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KSC Payload Facility Contamination Control Requirements/Plan

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APPROVAL PAGE

for

KSC Payload Facility
Contamination Control Requirements/Plan

CONCURRENCE:

[redacted]

Materials & Processes/Contamination Control — Chief, Laboratories & Test Facilities

[redacted]

Materials & Processes/Contamination Control — Chief Engineer for Launch Services

[redacted]

Chief Engineer for ISS and Orion Ground Processing, Engineering — Chief Engineer for GSDO Program, Engineering

APPROVED:

[redacted]

Director, Exploration Research and Technology Programs

[redacted]

Manager, Launch Services Program

[redacted]

Manager, Ground Systems Development and Operations Program

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ABBREVIATIONS AND ACRONYMS

The following abbreviations and acronyms are used in this plan.

ASTM	American Society for Testing and Materials
CCAFS	Cape Canaveral Air Force Station
CCE	Contamination Control Engineer
CCZ	Class Clean Zone
CWA	Clean Work Area
DOP	Dioctyl Phthalate
FTIR	Fourier-Transform Infrared Spectroscopy
GC	Generally Clean
GSE	Ground Support Equipment
HEPA	High Efficiency Particulate Air (filter)
HVAC	Heating, Ventilation, and Air Conditioning
ISO	International Organization for Standardization
KSC	John F. Kennedy Space Center
LCA	Localized Control Area
LSP	Launch Service Program
M&P	Materials and Processes
MPPF	Multi-Payload Processing Facility
µm	micrometer/micron
mg	milligrams
NASA	National Aeronautics and Space Administration
NVR	Non-Volatile Residue
NSSD	NASA Spacecraft Services Depot

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ABBREVIATIONS AND ACRONYMS (continued)

PAC	Percent Area Coverage
PHSF	Payload Hazardous Servicing Facility
PPF	Payload Processing Facility
ppm	parts per million
PRD	Program Requirements Document
SSPF	Space Station Processing Facility
TOSC	Test and Operations Support Contract
VAFB	Vandenberg Air Force Base
VC	Visibly Clean
v/v	volume/volume

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SECTION I - INTRODUCTION

1.1 PURPOSE

The purpose of this KSC Payload Facility Contamination Control Requirements/Plan is to present the entire spectrum of contamination control as it relates to payload and launch vehicle facilities at the John F. Kennedy Space Center (KSC), including certain KSC areas at the Cape Canaveral Air Force Station (CCAFS) and Vandenberg Air Force Base (VAFB). This is accomplished by establishing the KSC standard for facility operational guidelines. This document also establishes the requirements for the monitoring and maintenance of environmental and cleanliness conditions for five levels of Clean Work Areas (CWAs) and their corresponding International Organization for Standardization (ISO) Class Clean Zones (CCZs). These guidelines and requirements are based upon existing facility capabilities and the maintenance levels necessary to maintain these capabilities and are not based upon flight hardware requirements. Each flight hardware processing area is assigned one of the five CWA levels or ISO CCZ classes (unless designated otherwise).

1.2 SCOPE

This plan addresses the National Aeronautics and Space Administration (NASA) Spacecraft and Launch Services Program (LSP) Payload Processing Facilities (PPFs) at KSC, CCAFS, and VAFB. The Payload Processing Facility at CCAFS is Hangar AE and the Payload Processing Facility at VAFB is Building 836, Lab 1. The Payload Processing Facilities at KSC are the Space Station Processing Facility (SSPF), the Multi-Payoad Processing Facility (MPPF), the Payload Hazardous Servicing Facility (PHSF), and the NASA Spacecraft Services Depot (NSSD).

1.3 AUTHORITY

This plan is prepared by the authority of the International Space Station (ISS) Exploration Research and Technology Programs (UB), Launch Services Program (VA), and NASA/KSC Engineering (NE) Directorates in order to identify KSC's capability to satisfy flight hardware requirements. Deviations and variances to this plan shall be accomplished as defined in the authority paragraphs of Test and Operations Support Contract (TOSC) DRD-4.9-1, *KSC Payload Processing Area Contamination Control Requirements/Implementation Plan* or the KPL-PLN-50008, the *Payload Facility Contamination Control Implementation Plan*. (Deviations or variances can be obtained through a memo until this plan is formally revised.)

1.4 RESPONSIBILITY

The responsibility for implementing this plan in payload facilities lies with NASA Designated Spacecraft/Payloads Processing Contractor(s) at KSC, CCAFS, and VAFB. In each of these areas, a single designated authority shall be responsible for the implementation of this plan.

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1.5 IMPLEMENTATION

The implementation requirements for specific KSC CWAs/CCZs are set forth in either KPL-PLN-50008, the *Payload Facility Contamination Control Implementation Plan* or in TOSC DRD-4.9-1, *KSC Payload Processing Area Contamination Control Requirements/Implementation Plan*. The implementation of these plans will be by work authorization documents.

