MILITARY STANDARD

PROCESS FOR CLEANING

HYDRAZINE SYSTEMS AND COMPONENTS

FSC 9135

DEPARTMENT OF DEFENSE

Washington, DC 20301

Process for Cleaning Hydrazine Systems and Components

MIL-STD-1774

1. This Military Standard is approved for all Departments and Agencies of the Department of Defense.

2. Recommended corrections, additions, or deletion should be addressed to: Director, Air Force Rocket Propulsion Laboratory, ATTN: LKCP, Stop 24, Edwards AFB CA 93523.

FORWORD

1. This standard provides instructions for cleaning hydrazine storage and flight systems.

2. The project was jointly funded by National Aeronautics and Space Administration, and the Air Force Rocket Propulsion Laboratory with the effort conducted by the Jet Propulsion Laboratory.

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MILITARY STANDARD

HYDRAZINE PROPULSION SYSTEMS AND COMPONENTS

CLEANING OF

1. SCOPE

1.1 Scope. This standard defines the general chemical and particulate cleaning requirements for hydrazine (N_2H_4) propulsion systems, associated pressurant systems and related support equipment including assemblies, components, and all component (piece) parts. Descaling, chemical deburring, active pickling processes and propellant decontamination are not within the scope of this specification.

1.2 Purpose. The purpose of this document is to establish the cleaning level requirements, cleaning procedures, packaging, and documentation for the procurement of hydrazine systems and/or related hardware to be in contact with hydrazine propellant.

2. REFERENCED DOCUMENTS

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

SPECIFICATIONS

Federal

O-N-350	Acid, Nitric, Technical Grade
P-C-436	Cleaner, Alkaline, Boiling (Vat) Powder
O-S-595	Sodium Dichromate, Dihydrate, Technical
TT-I-735	Alcohol, Isopropyl, Grade B

Military

MIL-S-12071	Silver Nitrate, Technical
MIL-D-16791	Detergent, General Purpose Liquid

MIL-A-18455	Argon, Technical (99.996% High Purity Grade for Critical Needs)
MIL-B-22191	Barrier Material, Transparent, Flexible, Heat Sealable
MIL-P-27401	Propellant Pressurizing Agent, Nitrogen
MIL-P-27407	Propellant Pressurizing Agent, Helium
ASTM D1193	Water, Types I & II

STANDARDS

Military

MS-36052	Sulphuric Acid

Federal

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

OTHER GOVERNMENT ACTIVITY

U.S. Air Force

T.O. 00-25-203	Contamination Control of Aerospace Facilities

PUBLICATIONS

American Society for Testing and Materials

ASTM D1193	Requirements for Reagent Water, Types I & II
ASTM Method D-257	DC Resistance or Conductance of Insulating Materials, Tests for
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, Tests 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. Definitions.

a. Piece part. A piece part is the elementary unit of a component or system. It consists of one material and will be subject to later, permanent assembly with other piece parts to form a component part.

b. Component part. A component part is two or more piece parts joined together, which are not usually subject to disassembly. O-rings, poppets, valve housings, and fittings are piece parts of a valve component part. A component part does not necessarily contain any moving parts. A length of flared tubing with sleeves and fittings would be considered a component part rather than a component.

c. Component. A component is a unit consisting of two or more replaceable parts. The filter element, filter housing, and fittings comprise a filter component. Components have a common mounting and are 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. An assembly is capable of independant operation and checkout before being interconnected into a complete system.

e. System. A system is an interconnected assemblage of component assemblies in a particular configuration. The assembly of tubing, regulators, fill valves, explosive valves, propellant tanks, and rocket motor comprise a system.

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 systems and assemblies of components and piece parts that contact fluids.

i. Visibly clean. Visibly clean refers to observation by the unaided eye regarding the freedom of the surface from particulate matter approximately 50 microns (μm) and larger in size, and from all visible films other than known innocuous films.

j. Particulate matter. Particulate matter consists of very small discrete particles of solid material. Particulates are sized in micrometers (or μm) and counted as number of particles per unit of volume of gas or liquid.

k. Non-volatile residue (NVR). NVR is soluble (or suspended) material and insoluble particulate below 0.8 µm remaining after the controlled evaporation of a filtered, volatile liquid, usually measured in grams.

l. Test fluid. Any gas or liquid used for test purposes (i.e., proof pressure, leak, flow, functional, etc.) in any hydrazine or hydrazine pressurant system, assembly, or component.

m. Referee Fluid. Any inert liquid used directly as a substitute for hydrazine propellant during system, assembly, or component-level dynamic testing (i.e., vibration).

