



Designation: E 2042 – 99

Standard Practice for Cleaning and Maintaining Controlled Areas and Clean Rooms¹

This standard is issued under the fixed designation E 2042; 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 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 The values stated in SI units are to be regarded as 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:

- D 1193 Specification for Reagent Water²
- E 1234 Practice for Handling, Transporting, and Installing Nonvolatile Residue (NVR) Plates Used in Environmentally Controlled Areas for Spacecraft³
- E 1235 Test Method for Gravimetric Determination of Nonvolatile Residue (NVR) in Environmentally Controlled Areas for Spacecraft³
- E 1549 Specification for ESD Controlled Garments Required in Cleanrooms and Controlled Environments for Spacecraft for Non-Hazardous and Hazardous Operations³
- E 1560 Test Method for Gravimetric Determination of Nonvolatile Residue from Cleanroom Wipers³
- F 24 Method for Measuring and Counting Particulate Contamination on Surfaces⁴
- F 25 Test Method for Sizing and Counting Airborne Particulate Contamination in Clean Rooms and Other Dust-Controlled Areas Designed for Electronic and Similar Applications³
- F 50 Practice for Continuous Sizing and Counting of Airborne Particles in Dust-Controlled Areas and Clean Rooms

Using Instruments Capable of Detecting Single Sub-Micrometer and Larger Particles³

2.2 IEST Standards:

- IEST-RP-CC007 Testing ULPA Filters⁵
- IEST-RP-CC016 The Rate of Deposition of Nonvolatile Residue in Cleanrooms⁵
- IEST-CC0018.2 Cleanroom Housekeeping and Monitoring Procedures⁵
- IEST-RP-CC003 Garment System Considerations for Cleanrooms and Other Controlled Environments⁵
- 2.3 US Federal Standards:
 - FED-STD-209 Airborne Particulate Cleanliness Classes in Cleanrooms and Clean Zones⁶
 - TT-I-735 Isopropyl Alcohol⁶
 - O-A-51 Acetone⁶

2.4 US Department of Defense Standards:

- MIL-STD-1246C Product Cleanliness Levels and Contamination Control Program⁶
- T.O. 00-25-203 Contamination Control of Aerospace Facilities, U.S. Air Force⁶
- MIL-D-16791 Detergents, General Purpose (Liquid, Non-Ionic)⁶

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 FED-STD-209.

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

¹ This practice is under the jurisdiction of ASTM Committee E-21 on Space Simulation and is the direct responsibility of Subcommittee E21.05 on Contamination.

Current edition approved Oct. 10, 1999. Published February 2000.

² *Annual Book of ASTM Standards*, Vol 11.01.

³ *Annual Book of ASTM Standards*, Vol 15.03.

⁴ Discontinued; see 1992 *Annual Book of ASTM Standards*, Vol 15.03.

⁵ Available from IEST, 940 E. Northwest Highway, Mount Prospect, IL 60056.

⁶ Available from Superintendent of Documents, US Government Printing Office, Washington, DC 20402.

operable or operating, as specified, but without operating personnel in the room.

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.

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 are Class M 7 (283 000) for particles $\square$ 0.5 μm and Class M 6.5 (100 000) for particles $\square$ 5.0 μm . This limit, for sizes $\square$ 5.0 μm , is 24 700 particles/ m^3 or 700 particles/ ft^3 .

3.1.8 *DI water, n*—deionized water.

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 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 *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 FED-STD-209. 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.

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 FED-STD-209.

	Airflow	Air Filtration	Typical Airborne Particle Concentration Limits Under Operational Conditions In Accordance With FED-STD-209
Type I	Unidirectional, formerly known as "laminar flow"	HEPA or ULPA filtered with prefilters	Classes less than M 5.5 (Classes less than 10 000)
Type II	Nonunidirectional, formerly known as "turbulent" flow	HEPA filtered with prefilters	Classes M 5.5 to M 7 (Classes 10 000 to 283 000)
Type III	Nonunidirectional	without HEPA or ULPA filters but with prefilters	Classes M 6.5 to 7 (Classes 100 000 to 283 000)

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 MIL-STD-1246 and IES-RP-CC-016.1. 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 MIL-STD-1246 ($\mu\text{g}/\text{cm}^2$ or $\text{mg}/0.1 \text{ m}^2$). Category II is assumed unless Category I is expressly specified.

TABLE 1 Airborne Particulate Cleanliness Classes

Class Name		0.1		0.2		Class Units		0.5		5	
SI	English	(m^3)	(ft^3)	(m^3)	(ft^3)	(m^3)	(ft^3)	(m^3)	(ft^3)	(m^3)	(ft^3)
M1		350	9.91	75.5	2.14	30.9	0.875	10.0	0.283	...	...
M1.5	1	1240	35.0	265	7.50	106	3.00	35.3	1.00	...	...
M2		3500	99.1	757	21.40	309	8.75	100	2.83	...	...
M2.5	10	12400	350	2650	75.0	1060	30.0	353	10.0	...	...
M3		35000	991	7570	214	3090	87.5	1000	28.3	...	...
M3.5	100	...	...	26500	750	10600	300	3530	100	...	...

