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GENERAL CLEANING REQUIREMENTS FOR SPACECRAFT PROPULSION SYSTEMS AND SUPPORT EQUIPMENT DETAIL SPECIFICATION FOR

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1. SCOPE

1.1 Scope. This specification defines the general chemical and particulate cleaning requirements for Propulsion and Attitude Control Subsystems and related support equipment including assemblies, components, and all component (piece) parts.

1.2 Purpose. The purpose of this document is to establish the cleaning level requirements, cleaning procedures, packaging, and recording of documentations.

2. APPLICABLE DOCUMENTS

2.1 The following documents of the latest issue in effect, form a part of this specification to the extent specified herein.

SPECIFICATIONS

Jet Propulsion Laboratory

FS505146	Process Specification, General Cleaning of Materials, Detail Specification for

Manned Spacecraft Center

MSC-SPEC-C-20A	Water, High Purity and Distilled

Marshall Space Flight Center

MSFC-SPEC-237	Solvent, Precision Cleaning Agent (Trichlorotrifluoroethane) (Solvent 113, Freon 113, Freon TF)

Federal

O-A-51	Acetone, Technical
TT-I-735	Alcohol, Isopropyl, Grade B
O-N-350	Acid, Nitric, Technical Grade
O-S-595	Sodium Dichromate, Dehydrate, Technical
O-H-795	Hydrofluoric Acid, Technical

Military

MIL-E-199	Ether, Petroleum, Technical Grade
MIL-A-6091	Alcohol, Ethyl, Specially Denatured, Aircraft
MIL-S-12071	Silver Nitrate, Technical
MIL-D-16791	Detergent, General Purpose Liquid, Nonionic
MIL-P-27401	Propellant Pressurizing Agent, Nitrogen

STANDARDS

Marshall Space Flight Center

MSFC-STD-246	Design and Operational Criteria Controlled Environmental Areas, Standard for

Military

MS-36052	Sulphuric Acid

Federal

FED-STD-209	Clean Room and Work Station Requirements, Controlled Environment

PUBLICATIONS

American Society for Testing and Materials

ASTM Method D-257	D-C Resistance or Conductance of Insulating Materials, Tests for
ASTM Method D-512	Chloride Ion in Water and Waste Water, Test for (Method C)
ASTM Method D-1125	Conductivity of Industrial Water and Industrial Waste Water, Tests for
ASTM Method D-1293	pH of Industrial Water and Industrial Waste Water, Test for

(Copies of specifications, standards, drawings, and publications required by suppliers in accordance with specific procurement function should be obtained from the procuring activity or as directed by such activity.)

3. REQUIREMENTS

3.1 Conflicting requirements. In the event of a conflict between the requirements of this specification and the requirements of any other controlling document, the conflict shall be referred to the cognizant component or subsystem engineer for resolution.

3.1.1 Deviations. Deviations from this specification shall be authorized by the JPL Subsystem Cognizant Engineer. Deviations shall be included in the applicable component specification, or the applicable logbook.

3.2 Cleaning facility requirements.

3.2.1 Environmental. All cleaning of Propulsion and Attitude Control Subsystem components, assemblies, and related support equipment shall be performed in work areas free of contamination commensurate with the operation being performed per Table I.

Table I. Clean Room Classes, Particles Allowed

Class	Particles Allowed	
	0.5^+ Microns	5.0^+ Microns
Class 100	100	0
Class 1,000	1,000	7
Class 10,000	10,000	65

3.2.1.1 Precleaning (piece parts). All cleaning of piece parts, up to but not including the final rinse, shall be performed in a work area especially designed to accommodate the hazardous fluids and processes involved. Environmental control of this area is not required.

3.2.1.2 Final rinse (piece parts, components, assemblies, and subsystems). All final cleaning of piece parts and all handling of cleaned components, assemblies, and subsystems (until properly packaged) shall be performed in a work area commensurate with the particulate level to be attained and, in any case, shall conform to the requirements of FED-STD-209, class 10,000 minimum, and MSFC-STD-246. After initial certification, the work area shall be checked at least monthly to assure proper work area environments. Temperature and relative humidity shall be controlled within 22 ±3°C (72 ±5°F) and 40 ±10 percent respectively.

3.2.2 Equipment. All equipment used to accomplish the requirements of this specification shall be compatible with, and not adversely affected by, the fluids and processes specified herein. The equipment shall be designed to protect the operator and the hardware being cleaned. This requirement shall include protections such as ventilators or vapor traps, filters, pressure relief devices, and over temperature and safety devices. Soft goods exposed to the cleaning fluids shall be limited to those materials which do not leach plasticizers into the fluids contained therin. (For example, teflon FEP is acceptable.)

3.3 General cleaning requirements. Parts and components comprising Propulsion and Attitude Control Subsystems, shall be rendered compatible with the fluids to be contained therein and shall be cleaned until free of such particulate contamination (see Figure 1) as would inhibit the proper operation of the subsystem. Items shall be processed in accordance with 3.3.1 through 3.3.3 and per Tables II and III.

3.3.1 Newly machined parts. All newly machined piece parts shall be cleaned in accordance with the solutions, conditions, and sequences specified in Table II for the respective systems. Parts subject to later assembly processes shall be treated at the latest possible point in the manufacturing sequence that will still assure the proper treatment of the part.

3.3.2 Recycled parts and components. Parts or components verified to have previously been processed in accordance with Table II, or the applicable documents, shall not be subjected to acid or alkaline baths unless specifically requested by the cognizant component or subsystem engineer. Such parts or components shall be degreased (optional), rinsed, final rinsed, and dried in accordance with Table II and 3.4.2 herein. (Refer to 3.4.2.6 for restriction of fluids on certain components.)

3.3.3 Test and support equipment. Items of support equipment, or portions thereof, interfacing with clean assemblies, shall be cleaned equal to or better than the item or system to which the support equipment is connected. The equipment shall be verified capable of delivering fluids and gases of the required cleanliness and purity. Filtration may be employed to accomplish the particulate requirements; however, if the chemical purity requirements of a system cannot be verified or met, the equipment shall be cleaned as newly machined parts (3.3.1).

3.4 General cleaning procedures. The general instructions for cleaning typical items comprising the Propulsion and Attitude Control Subsystems and related support equipment are delineated in 3.4.1 through 3.4.2.7. These guidelines shall be followed unless dictated otherwise by other specific controlling documents (such as detailed specifications or cleaning requests signed by the cognizant engineer).

3.4.1 Cleaning solutions. All solutions and baths shall be maintained free of sludge and other contamination by solution filtration, certification to new solution specifications, or change of solution. Parameters affecting the capability to clean, or having the potential to contaminate or degrade the materials being cleaned, shall be periodically monitored to assure effective solutions (e.g., pH, resistivity, temperature, composition limits, halogen content, etc.). In any case, no bath or solution shall be used if the visual appearance is degraded below that of new solutions.

3.4.2 Cleaning of typical items. The general descriptions of cleaning techniques for selected types of items to be cleaned are specified in 3.4.2.1 through 3.4.2.4. Connections to components or assemblies having no mechanical external joints (e.g., flared tubes or AN ports) may be accomplished using cleaned amber latex surgical tubing or "swage-type" fittings designed to protect the interfacing surfaces.

3.4.2.1 Piping and tubing. Short lengths of piping and tubing (<1/2 meter or 18 inches) shall be cleaned as machined parts (3.4.2.5). Longer lengths (>1/2 meter or 18 inches) exceeding the ultrasonic or other cleaning bath capacity shall be cleaned by forced flow of the appropriate cleaning fluids and rinses, except that only the acid treatment may be performed by plugging one end of the line and filling with the appropriate acid per Table II. Close attention shall be paid to the time of exposure to the acid. Drying shall be accomplished by gas purge per 3.5.6.1. The ends of the line shall be wrapped with nylon sheet and, if possible, the entire line double-bagged.

3.4.2.2 Teflon-lined flexible plumbing. All Teflon-lined flexible hoses shall be cleaned by forced flow using the fluids and sequences specified in Table II. The hoses shall be exercised during flow to aid in cleaning. Drying shall be accomplished by gas purge per 3.5.6.1. The ends of the cleaned hose shall be wrapped with nylon, secured with tape, and the entire hose bagged for protection. A Clean Room History Card (Figure 2) shall be attached to each hose.

3.4.2.3 Flexible metal plumbing with convoluted lining. Convoluted metal plumbing shall be cleaned by forced flow or rinsing of the applicable fluids of Table II through the plumbing. The plumbing shall be submersed in an ultrasonic bath (5 minutes maximum) composed of the allowable fluids to aid in loosening particles within the convolutions. Specific cleaning procedures may be specified by the component specification or engineer. Drying shall be accomplished by gas purge (3.5.6.1) and then vacuum oven (3.5.6.2) for one hour at 65 ±5°C (150 ±10°F).

3.4.2.4 Pressure vessels and tanks. The very nature and variety of tanks makes a general cleaning procedure highly impractical. Precleaning (alkaline and acid treatments) and final rinse of individual tanks shall be detailed by the individual tank specification or as specified in the following paragraph.

3.4.2.4.1 Propulsion tanks. The general guidelines (a through f) shall be followed for propulsion tanks:

a. Tanks containing materials requiring different treatments shall be treated prior to final tank assembly. Precautions shall be taken to preclude formation or introduction of contaminants during subsequent operations. After final assembly, only those fluids compatible with all materials within the tank (e.g., baffles, bladders, or diaphragms) shall be introduced therein.

b. Tanks with configurations or sizes that preclude the introduction and removal of acids within the allowable exposure time shall be treated prior to final assembly. Precautions shall be taken to preclude the formation or introduction of contaminants during subsequent assembly operation.

c. Cleaning fluids shall be introduced to the tank by continuous flow through the tank, or by use of a flushing probe (Figure 3). Filling and draining through a single port is acceptable only when the above methods cannot be performed.

d. Tanks shall be proof-pressure tested after any acid treatment and shall use fluids and conditions specified in the tank specification.

e. Final rinse for cleaning verification shall conform to the requirements of 3.5.5.2. The quantity of fluid to be introduced shall be determined at the rate of 500 ml of fluid for each square foot of internal surface area or portion thereof (3.6.1.3). The fluid shall contact all internal surfaces of the tank and the tank shall be sloshed or agitated while expelling and collecting the sample fluid.