4. GENERAL REQUIREMENTS (Not applicable)

5. DETAILED REQUIREMENTS

5.1 Particulate cleanliness. The cleanliness of all piece parts, components, assemblies, systems and related and interfacing materials directly or indirectly exposed to hydrazine shall meet the particulate cleanliness requirements of this standard. The particulate cleanliness standards of Table I are listed in three classes, the basis of each being a range of flow system tube sizes:

a. Class 1: All sizes up to and including 3/4 inch outside diameter.

b. Class 2: Sizes above 3/4 inch outside diameter and up to and including 2 inches outside diameter.

c. Class 3: All sizes above 2 inches outside diameter.

5.1.1 Class selection. The procuring agency shall specify the class of particulate cleanliness in their procurement documents. Certain specific factors shall be considered in the selection of class level to be used:

a. In cases where flow systems (propellant or pressurant) consist of more than one line size, the smallest flow system size shall govern the selection.

b. In cases where a flow control component or device was originally designed for a smaller system but incorporated into a larger system, the smaller system size shall govern the selection.

5.2 Conflicting requirements. In the event of a conflict between the requirement of this standard and the requirements of any other controlling document, the conflict shall be referred to the procuring agency for resolution.

5.2.1 Deviations. Deviations from this standard shall only be authorized by the procuring agency. Deviations shall be included in the applicable document.

5.3 Cleaning facility requirements.

5.3.1 Environmental. All cleaning of hydrazine propulsion systems, components, assemblies, and related support equipment shall be performed in work areas, including laminar-flow work benches or stations, free of contamination commensurate with the operation being performed per Table II (reference FED-STD-209). General clean room operations shall conform to either T.O. 00-25-203 or FED-STD-209.

5.3.1.1 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, vapors and processes involved. Environmental control of this area is not required.

Table I. Particulate Contamination Levels for Hydrazine Propulsion Systems and their associated components and support equipment

Hardware[1] propellant gases packaging	CLASS 1							CLASS 2							CLASS 3								
	Range of particle sizes (microns)[2]							Range of particle sizes (microns)[2]							Range of particle sizes (microns)[2]								
	Level	0-5	6-10	11-25	26-50	51-100	101-200	Level	0-5	6-10	11-25	26-50	51-100	101-200	Level	0-5	6-10	11-25	26-50	51-100	101-200	201-500	501-1000
Piece parts	A	Do not count[9]	60	9	2	0	0	A	Do not count[9]	140	20	5	1	0	A	Do not count[9]	500	80	20	5	1	0	0
Components	B		140	20	5	1	0	[7]B		600	80	20	4	0	B[7]		1200	200	50	12	3	0	0
Assemblies[4]	C[7]		600	80	20	4	0	[7]C		1200	200	50	12	3	C[7]			1000	250	60	15	0	0
Systems [3],[5]	D[7]		1200	200	50	12	3	[7]D			1000	250	60	15	D[8][7]				800	200	40	6	1
Test fluid[6]	E		6	1	0	0	0	E		14	2	1	0	0	E		50	8	.2	1	0	0	0
Components with moving parts having minimum design clearances of 0.0010 to 0.0015 inch (25 to 38 μm)	F-1		5	0	0	0	0	F-1		10	0	0	0	0	F-1[7]		50	1	0	0	0	0	0
0.0016 to 0.0025 inch (40 to 63 μm)	F-2		20	2	0	0	0	F-2		30	3	0	0	0	F-2		100	10	0	0	0	0	0
0.0026 to 0.0035 inch (64 to 89 μm)	F-3		80	40	5	0	0	F-3		100	50	10	0	0	F-3		500	100	20	0	0	0	0
Hydrazine or referee fluid	G		140	20	5	1	0	[7]G		600	80	20	4	0	G[7]		1200	200	50	12	3	0	0
Gases	H		60	9	2	0	0	H		140	20	5	1	0	H[7]		500	80	20	5	1	0	0
Precision packaging material	I		10	3	1	0	0	J		20	10	1	0	0	J		50	20	5	1	0	0	0

NOTES:

