



Standard Practice for Cleaning and Maintaining Controlled Areas and Clean Rooms¹

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1. Scope

1.1 This practice covers the procedures to be followed for the initial cleaning and normal maintenance of cleanrooms and controlled areas. This practice is applicable to aerospace clean areas where both particles and molecular films (NVR) must be controlled.

1.2 *Units*—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.

1.3 *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 and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 ASTM Standards:²

- D1193 Specification for Reagent Water
- E1234 Practice for Handling, Transporting, and Installing Nonvolatile Residue (NVR) Sample Plates Used in Environmentally Controlled Areas for Spacecraft
- E1235 Test Method for Gravimetric Determination of Nonvolatile Residue (NVR) in Environmentally Controlled Areas for Spacecraft
- E1549 Specification for ESD Controlled Garments Required in Cleanrooms and Controlled Environments for Spacecraft for Non-Hazardous and Hazardous Operations
- E1560 Test Method for Gravimetric Determination of Nonvolatile Residue From Cleanroom Wipers

- E2352 Practice for Aerospace Cleanrooms and Associated Controlled Environments—Cleanroom Operations
- F24 Test Method for Measuring and Counting Particulate Contamination on Surfaces
- F25 Test Method for Sizing and Counting Airborne Particulate Contamination in Cleanrooms and Other Dust-Controlled Areas
- F50 Practice for Continuous Sizing and Counting of Airborne Particles in Dust-Controlled Areas and Clean Rooms Using Instruments Capable of Detecting Single Sub-Micrometre and Larger Particles

2.2 IEST Standards:³

- IEST-RP-CC007 Testing ULPA Filters
- IEST-RP-CC016 The Rate of Deposition of Nonvolatile Residue in Cleanrooms
- IEST-RP-CC0018 Cleanroom Housekeeping and Monitoring Procedures
- IEST-RP-CC003 Garment System Considerations for Cleanrooms and Other Controlled Environments
- IEST-RP-CC026 Cleanroom Operations
- IEST-STD-CC1246D Product Cleanliness Levels and Contamination Control Program⁴

2.3 US Federal Standards:⁵

- FED-STD-209E Airborne Particulate Cleanliness Classes in Cleanrooms and Clean Zones⁶
- TT-I-735 Isopropyl Alcohol
- O-A-51 Acetone⁵

2.4 US Department of Defense Standards:⁵

- MIL-D-16791 Detergents, General Purpose (Liquid, Non-Ionic)

¹ This practice 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 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.

³ Available from Institute of Environmental Science and Technology (IEST), 5005 Newport Dr., Suite 506, Rolling Meadows, IL 60008-3841.

⁴ IEST-STD-CC1246D replaced MIL-STD-1246.

⁵ Available from Superintendent of Documents, US Government Printing Office, Washington, DC 20402.

⁶ Cancelled Nov. 29, 2001 and replaced with ISO 14644-1 and 14644-2. FED-STD-209E may be used by mutual agreement between buyer and seller. Available from U.S. Government Printing Office, Superintendent of Documents, 732 N. Capitol St., NW, Mail Stop: SDE, Washington, DC 20401. FS209E cleanroom classes are given for reference in parentheses after the ISO classes.

2.5 *International Standards:*⁷

- ISO 14644-1 Cleanrooms and Associated Controlled Environments—Part 1: Classification of Air Cleanliness
- ISO 14644-2 Cleanrooms and Associated Controlled Environments—Part 2: Specifications for Testing and Monitoring to Prove Continued Compliance with ISO 14644-1

3.1.5 *cleanroom, operational, n*—a cleanroom in normal operation, with all services functioning and with equipment and personnel, if applicable, present and performing their normal work functions in the room.

3.1.6 *clean facility, n*—the total real property required to accomplish the cleanroom functions.

3.1.6.1 *Discussion*—In addition to the cleanroom and associated clean areas, this includes utility rooms, storage areas, offices, lockers, wash-rooms, and other areas that do not necessarily require precise environmental control.