CAUTION

Halogenated solvents (Freon TF, Trichlorethylene, etc.) shall not be used in the cleaning of titanium tanks, or systems containing titanium tanks, unless specifically authorized by the Cognizant Materials Engineer. If used, extreme care shall be taken to ensure the total removal of all traces of such solvent.

f. Tanks shall be dried by one of the following methods, listed in descending order of preference:

CAUTION

The application of internal vacuum to a tank shall be specifically approved by the Cognizant Tank Engineer.

1. Vacuum oven.
2. Ambient vacuum.
3. Hot gas purge.
4. Ambient gas purge.

3.4.2.4.2 Cold gas attitude control tanks. The following guidelines shall be followed for cold gas attitude control tanks:

a. A fitting specifically designed for pressure flushing of pressure vessels shall be used (Figure 3). The final configuration of the flush fitting shall be determined by the size and shape of the specific pressure vessel being cleaned. Prior to use, the fitting shall be cleaned to the same level as required for the pressure vessel.

b. A recirculating system capable of providing a continuous flow of cleaning solution at a minimum of 40 psig into the pressure vessel through the pressure flush fitting shall be used. A suggested design is shown in Figure 4. Cleaning solution shall be passed through a 1.2-micron (or finer) filter (Millipore, or equivalent), prior to entering the pressure vessel. A 5-micron prefilter may also be used to prevent excessively rapid clogging of the final 1.2-micron filter.

c. The solution of the ultrasonic tank, plus an added amount sufficient to fill the pressure vessel, can be used and recirculated with outflow from the pressure vessel returning to the ultrasonic tank.

d. Preliminary cleaning procedure of the pressure vessel shall be accomplished by the following steps:

  1) Thoroughly clean the exterior of the pressure vessel by degreasing or spray washing (3.5.1.2).
  2) Clean the pressure vessel inlet boss and sealing serrations using a spray rinser (or equivalent), containing an approved type of cleaning agent. Rinse thoroughly and blow dry with clean filtered nitrogen (3.5.6.1).
  3) Attach a cleaned pressure flush fitting to the pressure vessel, using an approved seal between fitting and serrations on the pressure vessel.
  4) Connect flush fitting inlet to a pressure flushing system containing fluids of Table II; place pressure vessel in ultrasonic tank; turn on flushing system and allow the pressure vessel to fill with cleaning solution.

5) When a steady outflow from the flush outlet is achieved, turn on the ultrasonic generator and operate for at least one hour.

6) Disconnect the pressure vessel from the pressure flushing system, and drain the cleaning solution from pressure vessel. Use filtered nitrogen at low pressure to aid in forcing out the solution.

7) Attach a pressure flush fitting to a pressurized source of filtered deionized water and flush the pressure vessel until no detergent can be noted in the flushing water.

8) Fill the pressure vessel with filtered deionized water, and submerge the entire vessel in a suitable precleaned subtank containing filtered deionized water. Place the subtank within the ultrasonic cleaning tank and ultrasonically clean for at least 15 minutes, assuring that no solution from the ultrasonic tank enters the subtank or the pressure vessel.

9) Drain the deionized water from the pressure vessel, using filtered nitrogen to aid in draining. Continue nitrogen flow for 2 to 3 minutes after the water flow has stopped.

10) Blow the external surface of the pressure vessel dry with filtered nitrogen and repeat steps 4 through 10 for a total of three detergent/deionized water washes.

e. Intermediate cleaning shall be performed with the following steps:

1) Remove nitrogen supply line from pressure flush fitting, and add 100 milliliters (ml) of filtered isopropyl alcohol (IPA) to the pressure vessel through the pressure flush fitting inlet.

2) Cap off flush fitting inlet and outlet ports, then manually rotate and vigorously shake pressure vessel for one minute. Alcohol will absorb any moisture remaining within the pressure vessel.

3) Drain the alcohol from the pressure vessel, and blow dry with filtered nitrogen.

4) Fill pressure vessel 1/3 to 1/2 full with IPA, which has been filtered through a 1.2-micron (or finer) filter (Millipore, or equivalent). Cap off flush fitting inlet and outlet ports.

5) Place pressure vessel in the ultrasonic cleaner subtank containing deionized water, and turn on the ultrasonic generator. Clean the pressure vessel for one hour, changing vessel position frequently to assure complete cleaning.

6) After one hour, remove the pressure vessel from the tank, and withdraw a 100 ml sample of IPA into a precleaned beaker for particle count.

7) If the particle count exceeds the acceptable limits (3.6.1.4.1), drain and flush the pressure vessel with filtered IPA, then repeat steps 4 through 6 until acceptable limits are reached.

8) Drain and flush the vessel a final time with filtered IPA, then flow filtered nitrogen through the pressure flush fitting inlet until no odor of Alochol can be noted at the outlet port.

9) Remove the pressure flush fitting and prepare the pressure vessel for storage as defined below.

f. Preparation for storage shall be performed with the following steps:

1) Assure that no contaminants remain in the pressure vessel inlet area, or in the adjacent serrations.

2) Place a small square of nylon "C" material (or equivalent) over the serrations and hold in place, using tape approved for clean room use.

3) Store the pressure vessel in a laminar flow bench, or similar area, until needed for assembly.

3.4.2.5 Machined parts. Machined parts shall be cleaned using the fluids and sequences specified in Table II and to the requirements of 3.3 and 3.6. Parts shall be protected during all phases of cleaning operations to prevent damage due to agitation and impact.

3.4.2.6 Assembled components, assemblies, and systems. Assembled items submitted for final rinse or cleanliness verification shall be handled per 3.3.2 using the final rinse fluids of Table II. The items shall be force-flowed or rinsed until the appropriate acceptable contamination level is attained. Drying shall be accomplished by the appropriate methods of 3.5.6. Certain components, or assemblies containing such components, not permitting the introduction of fluids, (e.g., regulators, cold gas components, and assemblies) shall be sampled for contamination by purging with gas per 3.6.1.3.2 and 3.6.1.5.2. Such items shall be so identified when submitted for cleaning.

3.4.2.7 Polymers and thermoplastics. Small parts which lend themselves to treatment as machined parts shall be handled accordingly. Larger items, such as diaphragms and bladders, shall be handled by submersion, scrubbing, or flushing as necessary using the fluids of Table II. Complete submersion and agitation for each step is preferred to simple rinsing; however, scrubbing with a nylon soft bristled brush shall be employed in any event. Sampling rinse fluid quantities shall be determined per 3.6.1.3.1. The drying process for polymers and thermoplastics shall be by vacuum oven per Table II and 3.5.6.2, unless otherwise authorized (i.e., >2 hours for H_2O rinse and >50 hours for IPA rinse).

3.5 General cleaning operations. The cleaning operations described below are guidelines for the general conductance of specified operations. Other specific procedures shall be authorized by the Cognizant Component or System Engineer (see 3.4.1 for solution controls).

3.5.1 Degreasing. Solvent degreasing shall be performed to remove surface oils, greases, and hydrocarbons that may have deposited during handling or manufacturing. The solvent shall be continuously filtered or controlled to prevent the re-deposit of contaminants on the parts being cleaned.

3.5.1.1 Hot vapor solvent degreasing. Hot vapor solvent degreasing shall be performed by immersing parts into hot vapor phase of the hot degreasing solvent specified in Table II until the solvent stops condensing on the part(s). If the equipment has spraying capability, the part shall be sprayed with hot solvent. Parts shall be immediately rinsed per Table II, unless otherwise specified.

3.5.1.2 Cold solvent or ultrasonic degreasing. Parts to be degreased shall be suspended in degreasing bath per Table II. Ultrasonic agitation or mechanical scrubbing with a nylon soft bristle brush or both, shall be employed to aid the degreasing action. If ultrasonic agitation is previously determined to be detrimental to the part, mechanical agitation and scrubbing shall be employed. Parts shall be rinsed per Table II immediately following removal from the bath, unless otherwise specified. All internal and external surfaces shall be exposed to the agitation and scrubbing.

3.5.2 Detergent cleaning. The detergent solution shall be from a non-ionic, additive-free detergent mixed with deionized water per Table II. Parts shall be detergent-cleaned per Table II by ultrasonic agitation and scrubbing with a nylon soft bristle brush. If ultrasonic agitation is detrimental to the part, mechanical agitation and scrubbing with the nylon soft bristle brush shall be employed. All internal and external passages and surfaces shall be exposed to the agitated solution, preferably by forced flow. Parts shall be immediately rinsed per Table II.

3.5.3 Alkaline cleaning. Surface oils, greases, and other contaminants shall be removed by immersion of the part in an alkaline cleaning solution. The bath shall be subjected to constant agitation by pneumatic or mechanical means to aid in contamination removal. The cleaned part shall be immersed in the alkaline bath per Table II and immediately rinsed. The alkaline solution shall not be allowed to dry on, or in, the part being treated.

3.5.4 Acid treatment. Corrosion-resistant steels, nickel steels, and titanium alloys shall be subjected to acid baths to remove surface embediments (manufacturing contaminants) and to develop a passive oxide film on the metal surface. Since these acid solutions are for the purpose of removing metallic contaminants and may affect the parent surface, the specified solutions, temperatures, and exposure times of Table II shall be strictly adhered to.

3.5.4.1 Acid solutions. Acid solutions shall be in accordance with Table II. The concentrations listed are percent by volume.

3.5.4.2 Mixing acids. Acids shall always be mixed by adding the correct amount of acid to the correct amount of distilled water. The mixture shall be stirred thoroughly to assure even mixing of the acid-water mixture. In the case of two or more additives to the water, they shall be added to the water in the order of descending concentration.