1. Gas flow through a 1.2 μm millipore filter shall be a minimum of 35 ft^3, at a rate of approximately 5 ft^3 per minute. Record total number of particles left on a 47-mm filter.
2. Particle count shall be based on a sample of 100 ml of fluid or 990 liters (35 standard ft^3) of gas.
3. Includes external surface cleanliness for Class 1 and Class 2 systems.
4. Includes propellant tank components.
5. Includes rocket engine (less propellant valve), and propellant tank assembly.
6. Test fluid particle count shall be a maximum of 10 percent of the desired item cleanliness level (listed for Level A).
7. Statistical sampling may be used where the maximum acceptable particle counts exceed 140 particles.
8. Includes external surface cleanliness for Class 3 system.
9. Particles in the "Do not count" range shall not cause discoloration of the filter pad (or sifting).

Table II. Clean Room Classes, Particles Allowed

Class	Particles allowed (per ft^3)	
	0.5 microns and greater	5.0 microns and greater
100	100	0
1,000	1,000	7
10,000	10,000	65

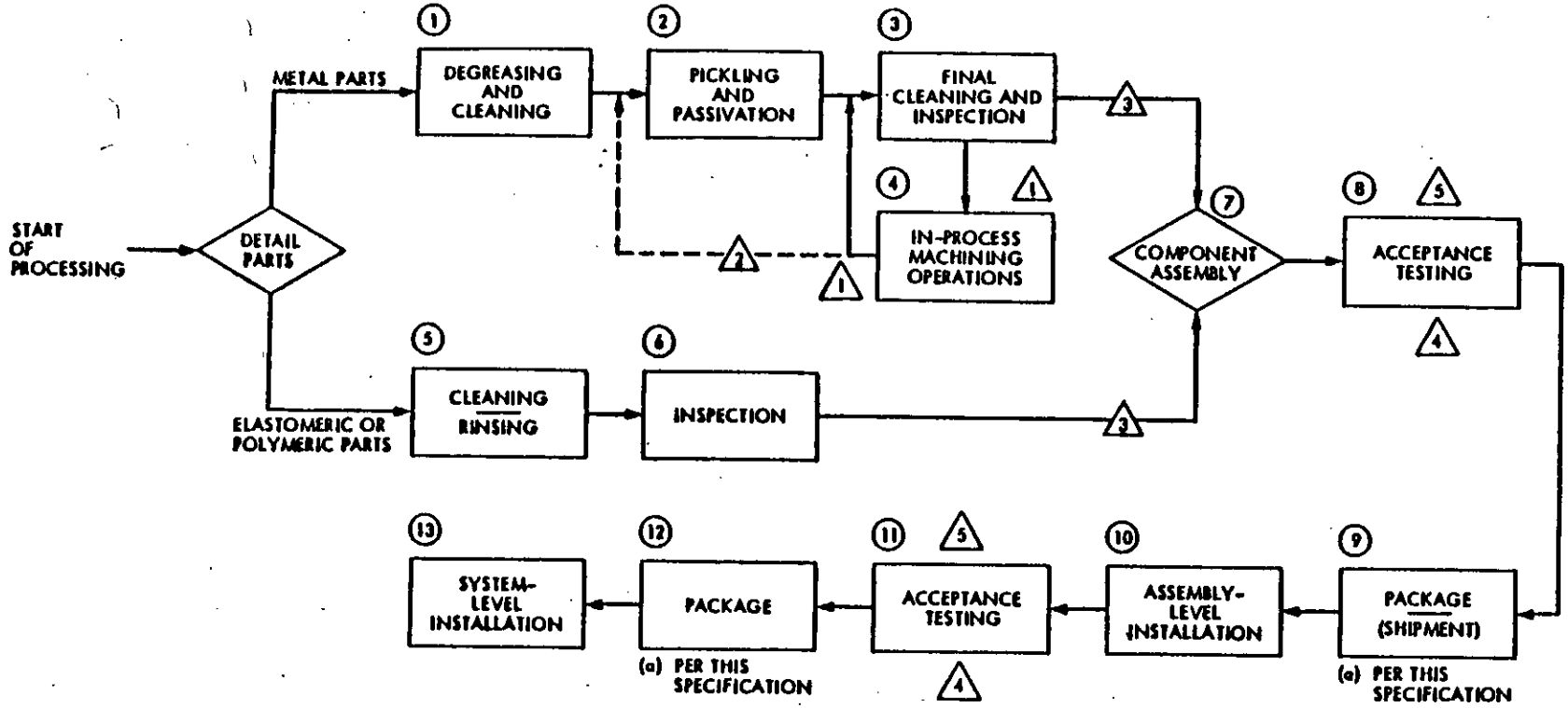
5.3.1.2 Final rinse (piece parts). All final cleaning of piece parts and all handling of cleaned components, assemblies, and systems (until properly packaged) shall be performed in a work area commensurate with the particulate level to be attained and, in any case, shall conform to the requirements of FED-STD-209, Class 10,000 minimum, and T.O. 00-25-203. Class 100 to 10,000 work stations contained within a Class 100,000 clean room may be substituted. After initial certification, the work area shall be checked daily to assure proper work area environments. Temperature and relative humidity shall be controlled to 23° ± 5°C (72° ± 8°F) and 45 ± 15 percent respectively.

