who is wearing a wrist strap, but who is not connected to ground. Employees are also ungrounded when the heel grounders on the underside of their footwear are not in full contact with the grounded surface (such as when balancing on toes or squatting, or when standing on ungrounded ladders or platforms). Verify that personnel wear heel or toe grounders on both feet.

12.4 Personnel Use of ESD Protective Transport Media

Verify that ungrounded personnel transport ESD-sensitive product inside appropriate transport media according to that media's specified requirements. For example, if an ESD bag is the appropriate transport media, the product must be transported INSIDE the bag. The bag should NOT be used as a "pot holder" to carry the sensitive product.

These requirements apply to all people working in, or visiting, an ESD-sensitive area. Without exception, everyone is required to wear ESD protection when handling sensitive products and while present in work areas posted "ESD Protection Required in this Area" or the equivalent.

13. ESD Warning Signs

13.1 ESD Protection Notices

Verify that all areas are posted with standard warning signs such as: (**ESD Protection Required in this Area**). In addition, signs should be placed near entrances to ESD controlled or safe areas. Non-essential untrained personnel should be discouraged from entering ESD safe areas where sensitive electronic equipment is either being used, stored, or handled.

13.2 Standard Protection Notices

Verify that all ESD protection notices conform to EOS/ESD Association ANSI EOS/ESD-DS8.1-1992,[14] *Symbols- ESD Awareness*. See BR 010-170-005,[1] for a description of ESD Symbols.

13.3 Standard Labeling for Packaging (for information only)

All packages having the EIA-471 symbol shall be opened at an ESD protective workstation. The MIL-STD 1285 symbol on packaging is allowed only when the EIA label is also present. Labels with "lightning bolts" or the words "warning" or "danger" are not approved for ESD control purposes.

14. Training

14.1 Training Records

Verify that ESD training records for all employees, including management, and engineering, are readily available.

14.2 Training Certification

Verify that all employees who require ESD training, including management, engineering, and maintenance personnel, are ESD certified according to their specific job requirements and that they have successfully completed the ESD training. Re-certification is recommended to be every two years.

14.3 ESD Practices

Verify that the most recent Bellcore ESD practices and Bellcore generic requirements are readily available to all employees. The ESD work area supervisor should explain the practices to all employees and address employee questions and concerns relating to ESD See BR 010-170-005[1].

15. Process Check Methods

15.1 Proper Visual Inspection Methods

Verify that the site coordinator conducts daily visual inspections in accordance with local process checking instructions. Inspections should include all visual aspects of a work area. For example, static-generating materials, proper use of wrist straps, proper loading and unloading of sensitive product, transport media, and carts should be visually inspected by the site coordinator.

15.2 Proper Electrical Measurement Methods

Verify that all required electrical measurements such as wrist strap testing, grounded floor mat, and grounded workstation testing are conducted in accordance with local process checking instructions.

16. Process Checking Documentation

16.1 Current and Official Documentation

Verify that current and official copies of applicable documents such as the ESD Generic Requirements, ESD Practices, and EOS/ESD Association Standards are readily available.

16.2 Proper Process Checking Records

Verify that process checking records are properly completed according to the current and official documentation. It is strongly recommended that control charts be included in the process records. Process checking records should be maintained for at least one year.

16.3 Records of Periodic Tests on Wrist Strap Testers

Verify that written records of periodic tests on wrist strap testers are readily available. Records should be maintained for at least one year.

16.4 Records of Periodic Tests on Wrist Strap Assemblies

Verify that written records of periodic tests on wrist strap assemblies are readily available. Records should be maintained for at least one year.

16.5 Records of Periodic Tests on ESD Protective Workstations

Verify that written records of periodic tests on ESD workstations are readily available. Records should be maintained for at least one year. This includes hard table tops, table mats and floor mats if present.

16.6 Records of Periodic Tests on Footwear

Verify that written records of periodic tests on footwear are readily available. Records should be maintained for at least one year.

16.7 Records of Periodic Tests on Flooring

Verify that written records of periodic tests on flooring are readily available. Records should be maintained for at least one year.

16.8 Records of Periodic Tests on Floor Finishes

Verify that written records of periodic tests on floor finishes are readily available. Records should be maintained for at least one year.

16.9 Records of Periodic Verification of ESD Signs Present

Confirm that written records of ESD signs present in ESD safe areas are readily available for up to a year period.