1.6 REFERENCES

The current issue of each reference document is applicable.

a. ASTM-D1356, *Atmospheric Sampling and Analysis*

b. ASTM-E1234, *Standard Practice for Handling Transporting, and Installing Nonvolatile Residue (NVR) Sample Plates Used in Environmentally Controlled Areas for Spacecraft.*

c. ASTM-E1235, *Standard Test Method for Gravimetric Determination of Nonvolatile Residue (NVR) in Environmentally Controlled Areas for Spacecraft*

d. ASTM-F25, *Sizing and Counting Airborne Particulate Contamination in Clean Rooms and Other Dust-Controlled Areas Designed for Electronic and Similar Applications*

e. ASTM-F50, *Continuous Sizing and Counting of Airborne Particles in Dust Controlled Areas Using Instruments Based Upon Light-Scattering Principles*

f. NSTS SN-C-0005, *Space Shuttle Contamination Control Requirements (NASA Legacy Document)*

g. KPL-PLN-50008, *Payload Facility Contamination Control Implementation Plan*

h. KSC-C-123, *Surface Cleanliness of Fluid Systems*

i. KSC-PLN-3442, *Ground Operations Processing Non-Flight Materials and Equipment Approved for Use in Clean Work Areas*

j. IEST-STD-CC1246E, *Product Cleanliness Levels - Applications, Requirements, and Determination*

j. FED-STD-209, *Airborne Particulate Cleanliness Classes in Cleanrooms and Clean Zones (Legacy Document)*

k. ISO 14644-1, *Cleanrooms and Associated Controlled Environments – Part 1: Classification of Air Cleanliness*

l. TOSC DRD-4.9-1, *KSC Payload Processing Area Contamination Control Requirements/Implementation Plan*

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m. OP-0031, *Design Modification Process*

1.7 DEFINITIONS

Definitions of terms used in this plan are contained in the Glossary, Appendix A.

1.8 TAILORING AND WAIVERS

Individual provisions of this document should be and are intended to be modified to meet specific program and mission needs. All tailoring shall be evaluated for use by Launch Service Program and/or NASA Materials & Processes (M&P)/Contamination Control Engineering Authority. Waivers to requirements shall follow OP-0031, *Design Modification Process*.

1.9 REVISION AND CONTROL

This document is under configuration control (per KNPR 8040.4). Comments and corrections should be directed to:

National Aeronautics and Space Administration
Mail Code NE-L4/Carol Waddell
Kennedy Space Center, Florida 32899
Telephone: (321) 861-4231
E-Mail:mailto: carol.a.waddell@nasa.gov

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SECTION II - CONTAMINATION CONTROL

2.1 TYPES OF CONTAMINATION

2.1.1 GENERAL

This section describes the various types of contamination that are regularly monitored in KSC, CCAFS, and VAFB facilities. These include both airborne contaminants and surface depositions. Airborne contaminants are generally dependent on the facility air conditioning and filtration system. However, airborne particle counts and volatile hydrocarbon levels have been shown to be heavily impacted by processing operations within a facility. To the payload customers, surface depositions on sample plates or surfaces are of greater concern. Although depositions on flight hardware are related to the facility air conditioning and filtration system, a strong correlation exists between surface deposition and operational activities and controls. It should be noted that even in the cleanest of facilities with minimal activities and strict controls, particle fallout will occur and continue to accumulate over a period of time.

2.1.2 AIRBORNE PARTICULATE MATTER

2.1.2.1 Description

Airborne particulate matter is matter suspended in the ambient atmosphere. These particles are usually very small, i.e., submicron to approximately 30 microns in size. This particulate type can best be described as an "aerosol" - a description of solid or liquid particles in a gaseous media (ASTM-D1356, *Atmospheric Sampling and Analysis*). Airborne particles are inclined, to some degree, to settle out of circulating air.

2.1.2.2 Source

Airborne particles consist of environmental soils such as dust, smoke, and mists from both natural and man-made processes. Additional sources include skin and clothing particles from personnel as well as particles generated by friction between surfaces or deterioration of materials in the area.

2.1.2.3 Measurement

Airborne particulates are monitored with electronic particle counters per ISO 14644-1, *Cleanrooms and Associated Controlled Environments – Part 1: Classification of Air Cleanliness*, or FED-STD-209, *Airborne Particulate Cleanliness Classes in Cleanrooms and Clean Zones (Legacy Document),* to assure that the facility air filtration system is fully functional and that work, housekeeping, and personnel procedures are effectively controlling generated airborne contamination.

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2.1.3 SURFACE PARTICULATE MATTER

2.1.3.1 Description

Surface particulate matter is matter deposited on the surface of an item.

2.1.3.2 Source

Particles are generated by personnel, particle producing operations, and environmental soils introduced into the facility. Specific sources include such items as paper, clothing fibers, lint, hair, dust, chipping and flaking of finishes, and friction surfaces. Particles may be deposited by fallout from overhead operations; may be generated at the surface by handling, touching, or deterioration of the finish or materials; or, may be produced by adjacent operations.

2.1.3.3 Measurement

Three methods are normally used to measure surface particulate matter:

a. The surface is cleaned using a solvent flush. The solvent is filtered and the particles on the filter sized and counted. The results are given as the number of particles (within the specific size range) per square foot.

b. Particle fallout filters or wafers are placed in an area for a period of time to collect particle fallout. The filters are examined microscopically or the filters/wafers are scanned electronically. Particles/fibers are sized and counted in the following ranges: 50-100 µm, 100-250 µm, 250-500 µm, 500-750 µm, 750-1000 µm, and >1000 µm. (Size ranges may vary based on customer requirements). Results are expressed as the number of particles and fibers (within the specified size range) per square foot/meter per day or as Percent Area Coverage (PAC). The data shall be converted per IEST-STD-CC1246E, *Product Cleanliness Levels - Applications, Requirements, and Determination,* to the average number of particles and fibers (in each size range) per square foot/meter for each 24-hour period. The Percent Area Coverage (PAC) can then be calculated and the level determined.

c. The surface is visually inspected for the level of cleanliness option desired per the Visibly Clean (VC) criteria in Appendix B. Results are expressed in terms of pass/fail.