5.3.2 Equipment. All equipment used to accomplish the requirements of this standard 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, over-temperature and other safety devices. Soft goods exposed to the cleaning fluids shall be limited to those materials which do not leach plasticizers into the fluids contained therein. (For example, Teflon FEP is acceptable.) 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 6.4.9.

CAUTION

Care shall be exercised when making connections to items being cleaned.

5.4 General cleaning requirements. The materials of construction of all parts, components, and assemblies scheduled for hydrazine service shall be cleaned in accordance with the solutions and sequences specified herein. The parts, components, and assemblies shall be processed in accordance with Figure 1 and Tables III through XII. (Tables III through XII are located at the back of this standard for reference convenience.)



NOTES:

1. LOCAL PICKLING AND PASSIVATION SHALL BE REQUIRED IF STEEL TOOL BITS ARE USED DURING FINAL MACHINING OPERATIONS AND SHALL BE LIMITED TO ONLY THOSE SURFACES SO MACHINED. THIS REQUIREMENT MAY BE OMITTED IF CARBIDE TOOL BITS ARE USED EXCLUSIVELY IN FINAL MACHINING OPERATIONS.

2. PARTS SHALL BE SUBJECTED TO STEP NO. 3 (FINAL CLEANING) BEFORE WELDING IF AN INTERFACING SURFACE BETWEEN NEWLY WELDED PARTS CAN BECOME A CONTAMINATION TRAP AND EXPOSABLE TO PROPELLANT.

3. CLEANLINESS VERIFICATION AT THE FINAL ACCEPTANCE LEVEL SHALL BE REQUIRED OF DETAIL PARTS.

4. (a) THOROUGH DRYING SHALL BE REQUIRED IN A VACUUM OVEN AT 66°C (150°F) AT IMMEDIATE CONCLUSION OF ACCEPTANCE TESTING (AND FOLLOWING LIQUID EXPOSURE) TO A MEASURED LEVEL APPROVED BY PROJECT DOCUMENTS.

   (b) CLEANLINESS VERIFICATION SHALL BE PERFORMED WITH 5 μm-FILTERED, OIL-FREE, DRY GN_2.

5. ONLY IF PERFORMED.

FIGURE 1. Parts Processing Flow Diagram

CAUTION

Halogenated solvents (Freon TF, Trichlorethylene, etc.) or solvents containing halogen impurities (i.e., methanol) should not be used in the cleaning of titanium tanks, systems containing titanium tanks, titanium piece parts or components. Furthermore, these solvents should not be used in any monopropellant hydrazine system, unless specifically requested and authorized by the procuring agency.

5.4.1 Newly machined parts. All newly machined piece parts shall be cleaned in accordance with the conditions and sequences specified for their identified material of construction. Parts subject to later assembly processes shall be treated at the latest possible point in the manufacturing sequence that will assure the proper treatment and cleanliness of the part.

5.4.2 Recycled parts and components. Parts or components previously exposed to propellant shall not be subjected to acid or alkaline baths unless specified in the appropriate manufacturing or reprocessing documents. Components to be recleaned should be completely disassembled before the start of cleaning. All parts shall be decontaminated and precleaned in accordance with the applicable documents and then processed in accordance with Figure 1, as applicable.

5.4.3 Test and support equipment. Support equipment, or portions thereof, interfacing with clean assemblies, shall be cleaned to a level equal to, or better than the assembly. The support equipment shall be verified capable of delivering fluids and gases of the required cleanliness and purity. Filtration should be employed as required.

