

Process Specification for Cleaning of Hardware

Engineering Directorate

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Process Specification for Cleaning of Hardware

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REVISIONS		
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1.0 **SCOPE**

This process specification establishes surface cleanliness requirements for cleaning, handling, processing, inspection and packaging of flight hardware, controlled hardware and ground support equipment (GSE) at Johnson Space Center (JSC).

2.0 **APPLICABILITY**

This process specification applies to cleaning of flight hardware including ground support equipment (GSE) after fabrication (prior to assembly, after assembly, and/or prior to delivery). It does not apply to in process cleaning during manufacturing (such as surface preparation for bonding or coating), except the descaling of stainless-steel parts.

3.0 **USAGE**

All parts, components, assemblies, subsystems, systems and related equipment requiring cleaning shall be cleaned to the specified cleanliness level and inspected in accordance with this specification. This process specification shall be called out on the engineering drawing by using a drawing note that identifies the process specification to be used and the required level of cleanliness. Consult the Materials and Processes Branch for approval of alternate specifications.

AFTER HEAT TREATING, REMOVE OXIDE TINT BY DESCALING PER NASA/JSC PRC- 5001

CLEAN ALL INTERNAL SURFACES TO LEVEL 300A PER NASA/JSC JPR 5322.1

CLEAN AND PHYSICALLY INSPECT ALL EXTERNAL SURFACES TO THE VC-SENSITIVE (VC-S) LEVEL PER NASA/JSC PRC-5001

NOTE: Hardware cleaned to the VC level at JSC is inspected to a distance of 12 inches or less with incident lighting.

Work requests for cleaning at JSC shall be made via JF 1615 *Clean Room Work Request and Laboratory Report* form.

It is the responsibility of the users of this specification to review pertinent Safety Data Sheets (SDSs) and materials specification to ensure safety of the personnel, protection of the environment and facilities in fulfilling the requirements of this document.

4.0 **REFERENCES**

The following documents developed this process specification:

SOP-007.1 *Preparation and Revision of Process Specifications*

JPR 8500.4 *Engineering Drawing System Manual*

JPR 5322.1 *Contamination Control Requirements Manual*

The following applicable documents are an extension of the requirements and information given in this specification. All documents listed assumed as the current revision unless a specific revision listed. Refer any conflicts between the documents referred in this list to the Materials and Processes Branch.

A-A-59150	Commercial Item Description Cleaning Compound, Solvent, Hydrofluoroether (HFE)
A-A-59503	Commercial Item Description Nitrogen, Technical
ASTM A380/A380M	Standard Practice for Cleaning, Descaling, and Passivation of Stainless-Steel Parts, Equipment and Systems
ASTM D1193-06	Standard Specification for Reagent Water
ASTM D2109-01	Standard Test Methods for Nonvolatile Matter in Halogenated Organic Solvents and Their Admixtures
ASTM F24	Standard Test Method for Measuring and Counting Particulate Contamination on Surfaces
ASTM F25	Standard Test Method for Sizing and Counting Airborne Particulate Contamination in Cleanrooms and Other Dust-Controlled Areas
ASTM F51	Standard Test Method for Sizing and Counting Particulate Contaminant In and On Clean Room Garments
ASTM F331	Standard Test Method for Nonvolatile Residue of Solvent Extract from Aerospace Components (Using Flash Evaporator)
ASTM G144-01	Standard Test Method for Determination of Residual Contamination of Materials and Components by Total Carbon Analysis Using a High Temperature Combustion Analyzer
DPI-5001-04K	Detailed Process Instruction for Cleaning of Hardware Made of Metallic Alloys
DPI-5001-04L	Detailed Process Instruction for Cleaning of Metallic Tubes and Hoses
DPI-5001-06	Detailed Process Instruction for Cleanliness Verification Using Deionized Water and Ultrasonics

DPI-5001-07	Detailed Process Instruction for Precision Cleanliness Verification Using HFE-7100
DPI 5001-10	Detailed Process Instruction for Final Cleaning and Cleanliness Verification of Hardware Using Solstice PF
CEV-T-02100	Project Orion Contamination Control Plan
GSDO-RQMT-1080	Cross Program Contamination Control Requirements
IEST-STD-CC1246	Product Cleanliness Levels-Applications, Requirements and Determination
ISO-14644-1	Cleanrooms and Associated Controlled Environment Part 1: Classification of Air Cleanliness by Particle Concentration
ISO-14644-2	Cleanrooms and Associated Controlled Environments Part 2: Monitoring to Provide Evidence of Cleanroom Performance Related to Air Cleanliness by Particle Concentration
ISO-14952-2	Space Systems Surface Cleanliness of Fluid Systems Part 2: Cleanliness Levels
JF 1615	Clean Room Work Request and Laboratory Report Form
JF 1225C	Task Performance Sheet
JF 881	Subassembly Process Sheet
JSC 29253	SR&QA Recommendation for Clean Room Gloves
JSC-SPEC-C-20D	Water, High Purity Specification
JSC 66695	EVA Office EMU Water Quality Specification
KSC-C-123	Specification for Surface Cleanliness of Fluid Systems
MIL-A-18455	Argon, Technical
MIL-P-27401	Propellant, Pressurizing Agent, Nitrogen
MPCV 70156	Cross Program Fluid Procurement and Use Control Specification
MSFC-PROC-166	Procedures for Cleaning, Testing and Handling Hydraulic System Detailed Parts, Components, Assemblies and Hydraulic Fluids for Space Vehicles.
MSFC-SPEC-164	Specification for Cleanliness of Components for Use in Oxygen, Fuel and Pneumatic Systems
MSFC-STD-246	Standard Design and Operation Criteria for Controlled Environmental Areas
MSFC-SPEC-3709	Baseline Specification for Cleaning Solvent Solstice PF

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NASA-STD-6012	Corrosion Protection for Space Flight Hardware
PRC 5002	Process Specification for Passivation of Metallic Materials
RPTSTD-8070-0001	Surface Cleanliness Standard of Fluid Systems for Rocket Engine Test Facilities of the NASA Rocket Propulsion Test Program
SAE-AS598	Aerospace Microscopic Sizing and Counting of Particulate Contamination for Fluid Power Systems
SSP 30573	Space Station Program Fluid Procurement and Use Control Specification
TT-I-735A	Isopropyl Alcohol

5.0 **MATERIAL REQUIREMENTS**

The responsible design or using organization selects cleanliness levels as defined in the system or program requirements document(s). GSE that interfaces with precision cleaned hardware shall be cleaned to meet or exceed the cleanliness level of the flight hardware. Assemblies and systems may require disassembly to permit cleaning. Remove any part or component that might degrade during cleaning and clean as a separate item. The responsible organizations shall perform hardware manufacture and assembly in a build clean manner to ensure the necessary minimum cleanliness levels are achieved and consistent with the maturity of the hardware assembly. Insufficient cleanliness of components used on oxygen systems may result in the ignition of contamination or components.

5.1 **CLEANLINESS LEVELS**

At JSC, cleanliness level requirements are defined in JPR 5322.1 *Contamination Control Requirements Manual* Table 3-1 Surface Cleanliness Levels for particulate and nonvolatile residue.

The surface cleanliness levels in JPR 5322.1, KSC-C-123 or this PRC are acceptable alternates to the levels in IEST-STD-CC1246. (The detailed numbers of particles allowed in each size bin vary slightly).

5.2 **NON-PRECISION CLEANLINESS LEVELS**

Generally Clean (GC): hardware shall be free from manufacturing residue, dirt, oil, grease etc. The GC level should be used for hardware that is not sensitive to contamination and is easily cleaned or recleaned. This level should be used for hardware items that do not require cleaning before inspection. Cleaning and recleaning is required only if the item does not pass GC inspection.

Visibly Clean (VC): hardware shall be free of all particulate and nonparticulate matter visible to the normal unaided eye or corrected vision eye with a specified illumination using incident lighting. Incident lighting for inspection of large acreage hardware shall be achieved by the

use of a handheld lighting source.

The cleaning contractor shall document and maintain evidence of inspection and acceptance criteria. Table 1 outlines the levels of VC requirements, incident light levels and inspection distances (*reference GSDO-RQMT-1080, Cross-Program Contamination Control Requirements*). JPR 5322.1 references these same requirements and Section 3.2 provides detailed inspection requirements for the VC level. The VC level is standard unless otherwise specified as sensitive (VC-S) or highly sensitive (VC-HS).

Table 1 Visibly Clean (VC) Levels and Inspection Criteria

VC Level	Incident Light Level	Inspection Distance	Remarks
VC Standard	$\geq 500 \text{ lm/m}^2$ (50 ft.-candles)	1.5 m to 3 m (5 to 10 feet)	Notes 2, 3, 5
VC-S Sensitive	$\geq 500 \text{ lm/m}^2$ (50 ft.-candles)	0.6 m to 1.2 m (2 to 4 feet)	Notes 2, 3, 5
VC-HS Highly Sensitive	$\geq 1000 \text{ lm/m}^2$ (100 ft.-candles)	0.15 m to 0.4 m (6 to 18 inches)	Notes 3, 4
VC-Custom	Incident light level and inspection distance specified by responsible Project/Elements		

NOTES:

- (1) One-foot-candle (lumens per square foot) is equivalent to 10.76 lumens per square meter.
- (2) Cleaning is required if the surface in question does not meet VC under the specified incident light and observation distance conditions.
- (3) Exposed and accessible surfaces only.
- (4) Initial cleaning is mandatory. Note (2) applies thereafter.
- (5) Examine areas of suspected contamination at distances closer than specified for final verification.

For all VC levels, inspect areas of suspected contamination may be inspected at closer distances than specified above. VC level inspections are limited to exposed and accessible surfaces. The use of inspection aids such as wipes, mirrors, borescopes, or tape lifts is permissible for those areas of suspect condition with limited or no direct line of sight. Allow closer inspection of piece parts when minimum inspection distance specified for the required cleanliness level is impractical (for example, having to hold parts cleaned to level VC Standard 1.5 m [5 feet away]).

Cleaning contractor shall inspect interior volumes at a distance that deviates from the defined range only to the extent required when sufficient access to physically conduct an inspection

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within the defined VC range.

The presence of contamination shall require test/evaluation to determine acceptance or rejection.

5.3 PRECISION CLEANLINESS LEVELS

The Visibly Clean, Ultraviolet level (VC+UV) inspection uses the aid of an ultraviolet light source (black light) of 3200 to 3800 angstroms wavelength. This level requires precision cleaning methods, but particle count is not required.

5.3.1 Black light (UV) Inspection

A visual observation of the part must be performed with the unaided eye (corrective lenses are acceptable) under UV light (3,200 to 3,800 angstroms wavelength) for the presence of hydrocarbons. If the surface is inaccessible, the inspector shall perform a wipe test.

Any contamination detected by visual or black light inspection shall be cause for recleaning. If recleaning fails to remove fluorescent indications, investigate to determine if the item material is naturally fluorescent. Contractor shall inspect parts as specified in JPR 5322.1.

5.4 SPECIFYING CLEANLINESS LEVELS

Cleanliness levels for hardware items shall be determined by program and system requirements specified in the following examples:

- a. Level 200 refers to size and count limits on particulate matter contamination only.
- b. Level A refers to nonvolatile residue (NVR) limits only (1 mg/0.1 m²)
- c. Level 200A refers to size and count limits on particulate matter and nonvolatile residue (NVR) contamination limits.
- d. Level 200A is a more stringent cleaning level than 200B for both particulate matter and NVR.
- e. A component cleaned to a more stringent level than required for a system level application may be used in a system application. (i.e., a Level 200A part may be used in a Level 300 or 300A system)
- f. The GC and VC cleanliness levels do not use particle counting or NVR methods. However, the VC-Sensitive (VC-S) cleanliness level is considered more stringent than IEST-STD-CC1246 Level 500, which is sometimes called out for visual cleanliness by other organizations.

5.5 CLEANING

Poor handling and exposure to contamination can easily compromise the state of

cleanliness. The intent of this section is to specify those general requirements applicable to cleaning processes. There are two categories for cleaning: precleaning (rough) and precision cleaning. Cleaning contractor shall control all cleaning processes with documented procedures approved by the NASA JSC Materials and Processes Branch. At JSC, procedures are detailed process instructions (DPI) or standard operating procedures (SOPs). The cleaning methods selected and used depend on the material selection for the fabricating parts. Since the characteristics of the assemblies or components vary, this section does not describe all cleaning methods and processes. At JSC, details of which cleaning solutions and solvents to use for which materials are in DPI-5001-04K *Detailed Process Instruction for Cleaning of Hardware Made of Metallic Alloys*, DPI-5001-04 *Detailed Process Instruction for Cleaning of Metallic Tubes and Hoses*, DP1-5001-06 *Detailed Process Instruction for Cleanliness Verification Using Deionized Water and Ultrasonics* and DPI-5001-07 *Detailed Process Instruction for Precision Cleanliness Verification Using HFE-7100*.

5.6 ROUGH CLEANING

Parts must be pre-cleaned to remove all visible contaminants without removing or changing the characteristics of the base materials. All traces of pre-cleaning materials shall be removed from parts at the completion of the pre-cleaning process to prevent the future formation of mineral salts and corrosion products. Use tests such as pH testing to verify removal of all residuals. Parts should be VC level before placing it in a clean room or clean work area. Nonmetallic materials shall be pre-cleaned with soap and water.

Assembled items that do not lend themselves to this type of treatment must be treated prior to assembly. Surface treated areas degraded during subsequent fabrication and assembly shall be reprocessed as required to restore the original protective finish.

All steps in pre-cleaning procedures must progress in an uninterrupted workflow through the final rinse and drying operation. If the workflow is unavoidably interrupted, a recycling operation shall be specified in the pre-cleaning procedure. Pre-cleaning procedures include, as a minimum, protection of the item by interim packaging or other approved means to prevent recontamination through all subsequent operations.

5.7 PRECISION CLEANING

Hardware that requires a level of product cleanliness greater than the level detected by visual means and cleanliness verification by particle analysis and/or nonvolatile residue analysis shall be precision cleaned. Parts/items shall be inspected to the visibly clean (VC) level prior to precision cleaning.

Hardware shall be precision-cleaned in a clean room environment per JPR 5322.1, following pre-cleaning operations described herein. Flush or wipe the items to be precision-cleaned with a suitable cleaning solution or solvent and/or vacuum clean or blow off with clean dry air to prevent the entry of gross contaminants into the clean room environment. Hardware must be precision cleaned using a precision-cleaning agent. For nonmetallic

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materials, reagent grade water must be used for precision cleaning and verification. Precision cleanliness shall be verified. Parts inspection and acceptance of precision cleaned items shall be documented. Precision cleaned items shall be protected after cleanliness verification before leaving the clean room or packaged immediately for release to the customer.

5.8 SPECIAL CLEANING PROCESSES

Cleaning contractor shall perform mechanical cleaning in manner that removes contamination without physical damage to the item cleaned. Control special cleaning processes, such as ultrasonic cleaning by documented procedures. Contractor shall test and maintain ultrasonic cleaning equipment using the manufacturer's instructions.

Special attention to cleaning convoluted flex hoses is required. All convoluted flex hose components shall be cleaned and dried in a vertical orientation. For cleanliness verification, the fluid sample must be collected while the flex hose is in the vertical position.

Metal convoluted flex hoses shall receive special attention to cleaning. All detail flex hoses shall be verified as precision cleaning in a vertical orientation. For flex hose tube diameters equal to or greater than one inch, verification of precision cleanliness shall be performed by sampling a rinse fluid applied internally through use of a high-pressure nozzle to the entire length of the flex hose. For flex tube diameters less than one inch, the use of a high-pressure nozzle is preferred, but verification may be performed by flushing a rinse fluid through the entire length of the flex hose with flex hose agitation. Precision cleaning shall be considered successful when the verification rinse fluid indicates compliance with the flex hose engineering drawing cleanliness requirement.

NOTE: This requirement shall be specified on the purchase order for any procurement of outside cleaning services for convoluted flex hoses. The horizontal cleaning and verification process used by many cleaning houses leave a significant amount of particulate in metal convolutes.

5.9 CLEANING COMPATIBILITY

It is the cleaning contractor's responsibility to ensure that the cleaning solution or cleaning process is compatible with any material or part used in that solution or process. The cleaning method comprised of cleaning fluid(s) and cleaning procedure(s) must be capable of cleaning the component, product or item to the required cleanliness level. The cleaning fluid must not react with, combine with, etch or cause immediate or later damage.

Cleaning fluid should be:

- a. Nontoxic (not harmful if inhaled or spilled on the skin) and nonpoisonous.

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- b. Non-explosive.
- c. Noncorrosive under normal use.
- d. Nonflammable.
- e. Environmentally sound.
- f. Compatible with the system, product materials and hardware.

NOTE:

(i) The cleaning contractor must verify complete solvent removal after final cleaning.

(ii) This does not limit potential cleaning fluids only to nonflammable fluids

(iii) Combustible cleaning agents must be used with care to clean systems or products that may combust the cleaning agent during cleaning; or even at a later time such as when the system or product is packaged, stored, used, etc.

Compatibility issues that must be evaluated before selecting a cleaning process are:

- a. Corrosion
- b. Embrittlement
- c. Leaching
- d. Residue
- e. Crazing (non-metallics)
- f. Reversion (non-metallics)
- g. Hydrolysis (non-metallics)

5.10 CLEANING FLUIDS AND SOLUTION CONTROL

For all cleaning fluids, establish, document, and implement requirements and procedures that control fluid composition, purity, cleanliness, and use. Cleaning fluids selected for use in pre-cleaning solutions shall be controlled by analysis, solution replacement, or adjustment to maintain cleaning effectiveness and compatibility with the specific material type.

5.11 CLEANING SOLUTION CONTROL RECORDS

The cleaning contractor must maintain records indicating the scheduled analysis, analysis results, and any solution replacement or adjustment activities.

For passivation baths at JSC, control tank chemistry per PRC-5002 Process Specification for Passivation of Metallic Materials.

All fluids, equipment, and facilities used for cleaning to the VC or VC + UV cleanliness levels shall be subject to the same minimum requirements specified for pre-cleaning procedures. Cleaning with an approved, compatible solvent (e.g., solvent wipe) is mandatory for VC and VC + UV items, unless other methods required by the hardware in question. GC items do not require cleaning before inspection; cleaning is required only if the item does not pass GC

inspection. Use a GC cleaning process compatible with the hardware materials.

5.12 TEST FLUIDS FOR PRECISION CLEANLINESS VERIFICATION

Test fluids shall be selected by the user from the approved list on the JF1615 form.

At JSC, HFE-7100, Solstice PF and high purity deionized water are approved test fluids and used for precision cleaning. Analyze final flush and verification fluids for precision cleanliness for NVR prior to use to determine compliance with the stipulated specification requirements.

Nonvolatile residue for HFE-7100 shall not be greater than 10 milligrams per one liter (mg/L) as determined by SSP 30573.

Nonvolatile residue for Solstice PF shall not be greater than 5 milligrams per one liter (mg/mL).

Isopropanol (IPA) must meet the requirements of TT-I-735A filtered to 10 microns or better prior to use.

Aqueous based fluids must utilize reagent grade water. The reagent water must meet the requirements of ASTM D1193, Type II except that silica content is not required. Milli-Q water is a permissible substitute for reagent water. If water is the verification fluid, it must meet the requirements of Grade A water in JSC-SPEC-C-20D

5.13 DRYING AND TESTING GAS

Flow pre-filtered drying gas through or over affected surfaces of the item cleaned. Use dry nitrogen gas (CGA G10.1 Grade L, Type II). When purging is specified, the purging material shall be a pre-cleaned, dry, inert gas (e.g., argon), conforming to MIL- A-18455; or nitrogen conforming to A-A-59503, Grade A, or equivalent. Pre-filter gases to meet the cleanliness level of the item being precision packaged.

NOTE: It is the cleaning contractor's responsibility to ensure removal of the above substances prior to packaging or placing hardware into service.

5.14 PROTECTING CLEANED SURFACES

Cleaning contractor shall use facilities for precision cleaning, assembly, processing and functional testing of the hardware that provide airborne contamination levels compatible with the hardware cleanliness requirements per JPR 5322.1 *Contamination Control Manual* or the engineering drawing. Clean rooms and other environmentally controlled areas (ECAs) shall be controlled by approved documented procedures.

Package all visibly cleaned and precision-cleaned items immediately after cleaning and

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drying in accordance to packaging methods per JPR 5322.1 *Contamination Control Manual* or approved documented procedures using materials that are compatible with the item to be protected.

5.15 HANDLING CLEAN PARTS

Refer to JSC 29253 "SR&QA Recommendation for Clean Room Gloves" for gloves for wet and dry handling of hardware. Clean room gloves shall be worn when handling VC cleaned and precision cleaned parts. Gloves are not required for handling generally clean parts. Any hardware not precision cleaned shall not be brought into the vicinity of precision cleaned hardware without protecting the precision cleaned hardware.

5.16 FILTERS

Ground support test equipment that interfaces with precision cleaned flight fluid systems must incorporate filters and located as close to the interface as possible where flow could occur into the flight hardware. This may also include outlet lines if it is determined that some operations such as servicing and describing fluids could permit flow in a reverse direction.

5.17 INSPECTIONS

Only trained and/or certified personnel must perform disassembly, cleaning and inspection operations on cleaned parts. Accomplish non-UV visual inspection under a white light of sufficient intensity to illuminate the surface being inspected.

Inspections shall be performed as follows: For VC and VC + UV levels, items must be inspected to the VC level. A visual inspection must be performed with the unaided eye (corrective lenses are acceptable) with handheld incident light of sufficient intensity to illuminate the surface being inspected (minimum intensities for each visible cleanliness level are specified in Table 1). Borescopes, mirrors, or other devices may be used to increase accessibility during inspection. Magnifying lenses may be used only to further identify visible contaminants.

Inspect stored precision-cleaned items periodically, at least once every two (2) years for the integrity of the outer bag and, on a sample basis, for corrosion or other degradation of the packaged item. To inspect, remove the outer bag and visually inspect the item through the inner wrap. Any discoloration, visible contamination, etc., shall be cause for rejection and recleaning of the lot sampled. If the part passes inspection, apply a new outer bag and reseal in the normal manner.

5.18 IDENTIFICATION OF CLEANED ITEMS

Cleaning contractor shall use documented procedures for packaging clean items. The GC level does not require a cleanliness certification decal, since protective packaging for contamination control is not required. Liquid oxygen (LOX) and gaseous oxygen (GOX) parts, components, subsystems, and systems shall be protected by an inner

bag of LOX/GOX-compatible film, as specified in JPR 5322.1.

NOTE: Electrical or electronic hardware sensitive to (ESD) damage shall be packaged in special antistatic packaging with suitable ESD controls meeting the requirements given in JPR 5322.1 Chapter 9, Requirements for Electrostatic Discharge (ESD) Control Program.

Identify the bagged item with a decal containing identification, inspection, and certification of cleanliness information. Decals procured to meet the requirements of this section are not intended for direct application to parts or equipment; therefore, the decals need not be compatible with fuels or oxidizers. Apply decals to the outside of the inner bag and over the ends of tape-sealed closures. Decals shall include:

- a. Part or identification number
- b. Date of Cleaning
- c. Title, date and number of this standard or JPR 5322.1
- d. Service medium or intended use of component
- e. Acceptance stamps
- f. Cleanliness Level

NOTE: To prevent galvanic corrosion, refer to NASA-STD-6012. Do not place or package dissimilar metals together.

NOTE: Do not use preservative materials on items, which have been precision-cleaned. Do not package dissimilar metals together.

5.19 ACCESS CONTROLS AND STORAGE OF CLEANED ITEMS

Establish adequate controls and procedures to limit access to storage areas for precision-cleaned items to personnel specifically trained in the handling of precision-cleaned items. At JSC, all cleaned hardware items treated as flight hardware.

Remove clean and precision-clean, packaged items from the clean room and place in an appropriate container or storage area to protect the plastic bags and contents.

Store all cleaned and precision-cleaned items in an enclosed, controlled area where temperature and humidity maintained within limits compatible with the item and its

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packaging material. Filter the air supply through an industrial-grade filter. Maintain the enclosed area in a manner consistent with good housekeeping practices. Establish and document periodic cleaning schedules.

5.20 CERTIFICATION

The cleaning contractor shall adhere to the applicable contamination control requirements of this specification and JPR 5322.1 Contamination Control Manual. The contractor shall perform periodic certifications to establish and implement the requirements for clean rooms, clean work areas or other environmentally controlled areas. The certification process shall use established and documented procedures. At JSC, the Safety and Mission Assurance Directorate has the approval authority for the certification.

6.0 PROCESS REQUIREMENTS

Perform all work to written procedures. The work instructions shall contain sufficient detail to ensure that the manufacturing process produces consistent, repeatable products that comply with this specification.

For work performed at JSC facilities, these work procedures consist of Detailed Process Instructions (DPI's).

For contracted work, the contractor shall be responsible for preparing, maintaining, and certifying written work procedures that meet the requirements of this specification.

7.0 PROCESS QUALIFICATION

For the introduction of new materials, cleaning solutions, cleaning solvents or the development of new cleaning processes not documented by existing procedures, the Materials and Processes Branch must be consulted to approve materials, cleaning processes and address compatibility concerns. Materials or sample parts that duplicate for use in the new process must be tested to demonstrate compatibility and to qualify the process.

To obtain approval, submit the following information to the Materials and Processes Branch:

- a. Proposed cleanliness levels including analysis and rationale for the selected cleanliness level.
- b. Descriptions of items to be cleaned including identification of materials including trade names, specifications, chemical and physical properties and compatibility information.
- c. Cleaning fluids information to include as applicable, trade names, specifications, safety data sheet, chemical and physical properties, and compatibility information.
- d. Processing equipment and cleaning procedures to be used (e.g. ultrasonic equipment, precision cleaning).

- e. Quality assurance provisions. This must include inspection(s) and in-process control procedures to prevent contamination, latent corrosion, or other degradation of surfaces and opened systems.
- f. Controlled environment levels maintained for cleaning and handling.
- g. Preservation methods and materials.
- h. Verification method.

8.0 PROCESS VERIFICATION

Consult the Materials and Processes Branch and the NASA procuring activity for approval alternate verification procedures.

8.1 NON-VOLATILE RESIDUE (NVR)

Following precision cleaning, each item shall be rinsed with an appropriate amount of unused precision-cleaning solvent usually 100 mL for each 1.08 ft² of critical surface area. Determine non-volatile residue (NVR) in accordance with ASTM D2109-01. If high purity water is the final rinse solution for verification, hydrocarbon content shall be determined using total organic carbon (TOC) analyzing techniques per ASTM G144-01 in conjunction with ASTM Practices G131 and G136.

8.2 PARTICLE COUNTS

Particulate determination shall be in accordance with the requirements of SAE- AS598.

8.3 DRYING

Flammable solvent used for cleaning, flushing, or testing the residual concentration of flammable solvent shall be verified as within acceptable limits. Positive verification requires purging with an inert gas and a 24-hour lockup” of the component or assembly at a minimum temperature of 15 °C. Analysis of lockup gas samples to shall be verified that the solvent concentration does not exceed 18 ppm when measured as methane or 10 ppm when measured using an instrument calibrated to the specific solvent utilized and capable of detecting 1 ppm.

9.0 **TRAINING AND CERTIFICATION OF PERSONNEL**

The cleaning contractor must provide training for all personnel performing contamination control and ECA operations per JPR 5322.1 and all operations that encompass their particular job responsibilities. The training certification course shall establish requirements for personnel working with precision-cleaned hardware. The cleaning contractor shall retrain and recertify all personnel at a specified time interval. Training records and certifications must be kept with traceable documentation.

Personnel requiring entry into the ECA on a visit or on a temporary basis must be trained basic ECA and contamination control disciplines. The ECA supervisor controls access to the ECA for visitors or temporary workers for overpopulation prevention or ECA compromise.

10.0 **DEFINITIONS**

Cleanliness Level	An established maximum of allowable contaminants based on size, distribution, or quantity on a given area or in a specific volume or absence of particulate and nonparticulate matter visible under white light and/or UV illumination
Contaminant	Any unwanted matter that could be detrimental to the required operation, reliability, or performance of a part, component, subsystem, or system
Environmentally Controlled Area	A classification which includes clean rooms, laminar flow clean workstations, and CWAs
Generally Clean (GC)	Free of manufacturing residue, dirt, oil, grease, processing debris or other extraneous contamination. Level achieved by washing, wiping, blowing, vacuuming, brushing or rinsing
Incident Light	Light that hits a surface at an angle
Micron	A unit of measurement equal to one-millionth of a meter or approximately 0.00003937 in. (e.g. 25 microns are approximately 0.001 in.)
Non-particulate Matter Nonvolatile Residue (NVR)	Matter (usually film) with no definite dimension Soluble (or suspended) material and insoluble particulate matter remaining after controlled evaporation of a filtered volatile solvent usually measured in milligrams. Filtration is normally through a 0.45-micrometer or 0.8-micrometer membrane filter before evaporation

Particulate Matter	The general term applied to matter with observable length, width and thickness (as contrasted to non-particulate film matter without definite dimensions)
Precision-cleaning	Final or fine cleaning accomplished in a controlled environment to achieve precision cleanliness. Surface cleaning with an approved, compatible solvent (e.g., solvent wipe) is satisfactory for VC + UV and VC items
Precision Cleanliness	A degree of cleanliness which requires special equipment and techniques for determination; precision cleanliness levels normally include limits for particulate sizes and quantities
Precision-Clean Packaging	Packaging or protection used to preserve precision cleanliness for a specific period and condition
Purge	To flow a gas through a system (or pipeline, tube, tank, etc.) for removing residual fluid or for providing a positive flow of gas from some opening in the system
Silting	Accumulation of minute particles in the size range normally not counted with the respective service medium
Total Organic Carbon (TOC)	Amount of carbon molecules in a sampling fluid (typically, water), as measured by controlled combustion. TOC is reported in parts per million (ppm) by weight as carbon.
Visibly Clean (VC)	Free of all particulate and nonparticulate matter visible to the unaided eye (corrective lenses are acceptable)
Visibly Clean + Ultraviolet (VC + UV)	Visibly clean (as defined above) and without fluorescent matter detectable with a UV light (black light) of 3,200 to 3,800 angstroms wavelength
Visual Cleanliness Levels	A category that includes VC, VC + UV, and GC cleanliness level.