3.5.4.3 General acid procedure. Items to be acid treated shall be degreased and free of obvious contamination. Acids will not penetrate oil and sludges remaining after previous operations. Parts shall be entirely submerged in the acid bath; i.e., treatment of a part by sections is specifically prohibited. The acid bath shall be periodically agitated during the treatment time to prevent contaminants settling on the parts and to assist in removing loosened surface particles. Parts from the acid bath shall proceed immediately to the prescribed rinse per Table II.

3.5.5 Rinses. Rinse solutions serve three functions by providing a non-reactive medium with which to:

a. Remove previous more reactive treatments and solutions.
b. Rinse away loosened particulate contaminants from the surfaces being cleaned.
c. Verify surface cleanliness by means of tests described in 3.6.

3.5.5.1 Preclean rinse. Water used for rinse during precleaning operations shall conform to MSC-SPEC-C-20 (refer to Table II).

Parts shall be rinsed until the pH of the rinse water is within 0.2 of the rinse source. The same water shall not be used as the rinse water for different treatments unless precautions are taken to verify that concentrations of the treatment solutions have not accumulated in the rinse water.

3.5.5.2 Final rinse. Final rinse fluids shall be used solely for the purpose of final rinse and cleanliness verification and shall be virgin fluids; i.e., shall not have been used in any previous cleaning steps. The fluids shall be filtered using a 1.2-micron absolute or finer filter, and verified to meet the test fluid requirements of Table III. Cleanliness verification shall be performed per 3.6. The final rinse shall be repeated until conformance to Table III is established when sampled per 3.6. Care shall be taken to assure that the final rinse fluid contacts all surfaces of the item being rinsed in the most vigorous manner permissible without damage to the item. The following rinse methods are listed in order of descending preference:

a. Ultrasonic agitation with fluid recirculation.
b. Ultrasonic agitation.
c. Fluid recirculation.
d. Rinse or flush.

The ultrasonic equipment shall be capable of providing at least 3 watts of power per square inch of tank bottom surface and shall be verified per 3.6.9 as required in Table IV.

3.5.6 Drying. Drying procedures are designed to remove all traces of liquid from the parts or assemblies being cleaned. Care shall be taken to assure that liquids are removed from trapped areas as well as exposed surfaces. The drying methods, in descending order of preference and effectiveness, are:

a. Hot vacuum.
b. Ambient temperature vacuum.
c. Hot gas purge.
d. Ambient temperature gas purge.

3.5.6.1 Gas purge. Dry filtered gas with a dewpoint <-54°C (<-65°F), hydrocarbon content <25 ppm, and filtered with a 5-micron maximum absolute filter shall be used to blow or purge the precleaned parts until visually dry. Gas used for sampling, or drying parts or assemblies after the final rinse, shall be additionally filtered with a 1.2-micron absolute maximum filter and verified to meet level 8 of the appropriate class of Table III. Components or assemblies having internal passages and liquid traps shall be purged until the dewpoint of the exit gas is equal to or drier than the gas source (<-54°C or -65°F). The temperature shall be controlled within the limits shown in Table II.

3.5.6.2 Vacuum dry. Parts to be vacuum dried shall be exposed to a vacuum within the temperature and time limits specified in Table II. All wetted surfaces of the items being dried shall be exposed to the vacuum. If internal surfaces only are to be dried, the item may be evacuated internally while exposed to the proper temperature. (See tank caution note below.) The equipment shall be capable of achieving an absolute pressure <133 N/m^2 (<0.02 psia or 1 torr). The pressure shall be monitored to verify that an acceptable vacuum is achieved for each evacuation. The chamber or pumping system shall be equipped with such safety devices as necessary to protect critical hardware from overtemperature and vacuum pump failure. Chamber location and repressurization systems shall be of such design and location as to assure an acceptable environment per FED-STD-209, commensurate with the cleanliness level of the items being dried.

CAUTION

Specific approval shall be obtained from the Tank Cognizant Engineer, prior to evacuating a propellant tank.

3.6 Cleanliness verification. All items shall be verified clean by performing one or more of the following tests as specified in Table IV. Results of all tests performed shall be recorded on the Clean Room History Card (Figure 2).

3.6.1 Particle count test. Particulate contamination of cleaned items shall be determined using Millipore particle sampling apparatus or equivalent as follows.

3.6.1.1 Environment. All sample fluid handling and evaluating shall be accomplished in a class 1000 or better work area. Fluids and filter elements shall not be handled in an environment worse than class 1000, unless protected from that environment.

3.6.1.2 Equipment. All equipment involved in the evaluation of particle cleanliness shall be of non-particle shedding materials and shall be verified to be at least as clean as the test fluid (level 5). Background particle counts of equipment other than the filter pad shall not be factored out of the final particle count.

3.6.1.3 Test fluid, amount, and usage.

3.6.1.3.1 Liquid. The amount of the test fluid specified in Table II shall be 500 ml for each 929 cm^2 (1 ft^2) of surface area checked. For items having less than 232 cm^2 (0.25 ft^2), 100 ml of sampling fluid shall be collected and analyzed. Samples shall be collected by vigorously flowing over, around, and through; or by filling, sloshing, and draining the item. The sample fluid shall contact all effective surfaces of the item being checked.

3.6.1.3.2 Gas. Items may be sampled for particulate contamination by passing gas through the item at the rate of 141.5 ±14 liters/minute (5 ±0.5 std ft^3/min) for 3 minutes (424.5 liters or 15 std ft^3 total). If the above flow rate cannot be obtained or may cause damage, the component shall be flowed at the maximum flow rate permissible for a total volume of 424.5 liters (15 ft^3) of gas.

3.6.1.4 Particulate contamination allowed. Particle counts obtained shall be compared with Table III for maximum allowable counts. The total particle count shall be divided by fluid quantity to obtain the particle count per 100 ml as follows:

$$\text{Liquid: } \frac{\text{Particle count - filter background}}{\text{Fluid quantity, ml}} \times 100 = \text{particles per 100 ml}$$

$$\text{Gas: } \frac{\text{Particle count - filter background}}{\text{Quantity flowed, liters (ft}^3)} \times \underset{(15\text{ std ft}^3)}{424.5\text{ liters}} = \text{particles per } \underset{(15\text{ std ft}^3)}{424.5\text{ liters}}$$

3.6.1.4.1 Cold gas attitude control systems. The maximum allowable particulate contamination for cold gas attitude control systems and components shall be as follows:

Particle Size	Metallic	Non-metallic
0-5 microns	unlimited	unlimited
5-25 microns	0	unlimited
>25 microns	0	0

Particles in the "unlimited" ranges shall not cause discoloration of the filter pad.

3.6.1.4.2 Propulsion systems. The applicable particulate class (A-H) shall be determined by the organization requesting the cleaning. The level (1-11) shall be determined by the description of the item being cleaned. See Table V for specific project/program authorizations.

3.6.1.5 Sampling techniques. Particle evaluation shall be accomplished by one of the following techniques.

3.6.1.5.1 Liquid flush or rinse method. Piece parts, components, and assemblies shall be sampled by flowing over and through, or force flushing through components or assemblies per 3.5.5.2 as follows:

a. Verify all sampling and related equipment is clean (3.6.1.2).

b. Precount a 1.2-micron gridded filter or equivalent using a 100-power magnification microscope.

c. Sample the item with the required volume of fluid per 3.6.1.3. Catch the sample fluid in a clean flask or beaker.

d. Pass the entire collected sample through the filter element. If necessary, a funnel (millipore sampling type or equivalent) may be installed on the vacuum flask to assure that all fluid passes through the filter.

e. Place the filter in a clean petri dish, taking care not to damage the filter. Handle the filter with clean, unserrated tweezers. Cover the dish and identify.

f. Count the particles in the size ranges specified in Table III using a minimum of 100-power magnification. The filter may be prescanned at a lesser magnification for obvious defects prior to actual count. The entire filter element must be counted; i.e., no factoring of filter area to obtain total particle count is permitted. Evaluate contamination level per 3.6.1.4.

Note: Liquid sample volumes may be obtained in a cleaned flask in a remote work area and evaluated in the cleaning facility. Flask background counts may not be factored out of total particulate counts.

3.6.1.5.2 <u>Filter bomb method.</u> Assemblies and subsystems of flight, support, or facility equipment may be sampled in place at a remote location using a millipore filter holder or equivalent to flow the required fluid or gas through the filter. The filter is then disassembled and evaluated in the cleaning facility. The procedure shall be as follows:

a. Clean the disassembled millipore filter holder (or equivalent) to Level 2 of the desired cleaning class (Table III).

b. Assemble filter with a 1.2 micron absolute or less element.

c. Flow the filter with nitrogen (3.5.6.1) at the greater of 141 liters/minute (5 ft^3/min) for 3 minutes, or the flow rate at which the sample shall be taken.

d. Carefully disassemble filter and read and record element background particle count.

Note: The particle count shall not exceed Level 2 of the applicable class.

e. Carefully reassemble the filter. Seal the inlet and outlet ports. Double bag per Figure 5 if transportation to another facility is required.

f. Carefully install the filter in the system to be sampled. Flow gas systems at the greater of 141.5 liter/minute (5 ft^3/min) for 3 minutes, or the expected system flow rate, for a total of 424.5 liters (15 ft^3). Flow liquid systems at the maximum expected flow rate for a total volume of at least 1 liter. Record the volume of flow. Remove the filter from system, bag, and return to the clean facility.

g. Carefully disassemble the filter and place the element in petri dish.

h. Evaluate total particulate contamination on the filter element at 100-power magnification.

i. Factor the total particle count per 3.6.1.4.

3.6.1.6 Particle counting, method of. The filter element shall be evaluated for particulate contamination in the size ranges of Table III by examination under a minimum of 100-power magnification. All grid squares of the effective filter area shall be counted. A calibrated scale shall be visible within the field of view for size reference. Preliminary examination of the filter area may be accomplished at reduced magnification (40x) to examine for obvious defects.