Appendix A: Sample ESD Survey Field Checklist

Company:_____Location:_____

Manager/s: _____

Date:___/___/___ Temperature:_____°F Relative Humidity:_____%RH

Sample ESD Facility Review Checklist

Test	Number	Pass	Fail	Notes
1. Wrist Strap testers?				
2. Wrists Straps?				
3. Workstation Present?				
-Workstation Grounded?				
-Wrist strap Jack?				
-Static Dissipative Worksurface Present?				
-Table Mat Present?				
-Floor mat Present?				
4. ESD Floor Covering?				
5. Grounded Metal Storage Cabinet Present?				
6. Circuit Packs Stored/Packaged Properly?				
7. Approved ESD Carts?				
8. ESD Signs Present?				
9. Personnel ESD?				
10. ESD Training?				
11. Documentation?				

12. Wrist Strap Tester Calibration	Minimum Pass/Fail	Maximum Pass/Fail
Unit Serial Number	710Kohms	11.1 Megohms

13. Testing Resistance of Table Mat

Test	Limits $1x(10)^6$ to $1x(10)^{10}$Ohms	Pass	Fail
Point to Point Resistance-Mat Number 1			
Mat Number 2			
Mat Number 3			
Point to Ground Resistance-Mat 1			
Mat Number 2			
Mat Number 3			

14. Testing Resistivity of Floor Mat

Test	Limits $1x(10)^6$ to $1x(10)^{10}$Ohms	Pass	Fail
Point to Point Resistance-Mat Number 1			
Mat Number 2			
Mat Number 3			
Point to Ground Resistance-Mat 1			
Mat Number 2			
Mat Number 3			

15. Personnel Charge Generation

Walking Test

First Name	Voltages Measured and Polarity				

Charge Generation on Ladder

First Name	Voltages Measured and Polarity				

Charge Generation on Chair or Rolling Cart

First Name	Voltages Measured and Polarity				

16. Packaging Measurements

Rs=Surface Resistivity in Ohms/Square.

Tribo=(Voltage) Charge Accumulation from contact and separation.

Supplier	Specimen type	Material	Rs	Tribo

Material Abbreviations

Abbreviation = Container Material	Abbreviation = Container Material
PVC = Stiff Plastic Clamshell Container	**PPB = Pink Poly Plastic Bag**
CGS = Corrugated Sleeve	PPF = Pink Poly Foam
CGB = Corrugated Container	PPBW = Pink Poly Bubble Wrap
CGBF = Corrugated Container with Foam Liner	PB = Plastic Bag
SHPB = Shielded Plastic Bag	BP = Bubble Pack (Cardboard & Plastic)

Appendix B: Sample Facility Inspectors Checklist

ESD INSPECTORS SUMMARY REPORT		
Company Name		Date of Inspection:
Facility		Tel. No.
Location		Temp.
Inspector		Humidity
Manager		
Attendees on Tour:		
Summary of Corrections (CRs) Required		
Section No. & Description	**CR**	**Notes on Inspection**
2. Wrist Strap Tester		
3. Wrist Strap		
4. ESD Workstation		
5. SD Flooring		
6. SD Finishes		
7. Footwear		
8. Packaging		
9. Transport Media		
10. Storage Media		
11. Static Gen. Materials		
12. Personnel Checks		
13. ESD Signs		
14. Training		
15. Process Check Methods		
16. Documentation		
Total Corrections Required		
Notes:		

