

INSTITUTE OF ENVIRONMENTAL SCIENCES AND TECHNOLOGY

Contamination Control Division Recommended Practice 022.2

IEST-RP-CC022.2

Electrostatic Charge in Cleanrooms and Other Controlled Environments

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1 SCOPE AND LIMITATIONS

1.1 Scope

This Recommended Practice (RP) discusses methods for specifying and evaluating the effectiveness of techniques for controlling electrostatic charge. Proper control of electrostatic charge may reduce particulate contamination on surfaces and the likelihood of electrostatic discharge. This document, which describes typical control systems and their applications, also lists methods of testing and measurement of charge generation, charge neutralization, resistivity of surfaces and materials, and static field attenuation.

1.2 Limitations

This RP excludes specific evaluation and qualification related to the protection of ordnance, flammable materials, and explosives. This RP does not prescribe design or control limits; quality acceptance standards; process issues; or health, safety, and environmental issues and practices outside of contamination control issues. Users should establish their own quality standards.

2 REFERENCES

2.1 Documents

2.1.1 ASTM

D257-78 Standard Test Methods for DC Resistance or Conductance of Insulating Materials

E595-93 Standard Test Method for Total Mass Loss and Collected Volatile Condensable Materials from Outgassing in a Vacuum Environment

E1235-01 Standard Test Method for Gravimetric Determination of Nonvolatile Residue (NVR) in Environmentally Controlled Areas for Spacecraft

F331 Test Method for Nonvolatile Residue Extract from Aerospace Components (Using Flash Evaporator)

2.1.2 EIA

EIA-583 Packaging Material Standards for Moisture Sensitive Items

2.1.3 ESD

ESD ADV1.0-1994 for Electrostatic Discharge Terminology – Glossary

ESD-STM5.1-2001 for Electrostatic Discharge Sensitivity Testing—Human Body Model (HBM) Component Level

ESD-STM7.1-2001 for Protection of Electrostatic Discharge Susceptible Items—Resistive Characterization of Floor Materials

2.1.4 Federal Test Method Standard

FTMS 101C Method 4046.1 Electrostatic Properties of Materials

2.1.5 FDA

21CFR1020.40 Title 21, Vol. 8, Part 1020 Performance Standards for Ionizing Radiation Emitting Products, Sec.1020.40 Cabinet X-Ray Systems

FFDCA, Chapter V, Subchapter C – Electronic Product Radiation Control, Sections 531-542

2.1.6 IDEMA

Document No. M7-98 Organic Contamination as Nonvolatile Residue (NVR)

Document No. M9-98 Particulate Contamination Test Methods for Hard Disk Drive Components

Document No. M11-99 General Outgas Test Procedure by Dynamic Headspace Analysis

Document No. M12-99 Measurement of Extractable/Leachable Cation Contamination Levels on Drive Components by Ion Chromatography

2.1.7 IEST

IEST-RP-CC004: Evaluating Wiping Materials Used in Cleanrooms and Other Controlled Environments

IEST-RP-CC005: Gloves and Finger Cots Used in Cleanrooms and Other Controlled Environments

IEST-RP-CC012: Considerations in Cleanroom Design

IEST-RP-CC018: Cleanroom Housekeeping—Operating and Monitoring Procedures

IEST-RP-CC020: Substrates and Forms for Documentation in Cleanrooms

IEST-RP-CC031: Method for Characterizing Outgassed Organic Compounds from Cleanroom Materials and Components

IEST-STD-CC1246D: Product Cleanliness Levels and Contamination Control Program

2.1.8 ISO

ISO 14952:¹

ISO 14644: Cleanrooms and associated controlled environments

2.1.9 Military standards

MIL-PRF-81705D Performance Specification: Barrier Materials, Flexible, Electrostatic Protective, Heat-sealable

MIL-STD-1686C Electrostatic Discharge Control Program for Protection of Electrical and Electronic Parts, Assemblies, and Equipment (Excluding Electrically Initiated Explosive Devices)

2.1.10 NASA

NASA KSC-C-123H Specification for Surface Cleanliness of Fluid Systems

NASA MMA-1985-79 Standard test method for evaluating triboelectric charge generation and decay

2.1.11 NFPA

NFPA 99: Standard for Health Care Facilities

2.1.12 NRC

10CFR20 Title 10, Part 20 Standards for Protection Against Radiation

2.1.13 SAE

ARP598 Aerospace Microscopic Sizing and Counting of Particulate Contamination for Fluid Power Systems

2.2 Sources and addresses

ASTM International

100 Barr Harbor Drive
P.O. Box C700
West Conshohocken, Pennsylvania 19428-2959 USA
www.astm.org

EIA

Electronic Industries Alliance
2500 Wilson Blvd.
Arlington, VA 22201
www.eia.org

ESDA

ESD Association
7900 Turin Bldg. 3, Suite 2
Rome, New York 13440-2069 USA
www.esda.org

FDA

U.S. Food and Drug Administration
5600 Fischers lane
Rockville, Maryland 20857 USA
www.fda.gov

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ISO

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Schaumburg, IL 60173 USA
www.iest.org

Outside U.S.: Documents available from representative ISO member body organization

JSA (JIS)

Japanese Standards Association
1-24, Akasaka, 4 Chome, Minatoka
Tokyo, 107, Japan
www.jsa.or.jp

Military standards (MIL)

Standardization Document Order Desk
700 Robbins Avenue
Bldg #4, Section D
Philadelphia, Pennsylvania 19111-5094 USA