3.6.2 Ultraviolet test. This test shall be performed in an area from which visible light has been excluded. The ultraviolet light source shall consist of 100 watts minimum, spot-type mercury ARC lamp, or equivalent, emitting light in the 3000 to 4400 Angstrom range. Eye glasses (not plastic lenses) shall be worn to protect eyes against the longwave portion of the ultra-violet band. Adaptation of the eyes to darkness is required prior to commencing the evaluation (generally 5 minutes minimum). This test shall be performed on either the item being cleaned or the filter used in 3.6.1. Any fluorescence shall be considered as failure of the test and shall require rejection or recleaning of the item.

3.6.3 Wipe test. The wipe test shall be performed by wiping the cleaned effective surfaces in several places using lint-free wipers. Any visible discolocation shall be cause for item rejection or recleaning.

3.6.4 Silver nitrate test. A silver nitrate test shall be used to determine the presence or verify the absence of brazing salts in a solution in which a brazed item has been boiled. This test specifically applies to components fabricated by any brazing or other metal joining process in which fluxes or salts were employed. The silver nitrate test shall be conducted in the following sequence:

Step

1. Use a 100-ml sample of water in which a component was boiled and add, if necessary, sulphuric acid conforming to MS-36052 to make the pH of the test solution between 5.7 and 6.2.
2. Add 5 grams of silver nitrate, conforming to MIL-S-12071, to the test solution and mix thoroughly.
3. A cloudy precipitate indicates that brazing salts are present and that the test is positive. The absence of precipitate indicates that brazing salts are not present and that the test is negative. A positive reaction shall be cause for item rejection or further cleaning.

3.6.5 Non-volatile residue test (NVR). The total residue shall be obtained by evaporating 1500-ml of solvent to dryness, then weighing the residue in accordance with the following procedures:

Step

1. Transfer 500 ml of solvent to a clean 800 ml capacity beaker.

Step

2. Boil the 500 ml gently on a hot plate until the volume is reduced so that the second 500 ml of solvent may be added. A clean glass stirring rod shall be placed in the 800-ml beaker to prevent bumping during boiling.
3. After the second quantity of 500 ml has been added, reduce the volume of solvent in the beaker to 50 to 100 ml and add another 490 ml. Boil the contents of the beaker down to approximately 20 ml.
4. Transfer the approximately 20 ml to a clean weighed 35-ml vial, containing a clean glass bead, and rinse the 800-ml beaker with the final 10-ml portion of the solvent. The 10-ml rinse shall also be transferred to the 35-ml vial.
5. Boil the contents of the 35-ml vial very gently until the volume has been reduced to approximately 5 to 10 ml. At this point, transfer the vial to a 100°C oven and allow to dry for one hour. The final 5 to 10 ml of solvent shall be allowed to evaporate in the oven.
6. Remove the vial from the oven after one hour, allow to cool, then reweigh to the nearest 0.1 mg.
7. Calculate the total residue as follows:

$$\frac{(A-B) \times 10^6}{W} = \text{ppm residue}$$

Where: A = weight of vial and residue in grams.

B = weight of vial in grams.

W = weight in grams of the initial 1500 ml of fluid (volume times specific gravity).

8. The results shall be compared with the applicable specification. Excessive NVR shall be cause to reject or reclean the item, or, if performed for fluid verification, excessive NVR shall be cause to reject the fluid.

3.6.6 pH test. The pH test shall be performed to verify that all acids, alkalines, and detergents have been rinsed from the item being cleaned. A sample of approximately 200 ml of the rinsing fluid effluent shall be compared with the rinse fluid source per Table II. The test shall be performed for ASTM D-1293.

3.6.7 Conductance test. The conductance of rinse water shall be determined prior to use per ASTM D-1125. Excessive conductance shall require rejection or further deionization of the water.

3.6.8 Halides test. The water used for cleaning and rinsing purposes shall be tested for chloride ion content per ASTM D-512, Method C. The results shall be compared with the water specification, MSC-SPEC-C-20 (Requirements summary on Table II).

3.6.9 Ultrasonic cleaner evaluation test. The activity of the ultrasonic unit shall be qualitatively tested using household alumiumum foil (annealed) suspended in the ultrasonic bath cavitating field. The foil, approximately 1.5 mils thick (0.0015-inch), shall be suspended on edge diagonally across the bath, and shall extend to within 25 mm (1 inch) of the bottom, corners, and surface of the bath. (The foil shall not touch the tank.) The bath for this test shall be water (<44°C or 110°F) and shall have been ultrasonically excited for at least 30 minutes before placing the foil in the bath. The foil shall be inserted and removed with the ultrasonic exitation turned OFF.

The foil should be exposed to the ultrasonic calitating field for approximately 60 seconds (actual time will vary with different equipment, but, once established, shall remain constant for a given ultrasonic cleaner). The exposed foil sheets shall show definite evidence of erosion, and shall be compared with previous exposed sheets to detect degradation of the equipment.

3.7 Protection of cleaned parts. Protection of cleaned parts shall be accomplished by following the requirements specified in 3.7.1 through 3.7.4.

3.7.1 Handling. Cleaned parts, or cleaned surfaces of cleaned components and assemblies shall not be handled with bare hands. Special attention shall be required for contamination control during shipping or moving finished component parts, components, and assemblies from a clean room to assembly and test areas. All such movement shall be performed with the hardware sealed in clean nylon static-free bags as shown on Figures 5 and 6 and placed in suitable containers. When a component is supplied to the subsystem assembly area, the handling of the component shall be controlled by procedures and techniques designed to minimize contamination. Such handling techniques shall be used to prevent components of the overall assembly from touching, rubbing, or impacting against other components or component parts and prevent the generation of contamination particles or chips. Therefore, it is imperative to properly support and control the movement of the component during all handling operations.

3.7.2 Proper enclosure and sealing materials. A component part, component, or assembly, which is in an identifiably clean condition, shall be maintained in this condition to the point of usage by sealing, as shown on Figures 5 and 6 within a cleaned enclosure. Parts shall be handled with clean, lint-free gloves during all cleaning, handling, drying, inspection, and packaging operations. Packaging of cleaned component parts or components shall be performed in an environmentally controlled area as soon as practical after completion of final cleaning. All ports leading to precision-cleaned internal surfaces or passages shall be closed with closures that are not detrimental to the item on which they are installed. The most preferred closure is a piece of clean, static-free nylon placed over the opening and held in place with tape. (Plastic screw-type closures are not acceptable.)

3.7.3 Film sheet or bag closures (inner). Each cleaned component part or component shall be placed in a clean, nylon, static-free bag, or between two clean, nylon, static-free sheets, and heat-sealed. A short portion of the seam shall be left open to remove as much of the air as practical. The package shall then be purged with dry filtered nitrogen (3.5.6.1) and finally, completely heat-sealed. Nylon anti-static closures, consisting of bags and sheet stock, shall be precleaned and shall meet the cleanliness requirements of Table III. Tubing and hoses shall be protected by enclosing each end with nylon materials, and then if possible, enclosing the entire item in the outer bag.

3.7.4 Film overwrap (outer). Each component part, or component, sealed in accordance with 3.7.3, shall be completely overwrapped with anti-static polyethylene film. The overwrap shall be secured with tape, or heat-sealed where practical. Anti-static polyethylene film, used for the overwrap, shall have a surface resistivity of not more than 10^{12} ohms when measured by the ASTM Method D-257.

3.8 Documentation. Results of all cleanliness verification tests performed shall be recorded on the Clean Room History Card (Figure 2) with an indelible pen. Examples of results to be recorded are particle count, ultra-violet, NVR, and pH test results.

3.8.1 Clean Room History Card (Figure 2). The Clean Room History Card shall be fabricated of non-shedding material equivalent to or better than Duralar 500 (supplied by Duralith Corp of Philadelphia, Pennsylvania) and measuring 3 by 5 inches. The card shall be sealed in bagging material and permanently attached to, but not inside, the inner bag (Figures 5 and 6).

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection. Unless otherwise specified in the contract or purchase order, the contractor shall be responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified, the contractor may use his own facilities or any commercial laboratory acceptable to JPL. JPL reserves the right to request or perform any of the inspections set forth in this specification where such inspections are seemed necessary to assure supplies and services conforming to prescribed requirements.

4.2 Tests. The schedule of tests, specified in Table IV shall be performed to assure conformance with the requirements of this specification.

4.3 Acceptance criteria. Acceptable criteria are specified in Table II, Table III, specific sections of this specification, or the applicable controlling specification.

5. PREPARATION FOR DELIVERY

5.1 Packaging. All cleaned hardware shall be packaged in accordance with the requirements specified in 3.7.

5.2 Packing for shipment. Hardware packaged for shipment or transportation to, or from, a cleaning facility shall be sealed in plastic per 5.1 and surrounded by a minimum of 2 inches of shock absorbant material. The material shall be of such a nature as to prevent the relocation or shifting of the material or hardware within the container during shipping handling.

6. NOTES

6.1 Definitions. The definitions listed herewith are for terms used in this specification.

a. Piece part. A piece part is a part consisting of one material and subject to later, permanent assembly with other piece parts to form a component part. If possible, acid treatments should be accomplished at the piece part level.

b. Component part. A component part is one piece, or two or more piece parts joined together, which are not normally subject to disassembly without destruction of design (i.e., O-ring, poppet, valve housing, or fittings or parts of a valve component), and not within itself containing any moving parts. A length of flared and formed tubing, with sleeves and fittings assembled that cannot be disassembled by normal means without destruction of designed use, should be considered as a component part rather than a component.

c. Component. A component is a unit consisting of two or more replaceable parts (i.e., filter element, filter housing, and fittings are parts of a filter component) having a common mounting and which is within a single makeup, capable of performing a definite function (e.g., filter, regulator, or valve).

d. Assembly. An assembly is a unit consisting of two or more components joined together to perform a definite function, and the unit is capable of independent operation and checkout when interconnected with simulated complete systems.

e. System. A system is a normal assemblage of assemblies in a spacecraft configuration (i.e., the assembly of tubing, regulators, fill valves, explosive valves, propellant tanks and rocket motor).

f. Newly machined parts. Newly machined parts are items which have been fabricated by any manufacturing process and have not received any surface treatment for the purpose of removing chemical or particulate contamination to make such part clean or compatible with propellants.

g. Effective filter area. Effective filter area refers to that area of a filter element which is directly involved in filtering the flowing media.

h. Internal surface. Internal surfaces are defined as those surfaces of assemblies, subsystems, systems, and ground support equipment that contact service medium during use.

i. <u>Visibly clean.</u> Visibly clean refers to the freedom of the surface from particulate matter approximately 50 microns and larger in size, and from all visible films other than known innocuous films.

j. <u>Particulate matter.</u> Particulate matter is soluble (or suspended) material and insoluble particulate remaining after the controlled evaporation of a filtered, volatile liquid, usually measured in grams.