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2.1.4 NON-VOLATILE RESIDUE (NVR)

2.1.4.1 Description

NVR is soluble (or suspended) material and insoluble particulate matter remaining after controlled evaporation of a filtered volatile liquid.

2.1.4.2 Source

Sources include plasticizers from non-metallic materials, oil fumes from electric or pneumatic motors, air systems, hydraulics, lubrication oils and greases, diesel fumes, vacuum pumps, skin oils, and similar materials.

2.1.4.3 Measurement

Per ASTM–E1234, *Standard Practice for Handling Transporting, and Installing Nonvolatile Residue (NVR) Sample Plates Used in Environmentally Controlled Areas for Spacecraft*, stainless steel witness plates are exposed to the facility environment for a known time interval (usually 4 weeks). During exposure, molecular contamination deposits on witness plate critical surfaces. Witness plates are then collected and delivered to the analysis laboratory where they are analyzed per the ASTM-E1235, *Standard Test Method for Gravimetric Determination of Nonvolatile Residue (NVR) in Environmentally Controlled Areas for Spacecraft*. This process involves rinsing with a low NVR solvent such as methylene chloride or ethyl acetate to remove collected residues. The solvent is then filtered and evaporated. The NVR weight is normally determined by standard gravimetric techniques and results are expressed as mg/0.1m^2/month.

2.1.5 VOLATILE HYDROCARBONS

2.1.5.1 Description

Volatile gaseous hydrocarbons are those gaseous hydrocarbons dispersed in the atmosphere. Methane and propane are common examples of volatile hydrocarbons.

2.1.5.2 Source

Naturally occurring and man-made sources in the air are generated by decomposition, combustion and volatile solvents, paints, and internal combustion engines. Volatile hydrocarbons are not removed by the High Efficiency Particulate Air (HEPA) filters, but are reduced by control of the source.

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2.1.5.3 Measurement

A sample of facility atmosphere is drawn into an evacuated sample container or on-site analyzers. The sample is either analyzed in place or is transported to a laboratory where analysis is accomplished by flame ionization techniques. Results are reported in parts per million (ppm) volume/volume (v/v) methane equivalent.

Photo ionization detectors or Fourier Transform Infrared (FTIR) Spectroscopy may be used to obtain volatile hydrocarbon measurements when real time data is required and safety considerations prevent the use of flame producing detectors.

2.1.6 MICROBIAL CONTAMINATION

2.1.6.1 Description

Microbial contamination includes biological materials such as bacteria (0.5 μm to 30 μm) and viruses (<0.1 μm).

2.1.6.2 Source

Microbial materials are introduced by the airflow from external sources, by personnel, and by environmental soils carried into the facility on personnel and equipment.

2.1.6.3 Measurement

Microbial monitoring of facilities will not be performed as a standard service at KSC, CCAFS, and VAFB. Decayed or living matter deposited on surfaces within the facility will be classified as particulate matter and/or NVR. It will be monitored by the appropriate particulate and NVR tests.

2.2 CLEAN WORK AREAS (CWAs)/ISO CLASS CLEAN ZONES (CCZs)

Good housekeeping procedures and stringent personnel controls are required to maintain cleanliness. At KSC, the CWAs/CCZs contain vertical structures, portable Ground Support Equipment (GSE), movable platforms, overhead cranes, and other equipment not normally found in clean rooms. Therefore, CWAs/CCZs, while having a requirement for airborne particle counts, are not clean rooms. The CWAs/CCZs can be any part of a facility. To establish a uniform contamination control program, this plan defines five CWA/CCZ cleanliness levels/classes. It also defines environmental parameters for each level/class and requirements for operating, cleaning, and inspecting the work areas. This plan assigns one cleanliness level/class to each CWA/CCZ at KSC, CCAFS, and VAFB. Achieving and maintaining the required cleanliness level of a flight hardware element depends upon the type of CWA/CCZ, the maintenance rules used in the CWA/CCZ, and the element exposure time in the CWA/CCZ. Since some facilities accommodate multiple flight elements or serve many functions simultaneously, facility housekeeping procedures, environmental monitoring plans, and cleanliness level/class capabilities of facilities normally do not change from element processing flow to element processing flow. Variations in element cleanliness can, however, be affected by operational controls implemented in the vicinity of sensitive space flight hardware.

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2.3 CWA/CCZ EQUIPMENT AND GSE

The cleanliness of equipment, such as fixed and portable platforms, flight element handling devices, cranes, crane rails, etc., is defined in terms of a surface cleanliness specification such as Visibly Clean (VC) or Generally Clean (GC). The cleanliness level of CWA/CCZ equipment shall be controlled by this plan.