3.1.7 *controlled area, n*—an environmentally controlled area, operated as a cleanroom, but without the final stage of HEPA filters. Controlled areas would meet ISO Class 8.5 (FED-STD-209E equivalent to Class 300 000) per Table 1.

3.1.7.1 *Discussion*—Only rough filters (50 to 60 % efficiency) and medium efficiency filters (80 to 85 % efficiency) are required for a controlled area. The maximum allowable airborne particle concentrations in a controlled area are 11 100 000/m³ per ISO Class 8.5 for particles ≥0.5 μm and 92 500/m³ (2620 particles/ft³ per Class 300 000/ft³ (FED-STD-209E) for particles ≥5.0 μm.

3.1.8 *DI water, n*—deionized water (see Specification D1193).

3.1.9 *discrete-particle counter (DPC), n*— an instrument, such as an optical particle counter or condensation nucleus counter, capable of resolving responses from individual particles.

3.1.10 *HEPA filter, n*—(high-efficiency particulate air filter) a throwaway, extended-medium, dry-type filter in a rigid

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *clean zone, n*—a defined space in which the concentration of airborne particles is controlled to specified limits.

3.1.2 *cleanroom, n*—a room in which the air filtration, air distribution, utilities, materials of construction, equipment, and operating procedures are specified and regulated to control airborne particle concentrations to meet appropriate airborne particulate cleanliness classifications, as defined by ISO 14644-1.

3.1.3 *cleanroom, as-built, n*—a cleanroom that is complete and ready for operation, with all services connected and functional, but without equipment or operating personnel in the room.

3.1.4 *cleanroom, at-rest, n*—a cleanroom that is complete, with all services functioning and with equipment installed and operable or operating, as specified, but without operating personnel in the room.

⁷ Available from International Organization for Standardization (ISO), 1 rue de Varembe, Case postale 56, CH-1211, Geneva 20, Switzerland.

TABLE 1 Comparison of ISO 14644-1 and FED-STD-209E Cleanliness Classes

ISO Class N Nominal FS209E Class	Particle Concentrations Maximum Number of Particles per Cubic Meter / Cubic Foot of Air for Particle Sizes Equal to or Greater than the Stated Size					
	0.1 μm	0.2 μm	0.3 μm	0.5 μm	1 μm ^A	5 μm
ISO Class 1	10	2	—	—	—	—
ISO Class 2	100	24	10	4	—	—
FS209E Class 0.1	3	1	—	—	—	—
ISO Class 3	1000	237	102	35	8	—
FS209E Class 1	35	7	3	1	—	—
ISO Class 4	10 000	2370	1020	352	83	—
FS209E Class 10	350	75	30	10	2	—
ISO Class 5	100 000	23 700	10 200	3520	832	29
FS209E Class 100	3500 ^B	750	300	100	24	—
ISO Class 6	1 000 000	237 000	102 000	35 200	8320	293
FS209E Class 1000	35 000 ^B	7500 ^B	3000 ^B	1000	236	7
ISO Class 6.7 ^C	—	—	—	176 000	41 700	1470
FS209E Class 5000 ^B	—	—	—	5000	1180	42
ISO Class 7	—	—	—	352 000	83 200	2930
FS209E Class 10 000	—	—	—	10 000	2360	70
ISO Class 8	—	—	—	3 520 000	832 000	29 300
FS209E Class 100 000	—	—	—	100 000	23 600	700
ISO Class 8.5 ^C	—	—	—	11 100 000	2 630 000	92 500
FS209E Class 300 000 ^D	—	—	—	300 000	74 500	2620
ISO Class 9	—	—	—	35 200 000	8 320 000	293 000
FS209E Class 1 000 000 ^D	—	—	—	1 000 000	236 000	8280

^A No 1 μm designation is listed in FS209E Table 1 for particulate classes. The values shown are equivalents of the ISO values.