Table II. Cleaning Solutions and Sequences (Sheet 1 of 2)

Paragraph	Purpose	Solution	Specification	Temperature °C	Temperature °F	Time, Minute	Notes	Titanium			Precip Hard S/S(6) 400 Series S/S Free Machining 300 Series S/S			Nickel Steels 200 and 300 Series(6) S/S			Steel			Copper			Glass			Polymers Elastomers Thermoplastics			Aluminum		
		Typical Cleaning Sequences:(5)																													
		Monopropellant Hydrazine Systems (N_2H_4)						▼			▼			▼									▼			▼			▼		
		Bipropellant Systems: MMH or N_2H_4, and N_2O_4							▼			▼			▼			▼			▼			▼			▼			▼	
		Cold Gas Attitude Control Systems								▼			▼			▼			▼												▼
3.5.1	Degrease																														
3.5.1.2		Isopropyl Alcohol (IPA)	TT-I-735A	Ambient	Ambient	5-10 Sonic (30-60 Hand Agitate, Secondary Option)		1	1	1	1	1	1	1	1	1		1	1		1		4			1			1	1	1
3.5.1.2		Solvent, PCA (Freon TF or equivalent)	MSFC-SPEC-237	43-54	120 ±10	90S-Vapor 120S-Bath 90S-Vapor			1(8)	1		1	1		1	1		1			1									1	
3.5.2	Detergent Clean (4)	1% Solution by volume	MIL-D-16791	65-87	170 ±20	5-10		8	8	3	8	8	3	8	8	3			3				1	1		3	2		5		3
3.5.3	Alkaline	Oakite, 3% by volume	61B(1)	71-82	170 ±10	5-10		3	3		3	3		3	3			3			3								3	3	
		Oakite, 3% by volume	61B	60-71	150 ±10	10-15																									
3.5.4	Acid(2)	HNO , 10% by volume	O-N-350	18-29	75 ±10	10-15								5	6																
		HNO_3, 45% by volume	O-N-350	18-29	75 ±10	20-30		5	6																						
		HNO_3, 21% + 22 Grams/Liter Sodium Dichromate	O-N-350 O-S-595	16-32	75 ±15	10-15					5	6																			
		HNO_3, 15%, +2% HF	O-A-8[illegible] O-H-795	18-29	75 ±10	1 ±0.1 * See footnote		5																							
3.5.5.1	Rinse	H_2O, Distilled	MSC-SPEC-C-20A (7)		Ambient			6	4 7	2 4	6	4 7	2 4	6	4 7	2 4		4	2 4		4									4	2 4
		H_2O, Distilled	MSC-SPEC-C-20A (7)	60-82	160 ±20																		2	2			2				
		H_2O, Distilled, Sonic (Performed Twice)	MSC-SPEC-C-20A (7)		Ambient	Until pH within 0.2 of source		2 4 7,9	9		2 4 7,9	9		2 4 7,9	9											2 4			2 4 6		

*Specific authorization must be obtained from the cognizant materials engineer prior to using the hydrogen-flouride acid treatment.

Table II. Cleaning Solutions and Sequences
(Sheet 2 of 2)

Paragraph	Purpose	Solution	Specification	Temperature °C	Temperature °F	Time, Minute	Notes	Titanium			Precip. Hard. S/S(6), 400 Series S/S, Free Machine, 300 Series S/S, Nickel Steels			200 and 300 Series(6) S/S			Steel			Copper			Glass			Polymers, Elastomers, Thermoplastics			Aluminum		
		Typical Cleaning Sequences:																													
		Monopropellant Hydrazine Systems						▼			▼			▼									▼			▼			▼		
		Bipropellant Systems: MMH or N_2H_4, and N_2O_4							▼			▼			▼			▼			▼			▼			▼			▼	
		Cold Gas Attitude Control Systems								▼			▼			▼			▼												▼
3.5.5.2	Final Rinse	H_2O, Deionized	MSC-SPEC-20	Ambient	Ambient	As necessary to achieve desired particulate level	General use	10										5			5									5	
		IPA	TT-I-735 A	Ambient	Ambient		Fuel (N_2H_4, MMH)	10	10,F	5,7	10	10,F	5,7	10	10,F	5,7			5,7				5	4		5			7		5,7
		Solvent, PCA (Freon TF or equivalent)	MSFC-SPEC-237	Ambient	Ambient		Oxidizer		10, OX			10, OX			10, OX																
3.5.6	Dry	Purge, Nitrogen	MIL-P-27401 B	Ambient	Ambient	3.5.6.1	Filtered	11		6,8	11		6,8	11		6,8			6,8				3 6	3 5		6			8		6,8
		Purge, Nitrogen, Hot	MIL-P-27401 B	49-71	120-160	3.5.6.1	Filtered		2,5			2,5			2,5			2 6			2 6						3			2 6	
		Vacuum, Ambient		Ambient	Ambient			13			13			13												8			10		
		Vacuum, Hot		43-54	120 ±10	1 Hr minimum(3)		12	11		12	11		12												7(3)			9		
		Vacuum, Hot		60-71	150 ±10	2 Hrs minimum																	7	6			4				

NOTES: (1) Equivalent - Turco 4215

(2) When mixing acids, always add acid to water.

(3) Non-metals rinsed in IPA shall be evacuated for a minimum of 50 hours.

(4) Suggested List of Detergents:

MIL-D-16791E
- Triton X-100, RHOM and Haas
- Triton X-102, RHOM and Haas
- Triton X-114, RHOM and Haas
- Igepal CA-630, Antara
- Igepal CA-716, Antara
- Igepal CO
- Synthetics B-29, Hercules
- Neutronyx, Onyx
- Turgetol, Unioncarbide

(5) Table Instructions:

a. Select type of system.

b. Extend horizontally to proper material.

c. Extend vertically - numbers indicate sequence of steps.

Acceptable Substitutes:
- Renex, Atlas
- Ethefats, Armour
- Emulphor VK-730, Antara
- Sterox CD, Monsanto
- Sterox AJ, Monsanto

(6) Stainless Steels:

Free Machining - 300 series: 302B, 303, 303SE, 309S, 310S

Precipitation Hardening: 17-4 PH, 17-7 PH, 15-7 PH, AM350, AM355

300 Series - S/S: 301, 302, 304, 3046, 309, 310, 316, 3166, 317, 321, 347

(7) MSC-SPEC-C-20A

	Distilled	Deionized (high purity)
Conductivity (resistivity)	2×10^{-6} ohms^{-1}/CM (500 K ohms/CM)	1×10^{-6} ohm^{-1}/CM (1 M ohm/CM)
Acidity (pH)	6.00 - 7.50	6.00 - 7.50
Non volatile residue (max)	1.0 mg/100 ml	0.2 mg/100 ml
Particulate		>100 micron = 0
Halides (max)$^{\Delta}$	1.0 ppm	1.0 ppm

ΔHalides test may be waived if conductivity is less than 2×10^{-7} ohm^{-1}/CM (5 M ohm/CM)

(8) Acceptable by specific materials engineering group authorization only.

Table III. Contamination Levels for Propulsion Subsystem and its Associated Components and Support Equipment (Sheet 1 of 3)

CLASS A — Range of Particle Sizes, Microns

Hardware / Propellant / Gases / Packaging	Level	2-5	6-10	11-25	26-50	51-100	101-200
Piece Parts	1	15	3	0	0	0	0
Components	2	30	7	1	0	0	0
Assemblies	3	40	10	2	0	0	0
Subsystems	4	120	30	4	0	0	0
Test Fluid[3]	5	2	1	0	0	0	0
Components with Moving Parts Having Minimum Design Clearances of 0.001 to 0.0015 inch (25-38μ)	6	100	1	0	0	0	0
0.0016 to 0.0025 inch (40-63μ)		200	5	1	0	0	0
0.0026 to 0.0035 inch (64-89μ)		300	20	10	0	0	0
Liquid Propellant	7	30	7	1	0	0	0
Gases	8	15	3	0	0	0	0
Cryogenic Propellant	9	100	20	10	0	0	0
Liquified Gases	10	100	5	0	0	0	0
Precision Packaging Material	11	50	1	0	0	0	0

CLASS B — Range of Particle Sizes, Microns

Hardware / Propellant / Gases / Packaging	Level	0-5	6-10	11-25	26-50	51-100	101-200
Piece Parts	1	Do Not Count[5]	10	2	0	0	0
Components	2		30	4	1	0	0
Assemblies	3		60	9	2	0	0
Subsystems	4		140	20	5	1	0
Test Fluid[3]	5		1	0	0	0	0
Components with Moving Parts Having Minimum Design Clearances of 0.001 to 0.0015 inch (25-38μ)	6		2	0	0	0	0
0.0016 to 0.0025 inch (40-63μ)			10	1	0	0	0
0.0026 to 0.0035 inch (64-89μ)			40	10	0	0	0
Liquid Propellant	7		30	4	0	0	0
Gases	8		10	2	0	0	0
Cryogenic Propellant	9		40	10	0	0	0
Liquified Gases	10		10	5	0	0	0
Precision Packaging Material	11		5	1	0	0	0

CLASS C — Range of Particle Sizes, Microns

Hardware / Propellant / Gases / Packaging	Level	0-5	6-10	11-25	26-50	51-100	101-200
Piece Parts	1	Do Not Count[5]	30	4	1	0	0
Components	2		60	9	2	0	0
Assemblies	3		140	20	5	1	0
Subsystems	4		600	80	20	4	0
Test Fluid[3]	5		3	0	0	0	0
Components with Moving Parts Having Minimum Design Clearances of 0.001 to 0.0015 inch (25-38μ)	6		3	0	0	0	0
0.0016 to 0.0025 inch (40-63μ)			15	1	0	0	0
0.0026 to 0.0035 inch (64-89μ)			60	20	1	0	0
Liquid Propellant	7		60	9	2	0	0
Gases	8		30	4	1	0	0
Cryogenic Propellant	9		60	20	10	0	0
Liquified Gases	10		20	10	1	0	0
Precision Packaging Material	11		5	1	0	0	0

NOTES:

1. Gas flow through a 1.2 micron millipore filter shall be a minimum of 15 cubic feet, at a rate of approximately 5 cubic feet per minute. Record total number left on a 47-mm filter.
2. Particle count shall be based on a sample of 100 ml of fluid or 424.5 liters (15 std ft^3) of gas.
3. Test fluid particle count shall be a maximum of 10% of the desired item cleanliness level (listed for level 1).
4. See Figure 1 for graphic comparison of levels 1 through 4.
5. Particles in the "Do Not Count" ranges shall not cause discoloration of the filter pad.