2.3.1 INSPECTION. The equipment in KSC, CCAFS, and VAFB facilities must be inspected to verify that it meets the requirements specified in Section III. Cleaning is performed regularly, as specified in the applicable implementation plan, to maintain this level.

2.3.2 OPERATIONAL CONTROL

Control must be maintained over the operation of all ground equipment in order to minimize the possibility of contamination. Any contamination-producing operations must be identified and restrictions implemented. In cases where these operations are necessary and flight hardware is present, actions must be taken to minimize the spread of contamination and to alert the customers that the possibility of contamination exists. Institutional controls/restrictions must be implemented for crane maintenance when the facility design does not allow for normal cleanroom practices for entering the CWA.

2.4 CLEAN WORK STATIONS

Clean work stations or flow benches are designed to provide a small, clean work space in uncontrolled shop areas. When flow benches are used to process flight hardware, certification is required per Section III.

2.5 PAYLOADS

ISS payload/Spacecraft customers will define their payload's surface cleanliness levels per Appendix B (see NASA Legacy SN-C-0005 Equivalence for ISS payloads). Upon arrival in a KSC payload integration facility, payloads will be inspected by the Customer's Contamination Control Engineer or designated representative to verify compliance with the selected cleanliness level (see paragraph 3.8). These measures, combined with the monitoring program, are intended to maintain clean environments and clean payloads; however, even the best CWAs/CCZs cannot keep payloads clean indefinitely. For this reason, customers are encouraged to provide covers fabricated of approved materials for contamination sensitive areas of their payloads. If the entire payload is sensitive, a protective enclosure with purge capability should be provided. In addition, if requested, KSC may provide payload debris shields above and between payloads (configuration permitting) while in the Launch Vehicle Integration Facility .

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2.6 CONTAMINATION CONTROL PLAN

2.6.1 MONITORING PLAN FOR PAYLOAD CWAs/CCZs

Because a uniform monitoring program is required, the same methods of data collection, analysis, and reduction will be used to enable a comparison between the cleanliness levels of the different CWAs/CCZs. Temperature, humidity, airborne particles, particle fallout, NVR, and volatile hydrocarbon levels will be measured in all CWAs/CCZs using the monitoring methods described in paragraph 2.1. The frequency of measurement will depend upon the required cleanliness level of the CWA/CCZ (see Section III). Each CWA/CCZ should keep a log, in accordance with Section III, of any operational activities that could affect the cleanliness level of that facility during the monitoring program. These activities include door operations, crane operations, air bearing pallet operations, and platform operations. This log, in conjunction with the monitoring results, can be used to determine which types of operations are producing contamination.

2.6.2 INSPECTION PROGRAM

A regular inspection program is required to determine the surface cleanliness of the CWAs/CCZs, their accommodations (gas outlets, receptacles, etc.), and their anterooms. Inspections or walkdowns are performed to verify that surfaces meet the specified surface cleanliness.

2.6.3 PERSONNEL AND EQUIPMENT CONTROL

Personnel and equipment are known contamination generating sources. For this reason, personnel access and equipment entry to payload CWAs/CCZs are required to be rigidly controlled. Only personnel and equipment authorized for the task at hand should be allowed access. Some operations are personnel limited to control the number of personnel for cleanliness or safety reasons. All equipment to be used in CWAs/CCZs must be cleaned and inspected before entry into the CWA/CCZ. Appropriate clean room garments shall be worn to prevent the spread of particles from skin and clothing. A Localized Control Area (LCA) or anteroom air lock shall be installed immediately outside the entrance to a CWA/CCZ (applicable for CWA Levels 1 through 4 and CCZ Classes 6.7 through 8). The LCA shall provide, as a minimum, a clean environment to prepare for CWA/CCZ entrance, i.e., cleanroom garment changing, final cleaning of equipment/hardware and environmental protection of the CWA/CCZ from outside conditions.

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2.6.4 HOUSEKEEPING

A cleaning maintenance program is required to maintain the housekeeping of the CWAs/CCZs. This program, outlined in the implementation plans, will define frequency and methods to be used in inspecting and cleaning the floors, walls, and ceilings, as well as other structures and equipment in the CWAs/CCZs.

2.6.5 CORRELATION BETWEEN MONITORING, INSPECTION, CONTROL, AND HOUSEKEEPING

The results of the CWA/CCZ data collection and inspection will be correlated to operations to determine which operations cause significant contamination. Those operations that produce contamination can then be controlled, or stopped if necessary, to minimize the spread of the contamination. At a minimum, customers shall be made aware of the possibility of contamination that could be caused by those operations.

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SECTION III - REQUIREMENTS

3.1 CLEAN WORK AREA/ISO CLASS CLEAN ZONE REQUIREMENTS

This section delineates the minimum requirements for contamination monitoring, operations and maintenance, and cleanliness for each CWA/CCZ, the associated equipment, and the flight hardware therein. Table 3-1 gives the CWA/CCZ environmental requirements for CWA Levels 1 through 5 and CCZ Classes 6.7 to 8.5. When the contracting document is ISO 14644-1, reference the airborne particulate counts per cubic meter and when the contracting document is per FED-STD-209 (legacy document), reference the airborne particulate counts per cubic foot. Additionally, this section lists requirements for the initial certification of new facility CWAs/CCZs and "Return to Service" as a CWA/CCZ following extensive facility modification or deactivation periods. Heating, Ventilating, and Air Conditioning (HVAC) certification requirements are also provided in this section.