NASA-KSC

National Aeronautics and Space Administration —
Kennedy Space Center
Manufacturers Materials Analysis Branch
Ground Systems Directorate
Kennedy Space Center, Florida USA
www.nasa.gov

NFPA

National Fire Protection Association
Battery March Park
Quincy, Massachusetts 02269 USA
www.nfpa.org

NPFC

The Naval Publications and Forms Center
5801 Tabor Avenue
Philadelphia, Pennsylvania 19120 USA

NRC

U.S. Nuclear Regulatory Commission
Attention: Director, Division of Document Control
P-130A
Washington, D.C. 20555 USA
www.nrc.gov

NTIS

National Technical Information Service
U.S. Department of Commerce
5285 Port Royal Road
Springfield, Virginia 22161 USA
www.ntis.gov

OSHA

Occupational Safety and Health Administration
U.S. Department of Labor
200 Constitution Avenue, NW

Washington, D.C. 20210 USA
www.osha.gov

SAE

SAE International
400 Commonwealth Drive
Warrendale, PA 15096-0001 USA
www.sae.org

SEMI

Semiconductor Equipment and Materials
International
805 East Middlefield Road
Mountain View, CA 94043
www.semi.org

3 TERMS AND DEFINITIONS

This section includes terms and definitions from Electrostatic Discharge Association.

air ions

molecular clusters of about ten molecules (water, impurities, etc.) bound by polarization forces to a singly charged oxygen or nitrogen molecule

conductive materials

for the purpose of controlling static charge, materials having a surface resistivity of less than 10^5 ohms/square or a volume resistivity of less than 10^4 ohm-cm

decay time

time required for an electrostatic potential to be reduced to a given percentage (usually 10%) of its initial value

discharge time

time necessary for a voltage (due to an electrostatic charge) to decay from an initial value to some arbitrarily chosen final value; used for testing ionizers

electrostatic charge control (ESCC)

system of installations, materials, accessories, and procedures that maintains electrostatic effects below the tolerance limits for a given product or process

electrostatic damage

damage to a product caused by static electricity resulting from either (1) discharge from a charged conductor, (2) field induction, or (3) self discharge

NOTE: Damage thresholds for each of these causes of failure may differ from product to product.

electrostatic discharge (ESD)

transfer of electrostatic charge between bodies at different electrostatic potentials, caused by relatively close proximity or direct contact

electrostatic discharge control (ESDC)

limitation or elimination of electrostatic charge transfer

electrostatic field

- a) region surrounding a charged object within which another charge will experience a force
- b) voltage gradient between an electrostatically charged surface and another surface at a different electrostatic potential

electrostatic field detector

device used to determine the presence of electrostatic charge

electrostatic potential

potential difference between a point and an agreed-upon reference point

ESD-protective material

materials capable of dissipating, avoiding, or shielding electrostatic occurrences; generally classified by resistivity as either conductive or static-dissipative

ground

conducting connection to the earth, or to some other conducting body that serves in place of the earth

ground lead

conductive cabling or a similar device for use in a wrist strap or other grounding system; in a wrist strap system, the lead connects the cuff and ground

Example: In a foot strap system, the lead may connect the body-contacting portion and the ground-contacting portion.

ground path

total system of connecting leads, straps, and surfaces between the controlled body and the ground

ground straps

skin-contacting wrist, leg, or ankle strap that rapidly and safely dissipates personnel electrostatic charges to the ground and equalizes electrostatic levels of personnel with that of the work surface; strap may contain a current-limiting resistor for safety

hot spots

charged islands of material formed when conductive additives are incompletely distributed, such as uneven topical antistat; may cause ESD damage as a result of the electrical potential of charges isolated on them; another form of hot spot may occur in some apparel constructions when conductive filaments become broken and are no longer in electrical contact with one another

induced charge

electrical charge on a conductor produced by isolating the conductor from ground, bringing the conductor near charged object, then momentarily touching the conductor to ground

insulative material

material having a surface resistivity of at least 10^{12} ohms/square, or 10^{11} ohm-cm volume resistivity

offset voltage

voltage created on an isolated conductive plate by an unequal number of positive and negative ions on the plate

static-dissipative clothing

body coverings specifically designed or treated to prevent buildup of electrostatic charge

static-dissipative materials

materials having a surface resistivity between 10^5 and 10^{12} ohms/square, or between 10^4 and 10^{11} ohm-cm volume resistivity

static electricity

electrical charge at rest; charge is due to the transfer of electrons within a body (polarization) or from one body to another

surface resistivity

inverse measure of the conductivity of a material equal to the ratio of the potential gradient to the current per unit width of the surface; potential gradient is measured in the direction of current flow in the material; is numerically equal to the surface resistance between two electrodes forming opposite sides of a square of the material; size of the square is irrelevant over a wide range of sizes; units are ohms per square (ohms/square)

topical antistats

chemical agents that, when applied to surfaces of insulative materials, reduce the ability of those surfaces to accumulate electrostatic charge; usually act by increasing the surface lubricity of the material

NOTE: A secondary effect of one type of topical antistat, an ionic hygroscopic antistat, is usually to increase surface conductivity, thereby delocalizing any triboelectric charge produced and allowing a slow bleed-off of charge, if the surface of the material is properly grounded.

triboelectric charging

generation of electrostatic charges when two materials make contact or are rubbed together, then separated

triboelectric test

test of the charge transfer between items; triboelectric tests are frequently employed to determine the propensity for ESD damage due to triboelectric charging

volume resistivity

inverse measure of the conductivity of a material equal to the ratio of the potential gradient to the current density, where the potential gradient is measured