5.5 General cleaning operations for piece parts. The cleaning operations described below are guidelines for the specified operations. Alternate operations or procedures shall be authorized by the procuring agency.

17 5.5.1 Degreasing. Solvent degreasing shall be performed to remove surface oils, greases, and other 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.

5.5.1.1 Hot vapor solvent degreasing. Hot vapor solvent degreasing shall be performed by immersing the part(s) into the hot vapor phase of the solvent until the solvent stops condensing on the part(s). If the equipment has spraying capability, the part should be sprayed with hot solvent. Parts shall be immediately rinsed per 5.5.5.1 unless otherwise specified.

Note: Vapor degreasing shall be performed only if requested by the procuring activity. The cleaning agent shall be approved by the procuring activity prior to use.

5.5.1.2 Cold solvent or ultrasonic degreasing. Parts to be degreased shall be suspended in a degreasing bath. 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 detrimental to the part, manual agitation and scrubbing shall be employed. Parts shall be immediately rinsed per 5.5.5.1 following removal from the bath, unless otherwise specified. All internal and external surfaces shall be exposed to the agitation and scrubbing.

5.5.2 Detergent cleaning. The detergent solution shall be from a nonionic, additive-free detergent mixed with deionized water. Parts shall be subjected to this detergent cleaning with ultrasonic agitation or 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 5.5.5.1.

5.5.3 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 immediately rinsed per 5.5.5.1. The alkaline solution shall not be allowed to dry on, or in, the part being treated.

5.5.4 Acid treatment. Corrosion-resistant steels, nickel steels, and titanium parts shall be subjected to acid baths to remove surface embedments (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 shall strictly adhere to the requirements of Tables III through VIII, as applicable.

5.5.4.1 Acid solutions. Acid solutions shall be in accordance with Tables III through VIII, as applicable.

5.5.4.2 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 mixture of the acid-water solution. In the case of two or more additives to the water, they shall be added to the water in the order of descending concentration.

5.5.4.3 General acid procedure. Items to be acid treated shall be degreased and free of obvious contaminations. Parts shall be entirely submerged in the acid bath. 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 shall be immediately rinsed per 5.5.5.1.

5.5.5 Rinses. Rinse solutions serve three functions by providing a nonreactive medium with which to:

a. Remove previous more reactive treatments and solutions

b. Rinse away loosened particulate contaminants from the surface being cleaned

c. Verify surface cleanliness by means of tests described in 10.4.

5.5.5.1 Preclean rinse. Water used for rinse during precleaning operations shall conform to [ASTM D 1193] (refer to Tables III through XII).

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 residues or any residual materials from the treatment solutions have not accumulated in the rinse water.

5.5.5.2 Final rinse. Final rinse fluids shall be used solely for the purpose of final rinse and cleanliness verification and 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 (Level E of all classes) of Table I. Verification frequency is shown in Table XIII. Cleanliness verification shall be performed per 10.4. The final rinse shall be repeated until conformance to Table I is established when sampled per 10.4. 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.

5.5.6 Drying. Drying procedures are designed to remove all traces of liquid from the item 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.

5.5.6.1 Gas purge. Dry filtered gas with a dewpoint of less than -54°C (less than -65°F), hydrocarbon content less than 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 (i.e., argon, helium, or nitrogen) 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 (Table XIII) to meet Level H of the appropriate class of Table I. Following any hot gas purging, the hardware shall be cooled to ambient conditions with an inert gas having a dewpoint of -54°C (-65°F) or less and verified as clean as stated above.

Components or assemblies having internal passages and liquid traps shall be purged until the dewpoint of the exit gas is equal to the gas source (less than -54°C or -65°F). A residual gas analyzer (a mass spectrometer) should be used when precision determination of gas quality is required. The temperature shall be controlled within the limits shown in Tables III through XII, as applicable.

5.5.6.2 Vacuum dry. Parts to be vacuum dried shall be exposed to a vacuum within the temperature and time limits specified in Tables III through XII. 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 less than 133 N/m^2 (less than 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 over temperature, oil back-migration, 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

For personnel and equipment safety purposes, specific approval shall be obtained from the procuring agency prior to evacuating a propellant tank.

5.6 General cleaning instructions. The general instructions are guidelines for cleaning typical items comprising the hydrazine propulsion systems and related support equipment delineated in 5.6.1 through 5.6.2.7.