3.1.1 CONTAMINATION MONITORING PROGRAM

The general contamination monitoring requirements that establish a comprehensive and continuous monitoring and control program are provided in this section. Data shall be reduced and presented in an approved data format. During major facility modifications or when flight hardware is not present in the CWA/CCZ, monitoring may be suspended or relaxed. However, before flight hardware arrival at a CWA/CCZ, the facility must be recertified and the monitoring program must be reestablished using the procedures outlined in the implementation plans.

The facility CWA/CCZ monitoring program may be abbreviated with respect to monitoring frequency, or number of sites monitored, provided that the facility systems, maintenance levels, and operating procedures remain stable and that adequate data exists to characterize the cleanliness/environmental capability of the CWA/CCZ. Monitoring frequency requirements for particle fallout, NVR, and volatile hydrocarbons are specified in applicable implementation plan(s).

3.1.1.1 Airborne Particles

Airborne particle concentrations shall be determined using light scattering equipment within the CWA/CCZ during normal activities. The sample locations will be selected carefully to assure evaluation of the major work locations and representative areas of the room. The concentration of particles per cubic foot or per cubic meter will be determined for a minimum of two size ranges: 0.5 microns and greater and 5.0 microns and greater.

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3.1.1.2 Temperature and Humidity

Temperature and relative humidity values within the CWA/CCZ shall be monitored continuously and as specified in Table 3-1.

3.1.1.3 Particle Fallout

Particle fallout filters or wafers shall be placed in selected locations in the CWAs/CCZs. The values in Table 3-1 are the goals of this program.

3.1.1.4 Non-volatile Residue

NVR witness plates shall be placed in the CWAs/CCZs. Analysis of NVR witness plates will be accomplished by the method outlined in paragraph 2.1.4.3.

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Table 3-1. KSC CWA/CCZ Environmental Requirements [1]

CLEAN WORK AREA LEVELS/ ISO CLASS CLEAN ZONES		Level #1	Level #2	Level #3	Level #4	Level #5
ISO14644 CLASS		ISO14644 Class 6.7	ISO14644 Class 7	ISO14644 Class 7.7	ISO14644 Class 8	ISO14644 Class 8.5
[FED-STD-209 Class (Legacy Document)]		(Class 5K)	(Class 10K)	(Class 50K)	(Class 100K)	(Class 300K)
PARAMETER	Air Flow	Laminar	Laminar	Non-Laminar	Non-Laminar	Non-Laminar
Maximum Airborne Particle Counts (ISO14644 - per m^3) [FED-STD-209 - per ft^3]	Req. ≥ 0.5 µm	176,000 [5,000]	352,000 [10,000]	1,760,000 [50,000]	3,520,000 [100,000]	11,100,000 [300,000]
	Req. 5.0 m	1,470 [35]	2,930 [70]	14,700 [350]	29,300 [700]	92,500 [1,000]
	Monitoring	Continuous	Continuous	Continuous	Continuous	Monthly
Temperature (°C) [°F] [3]	Requirement	22±3 [71±6]	22±3 [71±6]	22±3 [71±6]	22±3 [71±6]	22±3 [71±6]
	Monitoring	Continuous	Continuous	Continuous	Continuous	Monthly
Relative Humidity (%) [3] [5] [6]	Requirement	30 Min to 60 Max	30 Min to 60 Max	30 Min to 60 Max	30 Min to 60 Max	30 Min to 60 Max
	Monitoring	Continuous	Continuous	Continuous	Continuous	Monthly
Maximum Particle Fallout [2]	Goal	Level 200	Level 200	Level 500	Level 750	N/A
	Monitoring [4]	Continuous	Continuous	Continuous	Continuous	N/A
Maximum NVR (mg/0.1m^2/month)	Requirement	1	1	1	1	N/A
	Monitoring [4]	Continuous	Continuous	Continuous	Continuous	N/A
Maximum Volatile Hydrocarbons (ppm) (v/v)	Requirement	15	15	15	15	N/A
	Monitoring [4]	Monthly	Monthly	Monthly	Monthly	N/A
Minimum Positive Pressure [7]	Requirement	0.05 in H_2O	0.05 in H_2O	0.05 in H_2O	0.02 in H_2O	N/A
	Monitoring	Continuous	Continuous	Continuous	Continuous	N/A
Minimum Air Changes [3]	Requirement	20/Hour	20/Hour	6/Hour	4/Hour	2/Hour

[1] During periods of operation
[2] Levels per IEST-STD-CC1246E for a 24 hour period
[3] Program Specific Requirements may supersede these requirements
[4] As specified by KPL-PLN-50008
[5] No work will be performed on ESD sensitive equipment below 30% Relative Humidity levels
[6] No emergency notification required if Relative Humidity levels fall below 30% during non-processing periods
[7] Differential pressure of water minimum with all doors and pass-throughs closed (except when HVAC system is configured in a launch abort safety mode)
NOTE: Continuous monitoring means data collection is continuous

RELEASED - Printed documents may be obsolete; validate prior to use.

3.1.1.5 Volatile Hydrocarbons

Volatile hydrocarbon samples shall be taken every month, at a minimum, and analyzed per the methods discussed in paragraph 2.1.5.3.