TABLE 2 Product Cleanliness Levels for NVR Based on MIL-STD-1246C

NVR Level	NVR Limit ^A	
	Surface mg/0.1 m ²	Volume mg/L
A/100	0.01	0.1
A/50	0.02	0.2
A/20	0.05	0.5
A/10	0.1	1.0
A/5	0.2	2.0
A/2	0.5	5.0
A	1.0	10
B	2.0	20
C	3.0	30
D	4.0	40
E	5.0	50
F	7.0	70
G	10.0	100
H	15.0	150
J	25.0	250

^A1 mg/0.1m² = 1 µg/cm² = 0.929 mg/ft² = 10-nm-thick uniform film (ρ = 1 g/cm³).

TABLE 3 NVR Deposition Rates in Cleanrooms From IES-RP-CC016.1

NVR Rate Level	Maximum Average Deposition Rate
	mg·0.1 m ⁻² ·month ^{-1A}
I	0.10
II	0.30
III	1.0
IV	3.0
V	10

^AMonth = four weeks.

5.2.3 *NVR Verification*—Measurement of NVR in clean facilities may be done in accordance with Practice E 1234 and Test Method E 1235 or other methods that are compatible with the product requirements and types of NVR. Typical NVR compounds that are found in cleanrooms include hydrocarbons, esters, and silicones.

6. Materials Used

6.1 *Wipers, Cleanroom*, polyester or cellulose, low NVR and low particle generation.⁷

6.2 *Gloves, Cleanroom*, polyurethane, nitrile or latex.⁸

6.3 *Gloves, Cleanroom*, lint and powder free, latex.⁹

6.4 *Coveralls, Hoods, Shoe Covers*.¹⁰

⁷ The sole source of supply of the apparatus known to the committee at this time is Miracle Wipe 4000, Texwipe Alpha Wipe, Texwipe Alpha 10, Texwipe/ICP TX 4012, Anticon 100, Allter AI Sorb. If you are aware of alternative suppliers, please provide this information to ASTM Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend.

⁸ The sole sources of supply of the apparatus known to the committee at this time are Pioneer Trionic E-194, QRP Q095, Q125, and Q145 (according to length) and 27G-2700 (conductive) and Ansell-Edmont Nitrile. If you are aware of alternative suppliers, please provide this information to ASTM Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend.

⁹ Any available source not packaged in pink poly or other material that can transfer molecular contaminants.

¹⁰ Garments worn for maintenance should be the same type and quality as those worn by workers in the cleanroom during normal operations.

6.5 *Deionized Water*, shall have a minimum resistance of 50 000 ohms and be filtered to remove all particles greater than 30 µm in size. Total solids (both dissolved and undissolved) shall not exceed 25 ppm.

6.6 *Non-Ionic Detergent*, MIL-D-16791, Type 1.¹¹

6.7 *Isopropyl Alcohol*, TT-I-735, Grade A.

6.8 *Acetone*, ACS reagent STD11 or Federal Specification O-A-51.

6.9 *Buckets*, food grade, stainless steel or polypropylene or polyethylene. Buckets with two compartments are recommended.

6.10 *Mop*, synthetic sponge head, roller type, with corrosion resistant handle and mechanism; or polyvinyl acetate string mop.

6.11 *Vacuum Cleaning System*—Either a central facility with vacuum outlets in the cleanroom or a portable, HEPA-filtered, cleanroom vacuum with filters that have not been tested with DOP or other volatile aerosols.¹²

6.12 *Tacky Roll Mop*, for cleaning walls and ceiling. (**Warning**—Tacky roll mops can generate a static discharge and may be unsuitable in the presence of ESD sensitive items.)

7. Cleaning

7.1 Four types of cleaning operations are performed before clean operations can begin in cleanrooms: construction, preliminary, gross or primary, and final or precision cleaning.

7.2 A new facility must proceed through all four stages of cleaning.

7.3 If a cleanroom has been operated previously but has been shut down, has been decertified due to contamination, or is visibly dirty when observed from a distance of 2 to 3 m (6 to 9 ft) under normal room illumination, then both gross and final cleaning must be performed.

7.4 If a cleanroom that is in operation has been cleaned and meets current requirements but must be certified to a more stringent requirement then only a final cleaning is required. The final cleaning operations shall be continued until the requirements are met.

7.5 *Construction/Renovation Cleaning*:

7.5.1 Cleaning during the construction has been found to improve significantly the cleanliness within cleanrooms when they are placed in operation.

7.5.2 Construction shall be complete before the start of preliminary cleaning. Construction includes the installation of any utilities, sprinkler heads, penetrations, and all other permanent installations.

7.5.3 Debris and dust shall be removed frequently to prevent deterioration of room surfaces as a result of abrasion or

¹¹ The sole source of supply of the apparatus known to the committee at this time is Van Waters and Rogers 9N9 and GAF Corp. Igepal CO-630. If you are aware of alternative suppliers, please provide this information to ASTM Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend.

¹² The sole source of supply of the apparatus known to the committee at this time is Hako Minuteman KX series with filtered motor cooling air and Nilfisk GS series or Tornado Model 320. If you are aware of alternative suppliers, please provide this information to ASTM Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend.