



Designation: E1549/E1549M – 13 (Reapproved 2022)

Standard Specification for ESD Controlled Garments Required in Cleanrooms and Controlled Environments for Spacecraft for Non-Hazardous and Hazardous Operations¹

This standard is issued under the fixed designation E1549/E1549M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This document specifies special items of clothing (cleanroom garments) designed to protect aerospace products from electrostatic discharge and from contaminants released by personnel and garments. Special clothing includes low linting coveralls, footwear, and head covers.

1.2 The function of cleanroom garments is to contain the contaminants generated by people and to minimize contaminants from the garments.

1.3 Two types of fabrics can be selected for the garments. Both types are inherently static-dissipative materials to prevent electrical discharges that can damage sensitive hardware or initiate explosions in the presence of flammable vapors. The material specified for “hazardous environments” is flame resistant and provides additional protection to the wearer. Selection of garment design and fabric should be based on the user’s needs with respect to functional and environmental requirements.

1.4 Additional background information can be found in SD-TR-91-26 and IEST-RP-CC003.3.

1.5 *This standard is intended to be in compliance with the ASTM policy on Fire Standards.² Flammability tests specified in this standard should be used to measure and describe the properties of fabrics in response to heat and flame under controlled laboratory conditions and should not be used to describe or appraise the fabrics under actual fire conditions. However, results of the tests may be used as elements of a fire risk assessment which takes into account all of the factors which are pertinent to an assessment of the fire hazard of operations in controlled environment areas.*

¹ This specification is under the jurisdiction of ASTM Committee E21 on Space Simulation and Applications of Space Technology and is the direct responsibility of Subcommittee E21.05 on Contamination.

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² ASTM Fire Standards and Related Technical Material; 7th Edition, June 2007, ISBN13: 978-0-8031-5684-5, available on request from ASTM Headquarters, 100 Barr Harbor Dr., PO Box C700, West Conshohocken, PA 19428-2959.

1.6 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard.

1.7 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.8 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 ASTM Standards:³

- D123 Terminology Relating to Textiles
- D204 Test Methods for Sewing Threads
- D1683 Test Method for Failure in Sewn Seams of Woven Fabrics
- D1894 Test Method for Static and Kinetic Coefficients of Friction of Plastic Film and Sheet
- D2257 Test Method for Extractable Matter in Textiles
- D5034 Test Method for Breaking Strength and Elongation of Textile Fabrics (Grab Test)
- D6193 Practice for Stitches and Seams
- D737 Test Method for Air Permeability of Textile Fabrics
- E96/E96M Test Methods for Gravimetric Determination of Water Vapor Transmission Rate of Materials
- E176 Terminology of Fire Standards
- E535 Practice for Preparation of Fire-Test-Response Standards

³ For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard’s Document Summary page on the ASTM website.

E1560 Test Method for Gravimetric Determination of Non-volatile Residue From Cleanroom Wipers

F51 Test Method for Sizing and Counting Particulate Contaminant In and On Clean Room Garments

F739 Test Method for Permeation of Liquids and Gases Through Protective Clothing Materials Under Conditions of Continuous Contact

F1506 Performance Specification for Flame Resistant and Electric Arc Rated Protective Clothing Worn by Workers Exposed to Flames and Electric Arcs

2.2 *U.S. Federal Standards:*⁴

CFR Title 16 Part 1610 Standard for the Flammability of Clothing Textiles

A-A 50195 Thread, Aramid

FED-STD-209E Airborne Particulate Cleanliness Classes in Cleanrooms and Clean Zones

2.3 *U.S. Department of Defense:*

MIL-C-43122G Cloth, Sateen, Cotton, Flame Retardant Treated⁵

MIL-DTL-43685C Webbing and Tape, Textile, Aramid Fiber⁵

MIL-STD-3010B Test Procedures for Packaging Materials⁵

SD-TR-89-63 Standard Methods for Measurement of Non-volatile Residue on Surfaces, E. N. Borson, E. J. Watts, G. A. To; U.S. Air Force, Space Systems Division, 10 Aug. 1989⁶

SD-TR-91-26 Garment Selection for Cleanrooms and Controlled Environments for Spacecraft, E. J. Watts, U.S. Air Force, Space Systems Division, 1 April 1991⁶

2.4 *NASA:*

KSC-SPEC-P-0016 Specification for Minimum Requirements for Garment Snap Fastener⁷