3.1.1.6 Positive Pressure

Pressure differentials shall be monitored continuously in most CWAs/CCZs to verify that the air flow is from the inside to the outside of the area thus preventing an influx of contaminants. Positive pressure will be monitored continuously (except for CWA Level 5 and CCZ Class 8.5) and recorded periodically.

3.1.2 INSPECTIONS

Inspections will be performed at the prescribed intervals to verify that the CWAs/CCZs meet the Visibly Clean (reference Appendix A) cleanliness level. As a result of these inspections, any nonconformance will be reported in the approved format which includes: time, date, location, and nature of the nonconformance.

3.2 OPERATIONS AND MAINTENANCE REQUIREMENTS

Table 3-2 gives the minimum operations and maintenance requirements for the CWA/CCZ levels/classes. These requirements cover garments worn in the CWAs/CCZs; the cleanliness level/class of the CWAs/CCZs; and the inspection and cleaning of the floors, walls, ceilings, platforms, and cranes in the CWAs/CCZs. More specific requirements and rules are given in the applicable implementation plan.

3.3 FACILITY CLEANLINESS REQUIREMENTS

Table 3-3 assigns the appropriate cleanliness and maintenance levels/classes to any facility or portion of a facility involved in the processing of space flight hardware. These facilities must meet the requirements specified by that level/class. Occasionally, slightly more or less stringent requirements may be imposed upon the facility by a particular customer, per a Program Requirements Document (PRD) or other source such as a mission specific requirements document, which would then supersede this plan. Additional operational controls may be imposed to meet more stringent requirements. In no case will a requirement be accepted, however, that is beyond the design capability of a facility. Should a CWA/CCZ not be able to meet a requirement due to design limitation, waivers must be obtained from the applicable KSC operations directorate or office.

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3.4 GROUND SUPPORT EQUIPMENT REQUIREMENTS

Periodic inspection and cleaning of ground support equipment such as fixed and portable platforms, payload handling devices, cranes, crane rails, doors, and HVAC systems is required; specific rules are given in the applicable implementation plan.

3.4.1 INSPECTIONS

During operational periods or when flight hardware is present, inspections shall be performed at regular intervals to verify that the ground support equipment is at the proper cleanliness level. As a result of this inspection, any nonconforming condition shall be reported and will include the time, date, location, and the improper condition. This report will be sent to the responsible organization and corrective action taken on the improper condition within 24 hours.

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Table 3-2. KSC CWA/CCZ Operations and Maintenance Minimum Requirements

CWA/CCZ Levels/Classes		CWA 1 & 2/ CCZ 6.7 & 7	CWA 3 & 4/ CCZ 7.7 & 8	CWA 5/ CCZ 8.5
Cleanliness Level		VC	VC	GC
Clean Room Clothing *	Garments	Coveralls	Smocks	Smocks (Opt)
	Head Covering	Hoods	Caps/Hoods	Caps/Hoods(Opt)
	Shoe Covering	Booties	Booties (Opt)	Booties (Opt)
	Gloves	Optional	Optional	Optional
Personnel Access		Limited	Limited	Limited
Operations		Rigidly Controlled	Rigidly Controlled	Controlled
Tools and Fixtures		Rigidly Controlled	Rigidly Controlled	Controlled
Material Entry		Rigidly Controlled	Rigidly Controlled	Controlled
Floors (Including Platform Floors)	Inspection	Weekly	Weekly	Monthly
	Vacuum	Daily	Twice Weekly	Weekly
	Damp Mop	Daily	Twice Weekly	Weekly
Walls & Ledges Below 3.7 m (12')	Inspection	Monthly	Monthly	3 Months
	Cleaning	Weekly	As Required	As Required
Walls & Ledges Above 3.7 m (12') **	Inspection	Annual	Annual	Annual
	Cleaning	As Required	As Required	As Required
Ceilings **	Cleaning	As Required	As Required	As Required
Platform Structures	Inspection	Weekly	Weekly	Weekly
	Cleaning	Daily	Monthly	As Required
GSE	Inspection	Biweekly	Bimonthly	Bimonthly
	Cleaning	Weekly	Monthly	Monthly
Cranes Hoists, Etc.	Inspection	Annual	Annual	Annual
	Cleaning	As Required	As Required	As Required

* At a minimum, clean room garments are required within 3 feet of flight hardware and/or are only applicable while actively processing exposed flight hardware in the facility. Payload or individual facility garment requirements may supersede this table.

**Inspection and cleaning requirements will be at the discretion of NASA and contractor CCE/M&P Engineering and in coordination with the facility management contractor.

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Table 3-3. Facility ISO Class/CWA Level

Facility	Location	CCZ ISO Class/ CWA Level
CCAFS AE	High Bay	Class 7/ Level 2
MPPF	High Bay	Class 8/ Level 4
	Low Bay	Class 8/ Level 4
	Airlock	Class 8.5/ Level 5
NSSD	Cable Fabrication/Flight Repair (Room 1220 & 1235)	Class 8.5/Level 5*
	Flight Assembly (Room 1248A)	Class 7.7/Level 3*
	Sew Shop (Room 1015)	Class 8/Level 4*
	Photonics Lab (Room 1220A)	Class 8/Level 4*
PHSF	High Bay	Class 8/ Level 4
	Airlock	Class 8.5/ Level 5
SSPF	High Bay and Intermediate Bay	Class 8/ Level 4
	Test Stands and Specific Controlled Work Areas	Class 8/ Level 4
	Off-line Labs and Airlock	Class 8.5/ Level 5
VAFB Building 836	Lab 1 Laminar Flow Enclosure	Class 7 or 8/ Level 2 or 4**

*Due to lack of humidifiers in the environmental control system, minimum humidity level cannot be regulated.

**May be operational at either ISO Class/CWA Level. Consult facility manager.

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3.4.2 HOUSEKEEPING

Housekeeping of the ground support equipment is required at periodic intervals as specified in the applicable implementation plan. The time intervals listed in Table 3-2 are the minimum requirements; however, should an inspection reveal a nonconformance to a specification, housekeeping shall occur as necessary to remedy the nonconformance.

3.5 INITIAL CERTIFICATION OF CWA/CCZ FACILITIES

Following construction, initial cleaning, and activation phases in new CWA/CCZ facilities, the environmental capability must be certified per Table 3-1 prior to payload processing activities. This certification must demonstrate that facility cleanliness and HVAC systems are capable of maintaining CWA/CCZ parameters. This requirement applies to facilities being "Returned to Service" from major modifications and following any suspension of the CWA/CCZ Environmental Monitoring Program. The CWA/CCZ operations and maintenance requirements must be activated during the certification period. Baseline certifications of the CWAs/CCZs at KSC were performed per FED-STD-209B criteria.

3.6 HEATING, VENTILATING AND AIR CONDITIONING

The HVAC systems must be maintained to ensure compliance with CWA/CCZ parameters. Implementation plans are required to establish preventative maintenance schedules for HVAC systems. As a minimum, cooling, heating, air handler, and filtration systems must be included. Implementation plans shall establish HEPA filter certification requirements that address initial certification of new HEPA filters and periodic maintenance levels. Acceptable methods include measurement of pressure drop across the HEPA filter, flow rates, or scanning with a particle counter/probe assembly. Testing with Dioctyl Phthalate (DOP) is not permitted. HEPA filters procured for use at KSC will not be DOP tested by the manufacturer or the certifying agency.

3.7 CLEAN WORK STATION REQUIREMENTS (FLOW BENCHES)

Clean work stations, when used, shall be certified every 6 months. The certification shall consist of sampling the airborne particles to meet the requirements of equal to or less than ISO 14644-1, Class 7 (FED-STD-209 (legacy document), Class 10,000) . The flow rate of the HEPA filtered air shall meet a minimum of 21.3 m (70')/minute. Flow benches not meeting these requirements shall be taken out of service until repairs have been made and they are re-certified for use.

3.8 PAYLOAD/SPACECRAFT REQUIREMENTS

3.8.1 CLEANLINESS LEVELS

The payload/spacecraft project shall define a cleanliness level per Appendix B.

Visibly Clean "STANDARD" is the baseline level for all payloads/spacecraft. More stringent requirements must be identified in the customer requirements and agreed upon by NASA. These requirements must be defined in mission specific requirements documents.

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3.8.2 INSPECTIONS

Periodic inspections will be performed by NASA designated Spacecraft/Payloads Processing Contractor(s) and NASA Contamination Control Engineering (CCE) (as coordinated with the customer) to determine the cleanliness level of the payloads. Inspections will take place nominally at the following functional points in the pre-launch flow: upon arrival at a KSC integration facility, prior to transfer to a Launch Vehicle integration facility, prior to Launch Vehicle installation, and prior to final pre-launch closeout inspections. A report of these inspections will be available to each customer and a copy kept for historical references. Should the report indicate that a payload element does not meet the specified cleanliness level, then actions must be taken to bring the payload up to the required level.

3.9 LSP Spacecraft Requirements

3.9.1 Cleanliness Levels

The Spacecraft Project will define the cleanliness level for the LSP KSC ground processing phase. These requirements will be identified to the LSP Launch Site Integration Manager and documented in the applicable Launch Site Support Plan. These requirements may result in different CWA/CCZ requirements than identified in Section III.

3.9.2 Inspections

Periodic inspections of the spacecraft flight hardware will be performed by CCEs from the spacecraft project. Inspections will take place per each project's or payload's contamination control plan and typically include, but are not limited to, the following timeframes: upon arrival at the Payload Processing Facility, prior to integration with the launch vehicle adaptor, and prior to encapsulation within the launch vehicle faring. Any out of tolerance contamination will be cleaned and inspected for conformance by the spacecraft project personnel.

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APPENDIX A - GLOSSARY

This appendix contains a glossary of terms used in this handbook and their definitions.

Airborne Particles

Particulate matter suspended in the ambient atmosphere.

Class Clean Zone

An area that uses engineering controls, personnel controls, housekeeping procedures, and restraints on contamination-generating operations to maintain a high level of cleanliness.

Clean Room

An enclosed area employing control over the particulate matter in air with temperature, humidity, and pressure control, as required.

Clean Work Area

See Class Clean Zone.

Clean Work Station

A work bench or similar working enclosure characterized by having its own filtered air supply.

Contaminant

Any unwanted matter that could be detrimental to the required operation, reliability, or performance of a part, component, subsystem, or system.

Critical Surface

A surface that requires a level of cleanliness.

Fiber

A particle whose length-to-width ratio is in excess of 10 to 1 (minimum length of 100 micrometers).

Fluid

A liquid or gaseous material.

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APPENDIX A - GLOSSARY

Generally Clean

Freedom from manufacturing residue, dirt, oil, grease, processing debris, or other extraneous contamination. This level can be achieved by washing, wiping, blowing, vacuuming, brushing, or rinsing. This level shall not be designated for hardware that is sensitive to contamination.

Good Housekeeping Area

An area which utilizes conventional techniques in achieving and maintaining cleanliness. Operations that generate contaminants are minimized but, where necessary, are controlled and the contaminants are removed as soon as practical.

High Efficiency Particulate Air Filter

A filter with minimum efficiency of 99.97 percent for particles 0.3 micron and larger determined by an airborne particulate probe test at airflows of 100 percent of the rated flow capacity of the filter.

Localized Control Area

An area that has definite boundaries and which has the contamination control requirements of a CWA/CCZ or a good housekeeping area. An LCA can be a temporary or a permanent area for the processing of flight hardware (e.g., a clean tent or designated portion of a flight hardware processing area).

Micrometer/Micron

A unit of measurement equal to one-millionth of a meter or approximately 0.00003937 inch (e.g., 25 microns are approximately 0.001 inch).

Molecular Deposition

Matter (usually film) without definite dimension deposited on critical surfaces.

Non-Volatile Residue

Soluble (or suspended) material and insoluble matter remaining after controlled evaporation of a filtered volatile liquid; usually measured in milligrams. Filtration is normally through a nominal 0.2-micrometer membrane filter before evaporation.

Particle

Matter with observable length, width, and thickness; usually measured in microns. This definition includes fibers.

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APPENDIX A - GLOSSARY

Particle Counters

Automatic electronic devices designed to separate, size, and count individual airborne particles.

Visibly Clean

The absence of all particulate and non-particulate matter visible to the normal unaided (except corrected vision) eye using specified lighting (illuminance and angle) and viewing distance. Particulate is identified as matter of miniature size with observable length, width, and thickness. Non-particulate is film matter without definite dimension. Reference Appendix B for Visibly Clean (VC) as applied to Payloads and applicable GSE/tools.

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APPENDIX B - VISIBLY CLEAN (VC) CRITERIA (PER IEST-STD-CC1246E)

Below are the various VC levels that are available for the payloads during payload integration/launch vehicle operations at launch sites. These VC levels can also apply to pertinent GSE/tools. The VC definition in Appendix A is applicable to this table with the understanding that light intensity and inspection distances are specified herein.

IEST-VC-Distance-Lighting, distance expressed as meters, lighting as lumens/m^2. Magnification requirements may be expressed instead of distance, and UV may be added to the lighting.

Level	Distance (a) (b) (c)	Light Intensity (a)	NASA Legacy SN-C-0005 Equivalence
VC-0.5-1000	0.25 to 0.5 m (approximately 6 to 18 in.)	1000 lumens/m^2 (100 ft-candles)	Visibly Clean Highly Sensitive (VCHS)
VC-1-500	0.5 to 1 m (approximately 18 in. to 3 ft.)	500 lumens/m^2 (50 ft-candles)	Visibly Clean Sensitive (VCS) (g)
VC-2-500	1 to 2 m (approximately 3 to 6 ft.)	500 lumens/m^2 (50 ft-candles)	Not Applicable
VC-3-500	1.5 to 3 m (approximately 4.5 to 9 ft.)	500 lumens/m^2 (50 ft-candles)	Visibly Clean Standard (VC)
VC-10×-1000 (example of user-defined level)	Use 10× magnification	1000 lumens/m^2 (100 ft-candles)	Not Applicable
VC-0.5-1000-1500UV (example of user-defined level)	0.25 to 0.5 m (approximately 6 to 18 in.)	1000 lumens/m^2 white light 1500 lumens/m^2 and standard UV blacklight (d) (e) (f)	Not Applicable

Notes:

(a) Vision must be normal 20/20 or corrected to normal, not magnified, except when specified in the level designation.

(b) Distance specified in the level designation is the maximum, minimum inspection distance is one half the maximum except there is no minimum inspection distance when magnification is required.

(c) For all VC levels, areas of suspected contamination may be inspected at closer distances for confirmation; when a surface is not accessible for visual inspection at the specified distance, closer inspection or use of inspection aids such as wipes or mirrors is permitted.

(d) This designation requires two inspections of the surface at different lighting conditions. When using UV light (3200-3900 angstroms wavelength), the room lighting must be dimmed for effective viewing.

(e) Greater sensitivity can be achieved if grazing incidence light is used in a darkened room.

(f) Ultraviolet light can damage the human eye. Proper eye protection shall be worn to prevent eye damage. Consult with Safety to learn what steps must be taken to avoid eye damage.

(g) NSTS SN-C-0005 (NASA Legacy Equivalence) Visibly Clean Sensitive (VCS) required inspection at a distance of 0.6 to 1.2 m (2 to 4 feet). VC-1 in this standard most closely matches the VCS inspection distance, but does not completely include it. The light intensity is the same.

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