Table III. Contamination Levels for Propulsion Subsystem and its Associated Components and Support Equipment (Sheet 2 of 3)

CLASS D

Hardware Propellant Gases Packaging	Level	0-5	6-10	11-25	26-50	51-100	101-200
		Range of Particle Sizes Microns					
Piece Parts	1	Do Not Count[5]	60	9	2	0	0
Components	2		140	20	5	1	0
Assemblies	3		600	80	20	4	0
Systems	4		1200	200	50	12	3
Test Fluid[3]	5		6	1	0	0	0
Components with Moving Parts Having Minimum Design Clearances of 0.001 to 0.0015 inch (25-38μ)	6		5	0	0	0	0
0.0016 to 0.0025 inch (40-63μ)			20	2	0	0	0
0.0026 to 0.0035 inch (64-89μ)			80	40	5	0	0
Liquid Propellant	7		140	20	5	1	0
Gases	8		60	9	2	0	0
Cryogenic Propellant	9		120	40	20	1	0
Liquified Gases	10		40	20	2	0	0
Precision Packaging Material	11		10	3	1	0	0

CLASS E

Hardware Propellant Gases Packaging	Level	0-5	6-10	11-25	26-50	51-100	101-200
		Range of Particle Sizes Microns					
Piece Parts	1	Do Not Count[5]	140	20	5	1	0
Components	2		600	80	20	4	0
Assemblies	3		1200	200	50	12	3
Systems	4			1000	250	60	15
Test Fluid[3]	5		14	2	1	0	0
Components with Moving Parts Having Minimum Design Clearances of 0.001 to 0.0015 inch (25-38μ)	6		10	0	0	0	0
0.0016 to 0.0025 inch (40-63μ)			30	3	0	0	0
0.0026 to 0.0035 inch (64-89μ)			100	50	10	0	0
Liquid Propellant	7		600	80	20	4	0
Gases	8		140	20	5	1	0
Cryogenic Propellant	9		300	120	60	3	0
Liquified Gases	10		100	60	5	0	0
Precision Packaging Material	11		20	10	1	0	0

CLASS F

Hardware Propellant Gases Packaging	Level	0-5	6-10	11-25	26-50	51-100	101-200	201-500	501-1000
		Range of Particle Sizes Microns							
Piece Parts	1	Do Not Count[5]	500	80	20	5	1	0	0
Components	2		1200	200	50	12	3	0	0
Assemblies	3			1000	250	60	15	0	0
Systems	4				800	200	40	6	1
Test Fluid[3]	5		50	8	2	1	0	0	0
Components with Moving Parts Having Minimum Design Clearances of 0.001 to 0.0015 inch (25-38μ)	6		50	1	0	0	0	0	0
0.0016 to 0.0025 inch (40-63μ)			100	10	0	0	0	0	0
0.0026 to 0.0035 inch (64-89μ)			500	100	20	0	0	0	0
Liquid Propellant	7		1200	200	50	12	3	0	0
Gases	8		500	80	20	5	1	0	0
Cryogenic Propellant	9		1000	300	100	10	5	0	0
Liquified Gases	10		200	100	10	1	0	0	0
Precision Packaging Material	11		50	20	5	1	0	0	0

NOTES:

1. Gas flow through a 1.2 micron millipore filter shall be a minimum of 15 cubic feet, at a rate of approximately 5 cubic feet per minute. Record total number left on a 47-mm filter.
2. Particle count shall be based on a sample of 100 ml of fluid or 424.5 liters (15 std ft^3) of gas.
3. Test fluid particle count shall be a maximum of 10% of the desired item cleanliness level (listed for level 1).
4. See Figure 1 for comparison of levels 1 through 4.
5. Particles in the "Do Not Count" range shall not cause discoloration of the filter pad.

Table III. Contamination Levels for Propulsion Subsystem and its Associated Components and Support Equipment (Sheet 3 of 3)

CLASS G — Range of Particle Sizes, Microns

Hardware Propellant Gases Packaging	Level	0-5	6-10	11-25	26-50	51-100	101-200	201-500	501-1000
Piece Parts	1	Do Not Count (5)	1200	200	50	12	3	0	0
Components	2			1000	250	60	15	0	0
Assemblies	3				800	200	40	6	0
Systems	4					600	140	20	5
Test Fluid[3]	5		120	20	5	1	0	0	0
Components with Moving Parts Having Minimum Design Clearances of 0.001 to 0.0015 inch (25-38μ)	6		100	2	0	0	0	0	0
0.0016 to 0.0025 inch (40-63μ)			150	4	0	0	0	0	0
0.0026 to 0.0035 inch (64-89μ)			700	200	40	0	0	0	0
Liquid Propellant	7			1000	250	60	41 5	0	0
Gases	8		1200	200	50	12	3	0	0
Cryogenic Propellant	9		2000	600	200	20	10	2	0
Liquified Gases	10		300	150	15	2	1	0	0
Precision Packaging Material	11		70	30	10	2	1	0	0

CLASS H — Range of Particle Sizes, Microns

Hardware Propellant Gases Packaging	Level	0-5	6-10	11-25	26-50	51-100	101-200	201-500	501-1000
Piece Parts	1	Do Not Count (5)	Do Not Count (5)	1000	250	60	15	0	0
Components	2				800	200	40	6	0
Assemblies	3					600	140	20	5
Systems	4						500	70	15
Test Fluid[3]	5			100	25	6	1	0	0
Components with Moving Parts Having Minimum Design Clearances of 0.001 to 0.0015 inch (25-38μ)	6			5	0	0	0	0	0
0.0016 to 0.0025 inch (40-63μ)				10	0	0	0	0	0
0.0026 to 0.0035 inch (64-89μ)				1000	300	0	0	0	0
Liquid Propellant	7				800	200	40	6	0
Gases	8			1000	250	60	15	0	0
Cryogenic Propellant	9			3000	1000	100	50	10	1
Liquified Gases	10			400	200	4	2	1	0
Precision Packaging Material	11			50	15	3	1	0	0

NOTES:

1. Gas flow through a 1.2 micron millipore filter shall be a minimum of 15 cubic feet, at a rate of approximately 5 cubic feet per minute. Record total number left on a 47-mm filter.
2. Particle count shall be based on a sample of 100 ml of fluid or 424.5 liters (15 std ft^3) of gas.
3. Test fluid particle count shall be a maximum of 10% of the desired item cleanliness level (listed for level 1).
4. See Figure 1 for comparison of levels 1 through 4.
5. Particles in the "Do Not Count" ranges shall not cause discoloration of the filter pad.

Table IV. Test Frequency Requirements

	3.6.6 pH Measurement	3.6.1 Particle Count	3.6.2 Ultra-Violet	3.6.4 Silver Nitrate, Flux-Brazed Parts	3.6.5 Non Volatile Residue	3.5.6.1 Dewpoint Hydrocarbon (Gas Analysis) Purge Gas Source	3.6.3 Wipe	3.4.1 Solution Certification	3.5.6.1 Residual Gas Analyzer or Dewpoint Purge Gas Drying Method Only	3.6.8 Halides	3.6.7 Conductance	3.6.9 Ultrasonic Bath Test
Every Item	X (1)	X	X	X					X (3)			
Daily						X (Dewpoint)						
QA/QC/ENG Request	X	X	X	X	X	X	X	X	X	X	X	X
Change of, or addition to, source or solution	X					X (Dewpoint and Hydracarbon Content)		X		X	X	
Monthly		Work (2) area									X	X
Weekly								X				

(1) The pH test shall be performed as a part of the post bath rinse phase on all items subjected to acids, detergents, and alkaline baths.

(2) The work area shall be checked per 3.2.1.2.

(3) Items rinsed with water and dried per 3.5.6.1.

Table V. Authorized Cleaning Classes/Levels[1]

Items	Bipropellant Systems	Monopropellant Systems
Rocket Engine (less valve)	D-4	G-2
Propellant Tank Assembly	D-4	D-4
Propellant Tank Components	D-3	D-3
Gasses	E-8	D-8
External Surfaces	G-2	G-2

[1] Except as noted in the table, all flight propulsion subsystems and related support equipment shall be cleaned to the appropriate level of Class 'D'.