5.6.1 Cleaning solutions. All solutions and baths shall be maintained free of 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.). No bath or solution shall be used if the visual appearance is degraded below that of new solutions.

5.6.2 Cleaning of typical items. The general descriptions of cleaning techniques for selected types of items to be cleaned are provided in 5.6.2.1 through 5.6.2.4. 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 flareless fittings designed to protect the interfacing surfaces. Detailed cleaning procedures, conforming to the requirements of this standard shall be prepared as required by the cleaning agency or contractor.

5.6.2.1 Piping, tubing and machined manifolds. Piping, tubing, and machined manifolds should be processed in the following manner:

a. Lengths less than 18 inches should be cleaned in a manner similar to machined piece parts (5.6.2.5).

b. Lengths greater than 18 inches or exceeding ultrasonic or bath capacity should be cleaned by forced flow with the cleaning fluids specified for the appropriate alloy.

c. Acid treatments:

1) Plug one end

2) Fill with appropriate acid solutions (refer to Tables III through VIII).

CAUTION

Exposure time shall be closely followed.

3) Rinse per 5.5.5.1

d. Dry per 5.5.6.1

e. Package:

1) Wrap ends with nylon sheet per MIL-B-22191, Type III, and tape

2) Double bag.

5.6.2.2 Teflon-lined flexible plumbing. All Teflon-lined flexible hoses should be cleaned in the following manner:

a. Force flow of fluids in the sequence shown in Table IX.

b. Ultrasonic assistance during fluid flow.

c. Drying:

1) Gas purge per 5.5.6.1, or

2) Vacuum oven bake per 5.5.6.2.

d. Package by wrapping ends with nylon sheet per MIL-B-22191, Type III, and securing film only with tape. Bag plumbing for protection during storage and/or shipping out of clean room.

5.6.2.3 Flexible metal plumbing with convoluted lining. Convoluted metal plumbing should be cleaned in the following manner:

a. Forced flow or rinsing of the applicable fluids. It is desirable for the convolution centerline to be in the vertical position.

b. Ultrasonic assistance while immersed in the bath (5 minutes maximum).

c. Drying:

1) Gas purge per 5.5.6.1, or

2) Vacuum oven bake per 5.5.6.2.

d. Package per 5.7.

5.6.2.4 Pressure vessels and tanks. 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.

5.6.2.4.1 Propellant tanks. The following guidelines are provided 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 should be introduced to the tank by continuous flow through the tank, or by use of a flushing probe (Figure 2). Filling and draining through a single port is acceptable when the above methods cannot be performed.