KSC-MMA-1985-79, Revision 6, Standard Test Method for Evaluating Triboelectric Charge Generation and Decay⁷

NASA-STD-6001 Flammability, Offgassing, and Compatibility Requirements and Test Procedures, Upward Flame Propagation Test (Test 1)⁸

2.5 *Others:*

ANSI/ESD S20.20 Standard For the Development of an Electrostatic Discharge Control Program for Protection of Electrical and Electronic Parts, Assemblies and Equipment (Excluding Electrically Initiated Explosive Devices)⁹

ESD ADV1.0-2009 ESD Association Advisory for Electrostatic Discharge Terminology, Glossary⁹

IEST-RP-CC-003.3 Garments Required In Cleanrooms And Controlled Environment Areas¹⁰

IEST-RP-CC022.2 Electrostatic Charge in Cleanrooms and Other Controlled Environments¹⁰

NFPA 70E Electrical Safety in the Workplace¹¹

2.6 *International Standards:*¹²

ISO 14644-1 Cleanrooms and Associated Controlled Environments, Classification of Air Cleanliness

ISO 14644-2 Cleanrooms and Associated Controlled Environments-Specifications for testing and monitoring to prove continued compliance with ISO 14644-1

3. Terminology

3.1 Terminology related to textiles is based on Terminology **D123**. Terminology related to fire safety is based on Terminology **E176**.

3.2 *General Definitions:*

3.2.1 *cleanroom, n*—an area in which the airborne particle concentrations, temperature, humidity, molecular species, pressure, activities, and other environmental parameters are controlled, as required, to produce acceptable products.

3.2.1.1 *Discussion*—The use of HEPA, or better, filters are usually required for the incoming air, and the maximum allowable airborne particle concentrations are specified in accordance with the ISO 14644 standards.

3.2.2 *electrostatic discharge, ESD, n*—a high voltage electrical discharge that occurs when electrical charges accumulate on or in materials as a result of friction between materials.

3.2.3 *fiber, n*—a particle with a length to diameter ratio of ten or more. (See *textile fibers*.)

3.2.4 *gloss, n*—a shiny or lustrous appearance resulting from the tendency of a surface to reflect light at one angle more than at others.

3.2.5 *HEPA (high efficiency particulate air) filter, n*—a filter for air with a removal efficiency in excess of 99.97 % for 0.3-μm particles.

3.2.6 *NVR (nonvolatile residue), n*—quantity of residual soluble, suspended, and particulate matter remaining after the controlled evaporation of a volatile liquid at a specified temperature.

3.2.6.1 *Discussion*—The liquid is usually filtered through a membrane filter, of a specified size, before evaporation. The process used to determine the NVR may affect the quantitative measurement. Process factors include filter size, solvent, and the evaporation temperature and atmosphere. For this reason, the process must be defined. The NVR of fabrics is determined by extracting a specified quantity of fabric using a specified solvent. The solvent is then evaporated to determine the NVR extracted from the fabric. See *extractable matter*, 3.3.7, which is frequently used to describe NVR in fabrics.

3.2.7 *particle, n*—a solid or liquid object generally between 0.001 and 1000 μm (1 mm) in size.

⁴ Available from U.S. Government Printing Office, Washington, DC.

⁵ Available from U.S. Natick Research Development and Engineering Center, Natick, MA 07160-5014.

⁶ Reprints available from The Aerospace Corporation Library, P.O. Box 92957, El Segundo, CA 90009.

⁷ NASA Technical Standards Program Office, ED10, MSFC, AL, 35812; Online, available: <https://standards.nasa.gov/documents/ksc>

⁸ NASA Technical Standards Program Office, ED10, MSFC, AL 35812; Online, available: <https://standards.nasa.gov/documents/nasa>.

⁹ Available from Electrostatic Discharge Association 7900 Turin Road, Bldg. 3, Rome, NY 13440.

¹⁰ Available from the Institute of Environmental Sciences, 940 E. Northwest Highway, Mount Prospect, IL 60056.

¹¹ Available from National Fire Protection Association (NFPA), 1 Batterymarch Park, Quincy, MA 02169-7471, <http://www.nfpa.org>.

¹² Available from American National Standards Institute (ANSI), 25 W. 43rd. St., 4th Floor, New York, NY 10036. These standards supersede FED-STD-209E. The latter may still be used if mutually agreed to by customer and supplier.