LEVEL:
1 - Piece Parts, Gases (Level 8)
2 - Components, Propellants (Level 7)
3 - Subassemblies
4 - Assemblies, Systems

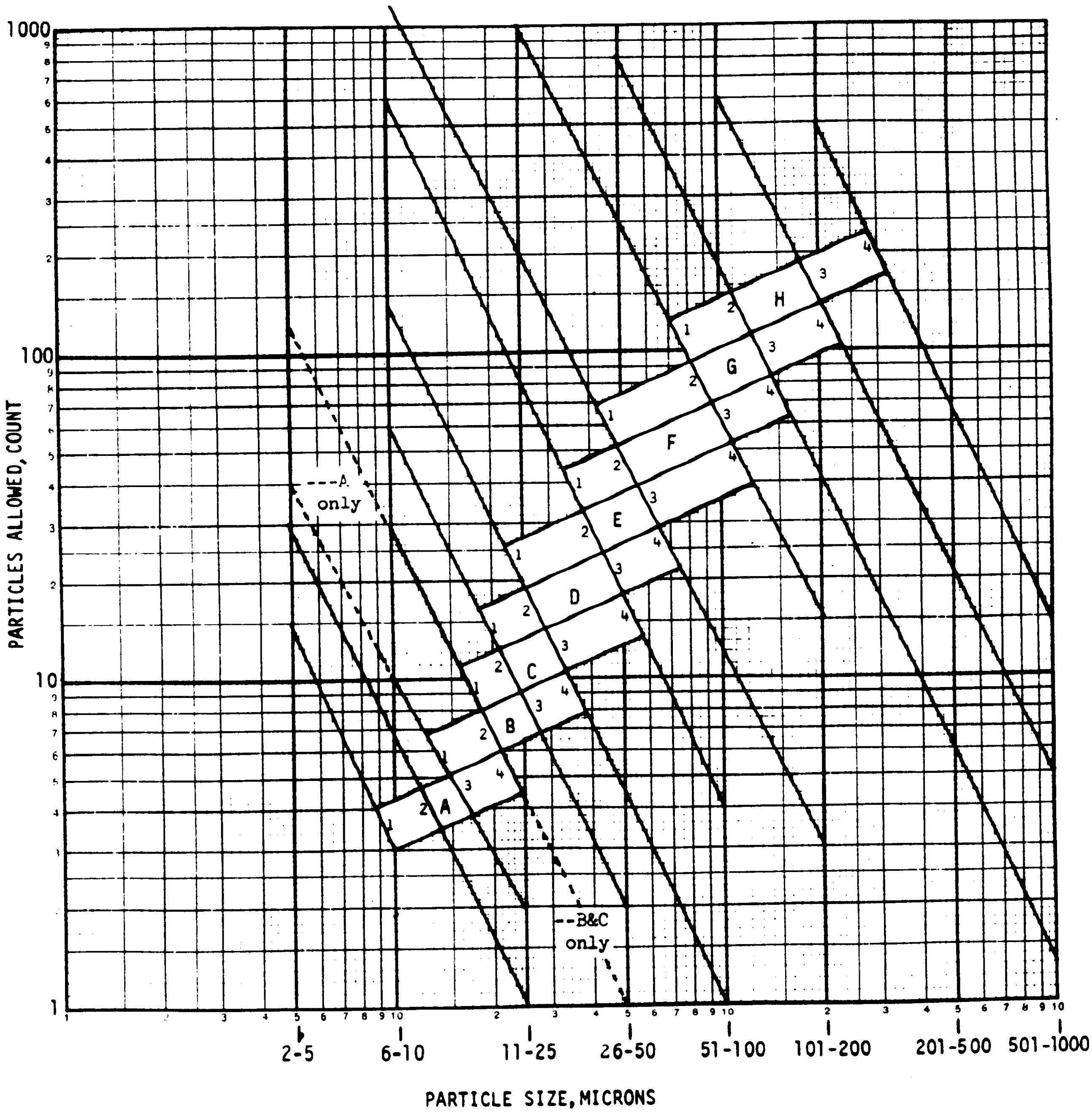


Figure 1. Comparison of Cleanliness Levels

CLEAN ROOM HISTORY CARD # _____

Component has been cleaned per specification __________ on ______ ______ ______ .
Month Day Year
Paragraph(s) __________________ .

DO NOT OPEN

Except in a Class (cross out two) 100 / 10,000 / 100,000 Controlled Area per Federal Standard 209.

Quantity __________ Component Part No. __________ Serial No.(s) __________

Component No. __________ Serial No. __________

Next Assembly No. __________ Serial No. __________

Unit Opened ____________________ Date __________

Where Opened ____________________ By Whom __________

QA Approved __________

JPL 3836 (8-69)

Front of Card

CLEANED FOR EQUIPMENT

RINSE ______ MILLILITERS

RINSE ______ CU. FEET

RINSE FLUID — NO PARTICULES GREATER THAN ______ MICRONS

RINSE FLUID USED __________

NO. OF SQUARES ON GRID COUNTED __________

MAGNIFICATION USED TO COUNT __________ X

SERVICE

SOFT-GOODS

LUBRICANT

CONTAMINATION OF THE COMPONENT

Date: Start ______ Time ______
Completion ______ Time ______

SIZE OF PARTICLES	METALLICS OF CERAMICS	NON METALLICS	FIBERS 10/1
0-5	DO NOT COUNT	DO NOT COUNT	
6-10			
11-25			
26-50			
51-100			
OVER 100			

ULTRA–VIOLET LIGHT TEST __________

CLEAN ROOM TECHNICIAN __________

DATED __________

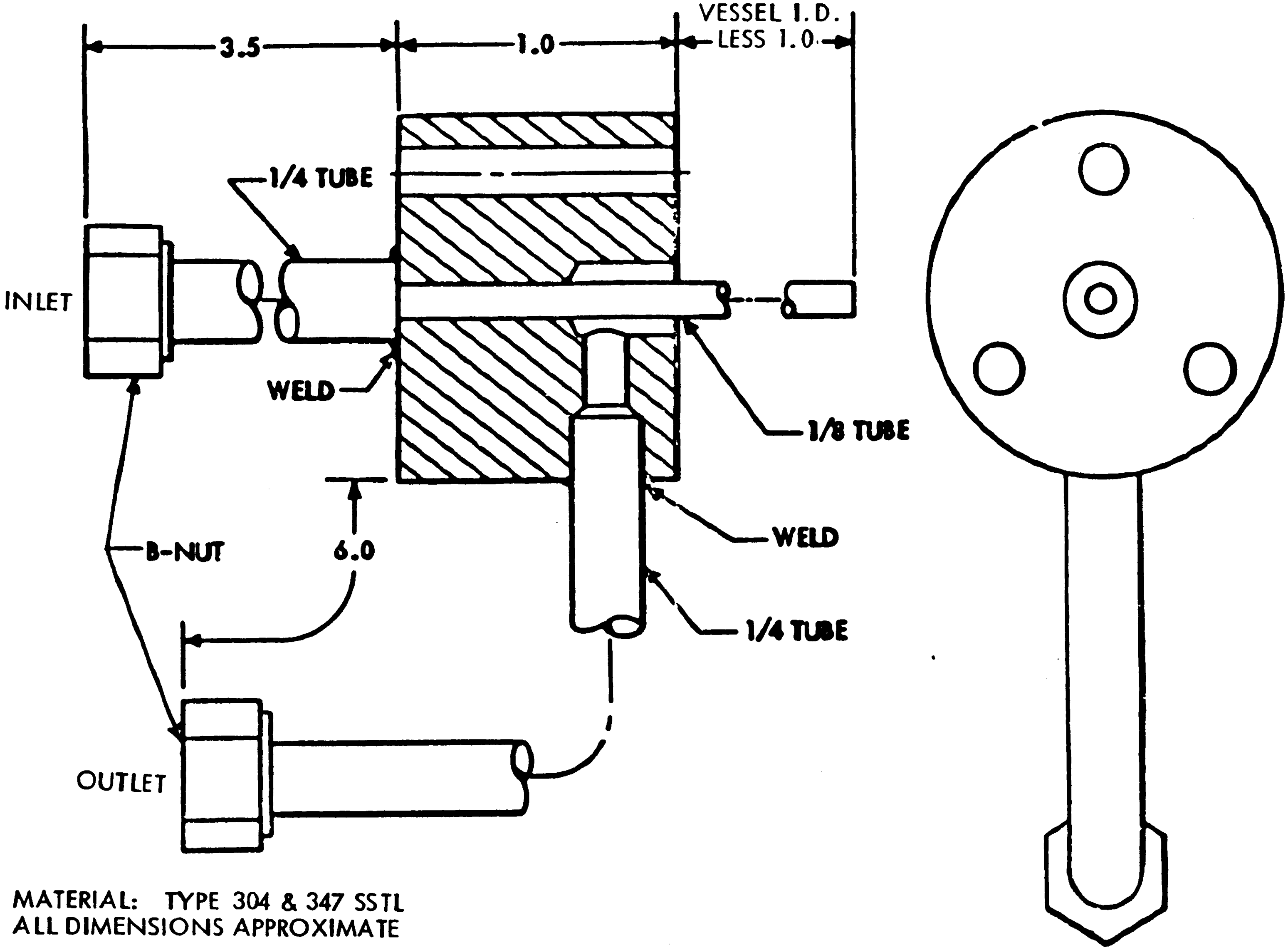
QUALITY ASSURANCE __________

DATED __________

REV. SIDE JPL 3836 (8-69)

Rear of Card

Figure 2. Clean Room History Card (Sample)



