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Standard Practice for Preparation of Aerospace Contamination Control Plans[1]

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1. Scope

1.1 This practice is intended to assist in the preparation of formal plans for contamination control, especially of aerospace critical surfaces. Requirements may be established at the systems level, either by the customer or the systems integrator, or at the subsystem level. Subsystem requirements may be imposed by the responsible subsystem supplier or they may be flowed down from the systems organization (4.7). The extent of detail and level of cleanliness required can vary with the particular application and type of hardware being built, but all aspects of contamination control must be included in a final plan. Therefore, each of the following elements must be considered for inclusion in a contamination control plan (CCP):

1.1.1 *Cleanliness requirements* for deliverable hardware addressing particulate, molecular, or biological contaminants or combination thereof. Specify contamination limits and any budget allocations.

1.1.2 *Implementation plans* to achieve, verify, and maintain the specified cleanliness requirements. Specify material and process controls, cleaning techniques, verification tests, protection and prevention plans, transportation controls, and corrective action for discrepancies.

1.1.3 *Environmental controls* including clean facilities to be used, facility maintenance, and monitoring schedule.

1.1.4 *Personnel and operational controls* including operating procedures, restrictions, training, motivation, and organizational responsibilities including the organization or individual for implementation and verification of the CCP.

2. Referenced Documents

2.1 *ASTM Standards:*

E 595 Test Method for Total Mass Loss and Collected Volatile Condensable Materials from Outgassing in a Vacuum Environment[2]

E 1216 Practice for Sampling for Surface Particulate Contamination by Tape Lift[2]

E 1235M Test Method for Gravimetric Determination of Nonvolatile Residue (NVR) in Environmentally Controlled Areas for Spacecraft[2]

E 1549M Specification for ESD Controlled Garments Required in Cleanrooms and Controlled Environments for Spacecraft for Non-Hazardous and Hazardous Operations[2]

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-Micrometre and Larger Particles[2]

F 303 Practices for Sampling Aerospace Fluids from Components[2]

F 312 Methods for Microscopical Sizing and Counting Particles from Aerospace Fluids on Membrane Filters[3]

2.2 *Government Standards:*

FED-STD-209 Airborne Particulate Cleanliness Classes in Cleanrooms and Clean Zones[4]

MIL-STD-1246 Product Cleanliness Levels and Contamination Control Program[4]

USAF Tech Order 00-25-203 Contamination Control of Aerospace Facilities, U.S. Air Force[4]

NOTE 1—The Institute of Environmental Sciences has several Recommended Practices which may also be useful in the preparation of a CCP.

3. Terminology

3.1 *Definitions:*

3.1.1 *bidirectional reflectance distribution function (BRDF)*—the scattering properties of light reflected off surfaces, expressed as the ratio of differential outputs of radiance divided by differential inputs of radiance. Surface contaminants scatter the incident radiation in all directions and with variable intensities; BRDF is a method to quantify the spatial distribution of the scattered energy.

3.1.2 *biological contamination*—living material such as algae, bacteria, fungus, etc. which is capable of reproducing, thus being an increasing contaminant source.

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

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[2] *Annual Book of ASTM Standards*, Vol 15.03.

[3] *Annual Book of ASTM Standards*, Vol 14.02.

[4] Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.

3.1.3 *budget allocation*—the itemized summary of contamination accumulation for a given critical hardware item distributed over all phases from manufacture through end of performance lifetime.

3.1.4 *cleanroom*—an environmentally conditioned area where temperature, humidity, and airborne contaminants are controlled by design and operation. High Efficiency Particulate Air (HEPA) filters or better are usually required to achieve the air cleanliness level. Air particulate cleanliness is classified in accordance with FED-STD-209.

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

3.1.4.2 *at-rest cleanroom*—a cleanroom that is complete and ready for operation, with all services connected and functional, and with equipment installed and operable, as specified but without operating personnel in the cleanroom.

3.1.4.3 *operational cleanroom*—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 cleanroom.

NOTE 2—For batch operations, specific conditions and requirements should be noted for monitoring and control.

3.1.5 *clean zone*—a defined space in which the concentration of airborne particles is controlled to meet a specified airborne particulate cleanliness class.

3.1.6 *controlled area*—an area which does not require a high degree of temperature and humidity control but a semi-clean atmosphere is desired. Air conditioning is standard commercial design except that filtration is rated to 80–85 % for 1.0 micrometer and larger particles to control airborne contaminants. These areas shall not exceed the airborne particle concentration of Class M7 (Class 283,000) at 0.5 µm and Class M6.5 (Class 100,000) at 5.0 µm per FED-STD-209. Reference USAF Tech Order 00-25-203.

3.1.7 *facility*—the total real property required to accomplish the environmental control and operation of cleanrooms, clean zones, and controlled areas as well as administrative and personnel support.

NOTE 3—This includes the cleanroom proper, air locks, change rooms, parts cleaning, storage, HVAC equipment, offices, etc.

3.1.8 *HVAC*—Heating, Ventilating, and Air Conditioning.

3.1.9 *image analysis*—the measurement of size, shape, number, position, orientation, brightness and other parameters of small objects using the combination of an autofocusing microscope, an imaging sensor, and a dedicated computer system. Can be used to perform particle counts or measure particle dimensions automatically, with far greater accuracy than manual techniques.

3.1.10 *molecular contamination*—nonparticulate matter in the form of droplets or thin films which adversely affects component or system performance.

3.1.11 *nonvolatile residue (NVR)*—soluble material remaining after evaporation of a filtered volatile fluid or precipitate form a gas phase, usually reported in milligrams per unit area (or volume).

3.1.12 *particulate contamination*—small discrete mass of solid matter, usually measured in micrometers (µm), which adversely affects component or system performance.

3.1.13 *precision cleaning*—cleaning of hardware surfaces by approved engineering methods to meet specific cleanliness criteria.

3.1.14 *visibly clean*—absence of particulate or molecular contaminants when viewed from a specified distance with normal (or corrected to normal) vision with a specified illumination level.

4. Contents of CCP

4.1 *General Items and Information*:

4.1.1 All CCPs shall include an introduction or scope specifying the contamination-sensitive component(s) or system(s) being addressed, a list of applicable documents, and a list of definitions including any acronyms and abbreviations used in the document.

4.1.2 The level of detail required and the nature and extent of controls needed depends upon a number of factors. The systems organization or systems integrator has a better overview of contamination limitations, sensitivity of specific components and hardware, and total mission requirements than sub-tier suppliers. Contamination limits for total systems are the primary responsibility of the systems organization. Final contamination limits at delivery of the integrated system and at end of life should be established by agreement between the purchaser and systems supplier. Each supplier is responsible for defining and controlling the contamination level of the particular hardware being supplied, with the approval of the systems organization, in addition to requirements levied by the systems integrator.

4.1.3 The buyer and seller should agree on the contents and implementation of the CCP before any parts are processed beyond the first cleaning or inspection point. Suppliers of subsystems and components should prepare Contamination Control Plans so that the functional requirements of the hardware are protected. If a subsystem is particularly sensitive to contamination, there must be adequate controls and compliance with system contamination requirements. Examples of sensitive subsystems include optical or non-optical sensors, gyros, thermal control systems, liquid propellant systems, and cryogenic devices.

4.1.4 Some subsystems are relatively insensitive to contamination. These should be identified and justifications given for limited contamination control efforts. Even if a particular subsystem or hardware is not sensitive to contamination it must not be a source of contamination for other, more sensitive or critical hardware. Also it is important that system performance or contamination allowables not be degraded by contaminants emanating from contamination tolerant hardware.

4.2 *Cleanliness Requirements*:

4.2.1 Cleanliness requirements must be specified for deliverable components or systems addressing particulate, molecular, or biological contaminants, or combination thereof. Primary responsibility for contamination control remains with the hardware or subsystem supplier. Levels of control and allowable types and quantities of contaminants shall be as agreed by the supplier and systems organization when applicable. Specify