Sample Facility Inspectors Checklist

FACILITY INSPECTORS CHECKLIST			
Designations:			
Item:	CR	Section	Description:
2. Wrist Strap Tester		2.0	No Wrist Strap Testers
		2.1	Wrist strap tester fails calibrations tests
		2.2	Wrist strap tester not serialized
		2.3	Wrist strap tester calibration label missing
		2.4	Wrist strap tester calibration past date
3. Wrist strap		3.0	No Wrist Straps
		3.1	Wrist strap assembly resistance, open
		3.2	or intermittent
		3.3	Intermittent cord verified with VOM
		3.4	Wrist strap bracelet snap condition
		3.5	Wrist strap bracelet condition
		3.6	Wrist strap banana plug condition
4. The ESD Protective Workstation			
		4.0	No ESD Protective Workstation
4.1 Wrist Strap Ground		4.1	No ESD ground jack present
		4.1.1	ESD ground jack not properly mounted
		4.1.2	ESD ground jack condition
		4.1.3	ESD ground jack not grounded properly
		4.1.4	ESD ground jack not labeled
4.2 ESD Protective Workstation Common Point Ground (CPG)			
		4.2.1	CPG not present or not labeled
		4.2.2	Work station not properly bonded to ground.
4.3 ESD Protective Workstation Electrostatic Performance			
		4.3	No ESD protective worksurface present
		4.3.1	Improper worksurface resistance
		4.3.2	Improper worksurface resistance to ground
		4.3.3	Improper grounding of peripheral equipment
4.4 ESD Protective Table mats Present			
		4.4	No ESD protective table mats present
		4.4.1	Improper table mat surface resistivity
		4.4.2	Table mats not grounded

Item	CR	Section	Description
4.5 ESD Protective Floor Mats Present			
		4.5	No ESD protective floor mats present
		4.5.1	Improper floor mat surface resistivity
		4.5.2	Floor mats not grounded
5.Static Dissipative Flooring		5.1	Static dissipative floor not present
		5.2	Static dissipative flooring not grounded properly
		5.3	Static dissipative floor surface resistivity out of range
6. Static Dissipative Floor Finishes		6.1	Static dissipative floor finish not present
		6.2	Floor finish appearance
		6.3	Floor finish maintenance
		6.4	Improper floor finish surface resistivity
		6.5	Improper Floor finish resistance to ground
7. ESD Protective Footwear		7.1	Improper ESD Footwear Assembly Resistance
		7.2	Improper heel of toe grounding tab condition
		7.3	General foot wear condition
8. ESD Protective Packaging Materials		8.1	ESD packaging label missing
		8.2	Packaging materials unsafe
9. ESD Protective Transport Media		9.1	Transport media not static dissipative
		9.2	Transport media not lined with static safe material
		9.3	Improper transport media condition
		9.4	Unapproved carts
		9.5	Unsafe stationary transport mechanisms
10. ESD Protective Storage Media		10.1	Improper storage media surface resistivity
		10.2	Storage media not grounded
		10.3	Sensitive assemblies improperly stored
11. Static-Generating Materials		11.1	Unnecessary static-generating materials on work surface
		11.2	Static-generating materials in contact with product
		11.3	New handling materials unsafe
		11.4	Static generating supplies
		11.5	Static-generating materials in area

Item:	CR	Section	Description:
12. Personnel Checks		12.1	Personnel not wearing wrist straps properly
		12.2	Personnel not wearing footwear properly
		12.3	Personnel not grounded
		12.4	Personnel transporting product via unapproved practices
13. ESD Warning Signs		13.1	Standard ESD protection signs not in work area
		13.2	Nonstandard ESD protection notices
		13.3	Standard Labeling for Packaging (Information only)
14. Training		14.1	No training records (or incomplete)
		14.2	No training certification
		14.3	No ESD practices available
15. Process check methods		15.1	Improper visual inspection methods
		15.2	Improper electrical measurement methods
16. Documentation		16.1	No current and official documentation
		16.2	Improper checking records
		16.3	No records of periodic tests on wrist strap testers
		16.4	No records of periodic tests on wrist straps
		16.5	No records of periodic tests on ESD workstations
		16.6	No records of periodic tests on footwear
		16.7	No records of periodic tests on static dissipative flooring
		16.8	No records of periodic tests on static dissipative floor finishes
		16.9	No records of periodic verification of ESD Signs in ESD safe areas
Notes:			

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Note

All Bellcore documents are subject to change, and their citation in this document reflects the most current information available at the time of this printing. Readers are advised to check current status and availability of all documents.

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Glossary

Definition of Terms

Antistatic — Usually refers to the property of a material that inhibits triboelectric charging. Note: A materials antistatic characteristic is not necessarily correlatable with its resistivity or resistance. Although this term "Antistatic" and the term "Astatic" still appear in the literature, both these terms were replaced by the new term "**Low Charging**" in April 1996 by the International Electrotechnical Commission (IEC).

Bond Or Bonding — The permanent joining of metallic parts to form an electrically conductive path that will assure electrical continuity and the capacity to safely conduct any current likely to be imposed. (from ANSI EOS/ESD-S6.1-1991).

Bus Bar — A metal strip or bar to which several conductors may be bonded. (from ANSI EOS/ESD-S6.1-1991)

Charge Decay — The decrease and/or neutralization of a net electrostatic charge. (from ANSI EOS/ESD-S3.1-1991)

Charged Device Model — A specified circuit characterizing an electrostatic discharge which results when a device isolated from ground is first charged and then subsequently grounded.

Circuit Card Assembly — An assembled printed circuit board with components; in telecommunications systems, this typically refers to a plug-in-board that has a modular function (same as printed board assembly or circuit pack).

Circuit Pack — (See Circuit Card Assemblies)

Common Point Ground (CPG) — (1) A grounded device where two or more conductors are bonded. (2) A system or method of connecting two or more grounding connectors to the same electrical potential. (from ANSI EOS/ESD-S6.1-1991 See also (PGP).

Component — An item such as a resistor, diode, transistor, integrated circuit and hybrid. (from ESD-S5.2-1994).

Conductive Material — A material that has a surface resistivity less than 1×10^5 ohms/square or a volume resistivity less than 1×10^4 ohm-cm.

Continuity— — Uninterrupted electrical connection from one point to another in a circuit or wiring

CRT (CRT Monitor) — See VDT.

Electric Charge — An absence or excess of electrons.

Electrostatic Charge — Electric charge at rest.

Electrostatic Discharge (ESD) — The rapid, spontaneous transfer of electrostatic charge induced by a high electrostatic field. Note: Usually, the charge flows through a spark between the two bodies at different electrostatic potentials as they approach one another. Details of such process, such as rate of charge transfer, are described in specific electrostatic discharge models.

Electrostatic Discharge Susceptibility (sensitivity) (ESDS) — The propensity to be damaged by electrostatic discharge.

Electrostatic Field — An attractive or repulsive force in space due to the presence of electric charge.

Electrostatic Locator — A non-contact voltmeter that indicates electrostatic field voltage and polarity on charged surfaces.

Electrostatic Potential — The voltage difference between a point and an agreed-upon reference.

Electrostatic Shield — A barrier or enclosure that limits the penetration of an electrostatic field.

EOS/ESD Standards — Refer to the EOS/ESD Association, Inc., 7902 Turin Road, Suite 4, Rome, NY 13440

Equipment Ground (ACEG) — (1) The ground point at which the equipment grounding conductor is bonded to any piece of equipment, at the equipment end of the conductor. (2) The third wire (green) terminal of a receptacle. (3) The entire low impedance path form a piece of electrical equipment to a hard ground electrode. (from ANSO EOS/ESD-S6.1-1991).

ESD Protective Storage Media — A storage area constructed and equipped with the necessary protective materials and equipment to limit damage to stored ESD susceptible items.

ESD Protective Workstation — An area that is constructed and equipped with the necessary protective materials and equipment to limit damage to ESD susceptible items handled therein.

ESD Safe — Denotes conditions under which electronic equipment has a low probability of being upset or damaged by electrostatic discharge.

ESDS Systems — Electrostatic Discharge Sensitive (susceptible) systems with a propensity to be damaged by electrostatic discharge.

Field Induced Charging — A charging method using electrostatic induction.

Footwear Tester — A device that is equipped with a footplate that allows an inspector to perform various tests when the footwear falls outside of the operating range of a wrist strap tester

Ground — (1) A conducting connection, whether intentional or accidental between an

electrical circuit or equipment and the earth, or some conducting body that serves in place of earth. (2) The position or portion of an electrical circuit at zero potential with respect to earth. (from ANSI EOS/ESD-S6.1-1991)

Grounded — Connected to earth or some other conducting body that serves in place of the earth. (from ANSI EOS/ESD -S6.1-1991).

Hard Ground — A connection to ground through a wire or other conductor that has very little or nearly no resistance (impedance) to ground. (from ANSI EOS/ESD-S6.1-1991)

Human Body Model — An electrostatic discharge circuit that meets the set model values by conforming to the waveform criteria specified in ANSI EOS/ESD-S5.1-1993, the electrostatic discharge from a human being. Approximates the ESD from the fingertip of typical human being.

Inductive Charging — The transfer of an electric charge to an object when it is momentarily contacted to ground in the presence of an electric field.

Insulating Material — A material having a surface resistivity of at least 1×10^{12} ohms/square of 1×10^{11} ohm-cm volume resistivity.

Low Charging — See Antistatic. The new term "**Low Charging**" replaced the term "Antistatic" in April 1996 by the International Electrotechnical Commission (IEC).

Megger — portable megohmmeter (able to source 100 volts) that enables the measurement of high resistances with two NFPA probes.

Ohm per Square — Units of surface resistivity.

Plug-in — (See circuit card assembly).

Principal Ground Point — A point within a structure that provides a means to join conductors requiring an earth reference to grounding electrodes. This point may be a separate busbar located in the structure near the entrance of the grounding electrode conductor (s), or it may be a point on a grounding electrode. In a central office, the PGP is reference point 0 (see ANSI T1.313).

Shielding — See static shielding.

Static Dissipative — A property of a material having a surface resistivity of a least 1×10^5 ohms/square or less that 1×10^{12} ohms/square surface resistivity or 1×10^{11} ohm-cm volume resistivity.

Static Generating Material — See static generator.

Static Generator — Any material which when contacted or rubbed with itself or a different material accumulates sufficient electrostatic charge to be an ESD hazard to electronic components or assemblies. See triboelectric series.

Static Shielding — An electrostatic shield or barrier that limits the penetration of an

electric field.

Surface Resistance — The ratio of DC voltage to the current flowing between two electrodes of specified configuration that contact the same side of the material (from ANSI EOS/ESD-S11.11-1993).

Surface Resistivity(ρ_s) — For electric current flowing across a surface, the ratio of dc voltage drop per unit length to the surface current per unit width. In effect, the surface resistivity is the resistance between two opposite sides of a square and is independent of the size of the square or its dimensional units. Surface resistivity is expressed in ohms/square. When using a concentric ring fixture, resistivity is calculated using the following expression, where D1=the outside diameter of the inner electrode, D2= the inside diameter of the outer electrode, and R=is measured in ohms (from ANSI EOS/ESD-S11.11-1993).

$$\rho_S = \left[\frac{2\pi}{\ln((D2)/(D1))}\right]R$$

System — A combination of complete assemblies, components, parts, and accessories connected to perform a specific operation function.

Triboelectric Charging — The acquisition of charge on a material contact or friction with another surface of dissimilar material.

Topical Anistat — An anistat that is applied to the surface of a material for the purpose of making the surface static dissipative or low charging (reduce triboelectric charging). This method of minimizing charge generation is not recommended, and is not permanent, especially in low humidity conditions.

VDT (Video Display Tube) — Synonymous with CRT (Cathode Ray Tube), or CRT Monitor. A device used to display images, typically from broadcast television or a computer.

Volume Resistivity(ρ_v) — The ratio of the dc voltage per unit thickness to the amount of current per unit area passing through a material. Volume resistivity is given in ohm-centimeters.

Workstation — A work area which consists of a tabletop work surface, shelves, storage facilities, powered and/or not powered equipment, assemblies, black boxes, or systems.

Worksurface Groundable Point — A point on the work surface that is intended to accommodate an electrical connection from the work surface to an appropriate electrical ground (from ANSI EOS/ESD-S4.1-1990).

Wrist Strap Tester — Used to check wrist straps and foot straps.

Zap — (colloquial term) See Electrostatic Discharge.

For additional information see ESD Association Advisory for Electrostatic Discharge Terminology - Glossary, ESD ADV1.0-1994 and ESD Association Advisory for the Protection of Electrostatic Discharge Susceptible Items-Handbook, ESD ADV-2.0-1994.

Acronyms

ANSI —American National Standards Institute

ACEG —Alternating Current (a-c) Equipment Ground

ASTM —American Society for Testing Methods

CEV —Controlled Environment Vault

CO —Central Office

CPG —Common Point Ground

EIA —Electronic Industry Association

EMI —Electromagnetic Interference

EOS —Electrical Overstress

ESD —Electrostatic Discharge

ESDS —Electrostatic Discharge Sensitive

GR —Generic Requirement

IC —Integrated circuit

IEC —International Electronic Commission

NFPA —National Fire Protection Association

PWB —Printed wiring board

RBOC —Regional Bell Operating Company

RTG —Resistance to ground

SRM —Surface resistance meter

VOM —Volt-Ohm-Meter