MATERIAL: TYPE 304 & 347 SSTL
ALL DIMENSIONS APPROXIMATE

TUBE BEND CONFIGURATION
IS OPTIONAL

Figure 3. Fitting for Pressure Flushing a Cold Gas Attitude Control Tank

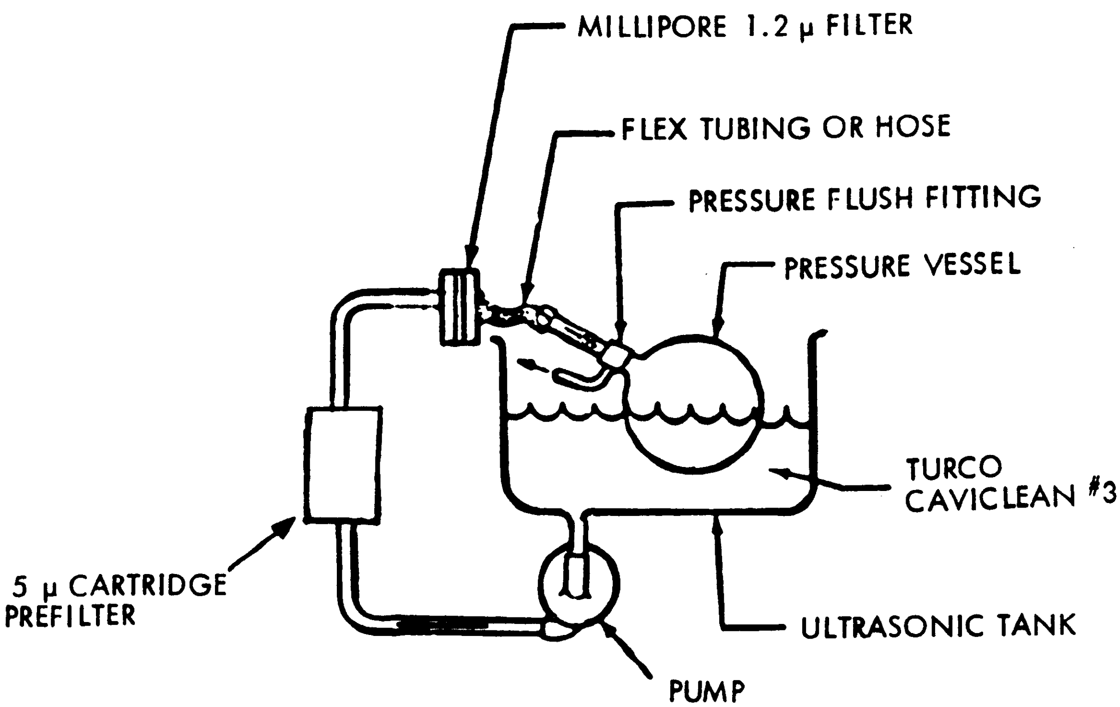


Figure 4. Pressure Flushing Setup for Cold Gas Attitude Control Tank

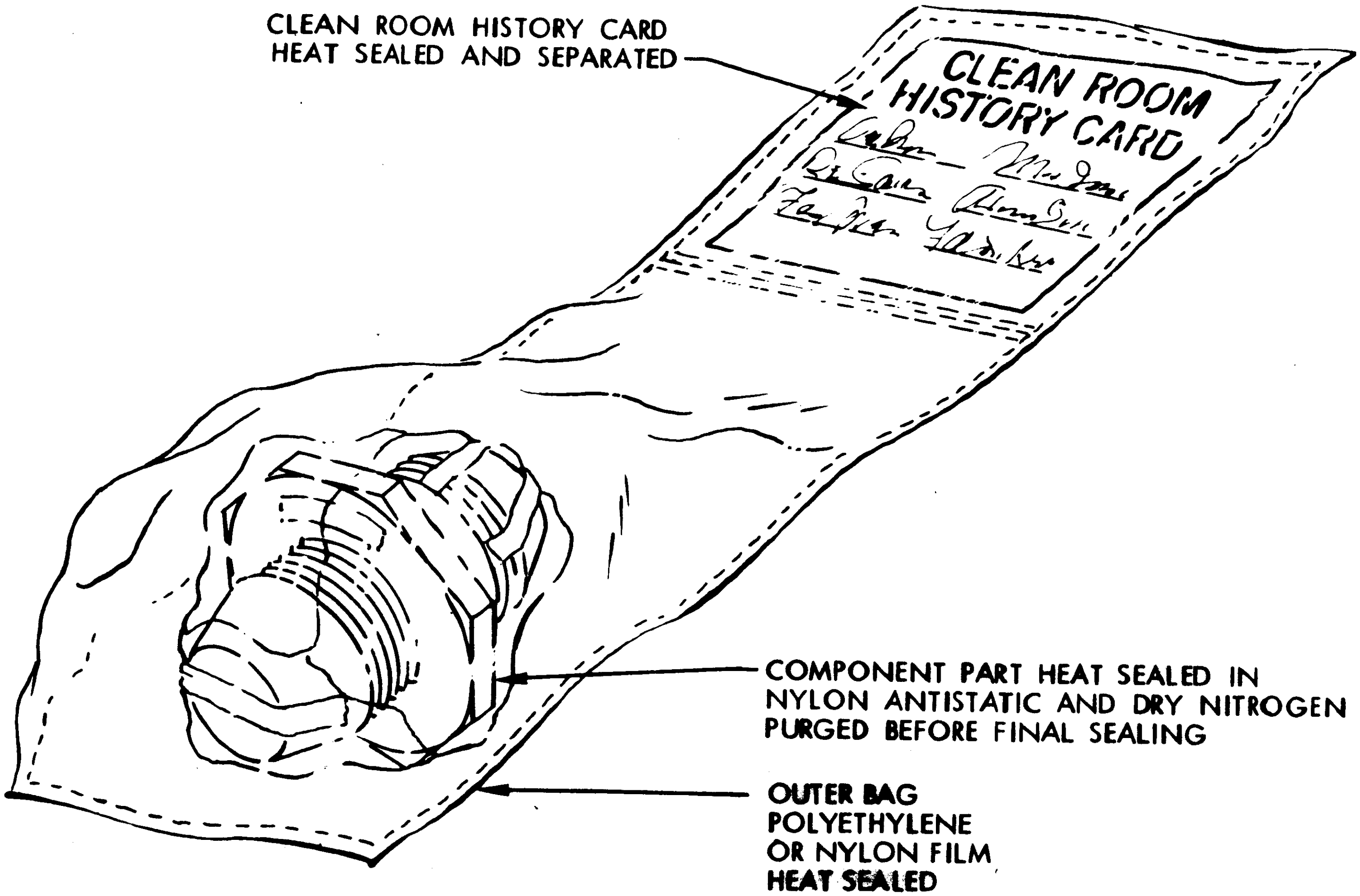


Figure 5. Packaging Single Items

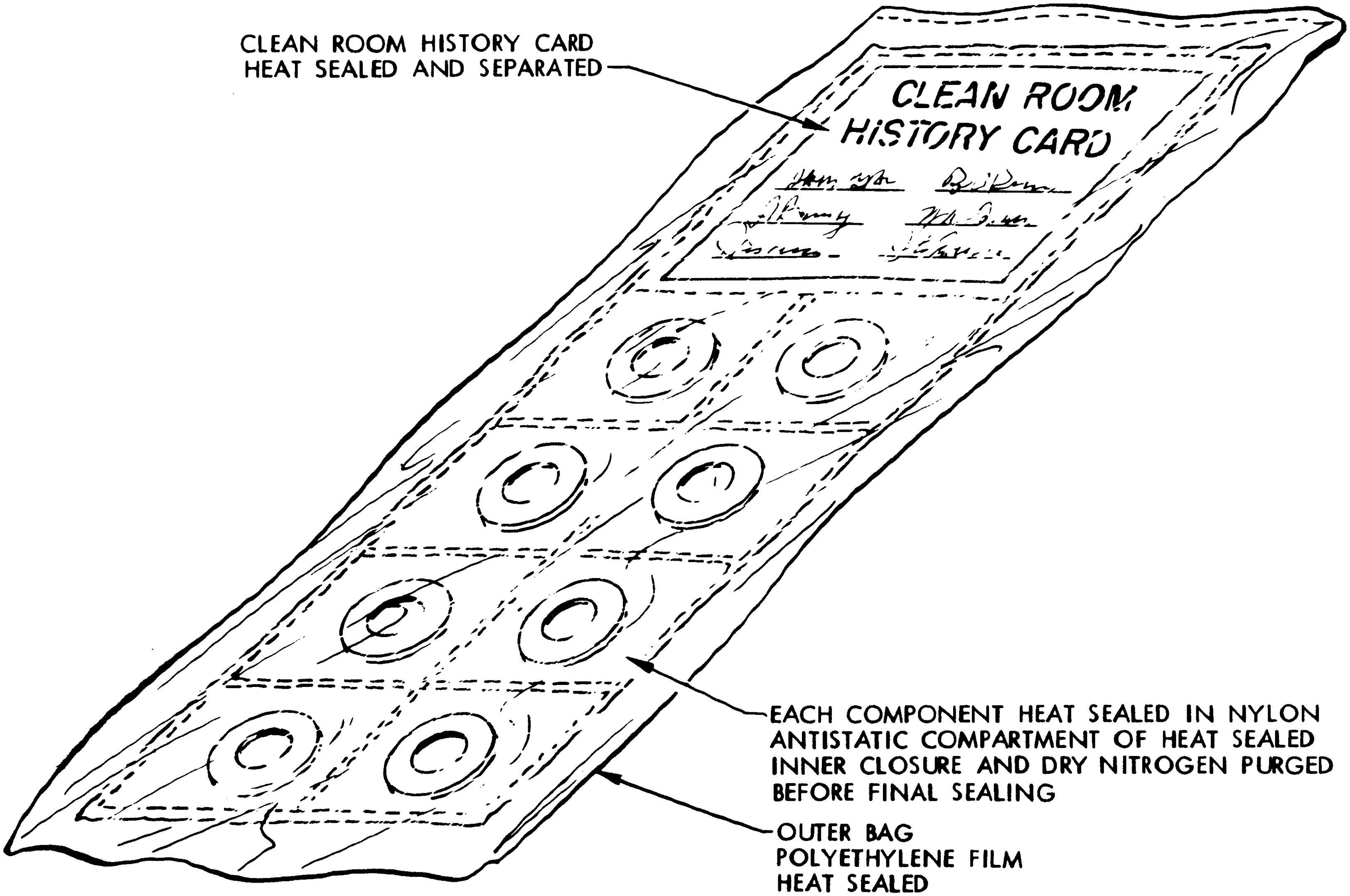


Figure 6. Packaging Multiple Items