^B These values were not directly listed in FS209E. Allowances are made in FS209E for intermediate classes and associated calculations have been shown. If used, a notation should be made indicating that they have been derived.

^C ISO 14644-1 does not include Class 6.7 or 8.5. The values shown are equivalent to those derived for FED-STD-209E Class 5000 and 300 000.

^D FS209E does not include Class 300 000 and 1 000 000. The values shown are equivalents of the ISO values for ISO Class 8.5 and 9.

frame, having a minimum particle-collection efficiency of 99.97 % (that is, a maximum particle penetration of 0.03 %) for 0.3- μm particles of thermally generated DOP of specified alternative aerosol.

3.1.11 *HVAC, n*—heating, ventilating, and air conditioning.

3.1.12 *nonvolatile residue (NVR), n*—matter remaining after solvent containing such matter has been evaporated or cleaned.

3.1.13 *ULPA filter, n*—(ultra-low-penetration air filter) a throwaway, extended-medium, dry-type filter in a rigid frame, having a minimum particle-collection efficiency of 99.999 % (that is, a maximum particle penetration of 0.001 %) for particles in the size range of 0.1 to 0.2 μm , when tested in accordance with the methods of IES-RP-CC007.1.

4. Significance and Use

4.1 This practice identifies methods for cleaning and maintaining controlled areas and clean rooms as defined by ISO 14644-1 and ISO 14644-2. Cleaning procedures are described, and cleaning frequency for different classes of facility are given. Compliance with this practice will make it easier and more likely that the required level of facility cleanliness will be maintained. A cleaner facility also will help to protect flight hardware from contamination and should reduce the frequency for cleaning flight hardware. This practice does not discuss operation and operational procedures for cleanrooms and controlled areas. Other documents such as IEST-RP-CC026 and Practice E2352 provide recommended practices for operating cleanrooms and controlled areas.

5. Cleanrooms and Clean Zones

5.1 *Airborne Particle Concentrations*—The types of cleanrooms and clean zones used in this practice are based on airflow, air filtration, and airborne particle concentration limits. The classification of airborne particle concentration limits in cleanrooms, clean zones, and controlled areas are defined in Table 1 which is based on ISO 14644-1 and ISO 14644-2.

	Airflow	Air Filtration	Typical Airborne Particle Concentration Limits Under Operational Conditions In Accordance With ISO 14644-1
Type I	Unidirectional, formerly known as "laminar flow"	HEPA or ULPA filtered with prefilters	Classes less than 7 (Classes less than 10 000 per FED-STD-209E)
Type II	Nonunidirectional, formerly known as "turbulent" flow	HEPA filtered with prefilters	Classes 7 to 8.5 (Classes 10 000 to 300 000 per FED-STD-209E)
Type III	Nonunidirectional	without HEPA or ULPA filters but with prefilters	Classes 8 to 8.5 (Classes 100 000 to 300 000 per FED-STD-209E)

5.2 *NVR Concentrations*—There are two categories for NVR requirements in clean areas:

5.2.1 *Category I*—Critical clean areas that require specific control and removal of molecular contaminants because of products that either are very sensitive to NVR or can not be cleaned. Quantitative NVR measurements may be required as defined in IEST-STD-CC1246D and IES-RP-CC016. NVR deposition criteria are defined in Tables 2 and 3.

5.2.2 *Category II*—Standard clean areas that do not require quantitative measurements of NVR. All aerospace clean facilities, including support shops for the fabrication of components for aerospace hardware, must limit the deposition of nonvolatile residue (NVR), also known as molecular films. The cleaning supplies recommended in this practice are selected for the minimal production of NVR.

5.2.2.1 Some clean areas require very low levels of NVR to be compatible with product cleanliness requirements. These areas require cleaning methods that will remove NVR. The user will state when Category I is required and allowable levels of NVR on surfaces, that is, NVR level in accordance with