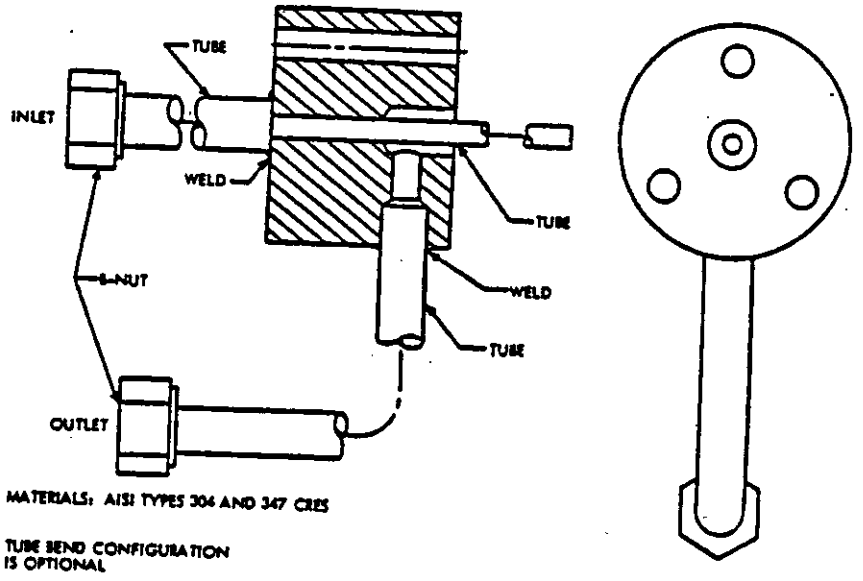


FIGURE 2. Typical Fitting for Pressure Flushing a Pressure Vessel or Tank

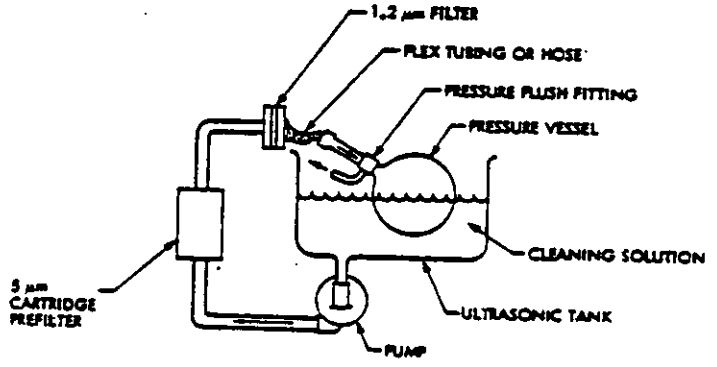


FIGURE 3. Typical Pressure Flushing Installation for a Pressurant Tank

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 5.5.5.2. The quantity of fluid to be introduced shall be determined at the rate of 500 milliliters (ml) of fluid for each square foot of internal surface area or portion thereof (10.4.1.3). The fluid shall contact all internal surfaces of the tank and, where possible, the tank shall be sloshed or agitated while expelling and collecting the sample fluid.

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 procuring agency.

1) Vacuum oven at 66°C (150°F).

2) Ambient temperature vacuum.

3) Hot gas purge.

4) Ambient temperature gas purge.

CAUTION

Care shall be maintained throughout the cleaning process to prevent damaging thin-walled tanks.

5.6.2.4.2 Pressurant tanks. The following guidelines are provided for pressurant tanks:

a. A fitting specifically designed for pressure flushing of pressure vessels should be used (Figure 2). The final configuration of the flush fitting will 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 should be used. A suggested design is shown in Figure 3. Cleaning solution should be passed through a 1.2 µm (or finer) filter (Millipore, or equivalent), prior to entering the pressure vessel. A 5 µm prefilter may also be used to prevent excessively rapid clogging of the final 1.2 µm 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 of the pressure vessel should be performed as follows:

Step

1. Thoroughly clean the exterior of the pressure vessel by degreasing or spray washing (5.5.1.2).

2. Clean the pressure vessel inlet boss and sealing surface(s) using a spray rinser (or equivalent), containing an approved type of cleaning agent. Rinse thoroughly and blow dry with clean filtered nitrogen (5.5.6.1).

3. Attach a cleaned pressure flush fitting to the pressure vessel using an approved seal between fitting and sealing surface on the pressure vessel.

4. Connect flush fitting inlet to a pressure flushing system containing a detergent solution per 5.5.2; where possible, 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 of the pressure vessel should be performed as follows:

Step

1. Remove nitrogen supply line from pressure flush fitting, and add 100 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 µm (or finer) filter (Millipore, or equivalent). Cap off flush fitting inlet and outlet ports.

5. Where possible, 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 10.4.1.4.1, 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 alcohol can be noted at the outlet port.

f. Vacuum rated vessels may be evacuated and monitored with a partial pressure analyzer for residual alcohol.

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

g. Preparation for storage should be performed as follows:

Step

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.

5.6.2.5 Machined piece parts. Machined piece parts shall be cleaned using the fluids and sequences specified in Tables III through XI. Cleaned parts shall be submitted for cleanliness verification per 10.4.1.3.1 and 10.4.1.5.1. Parts shall be protected during all phases of cleaning operations to prevent damage due to agitation and impact.

5.6.2.6 Assembled components, assemblies, and systems. Assembled items submitted for cleanliness verification should be sampled by gas purging per 10.4.1.3.2 and 10.4.1.5.2. Assembled items which may require liquid sampling should be identified when submitted for cleanliness verification. Such items should be thoroughly dried per 5.5.6 following verification.

5.6.2.7 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. 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 10.4.1.3.1. The drying process for polymers and thermoplastics shall be by vacuum oven per 5.5.6.2.

5.7 Protection of cleaned parts. Protection of cleaned parts shall be accomplished by following the requirements specified in 5.7.1 through 5.7.4.

5.7.1 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 of 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 per MIL-B-22191, Type III, as shown on Figures 4 and 5 and placed in suitable containers. When a component is supplied to the system 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.

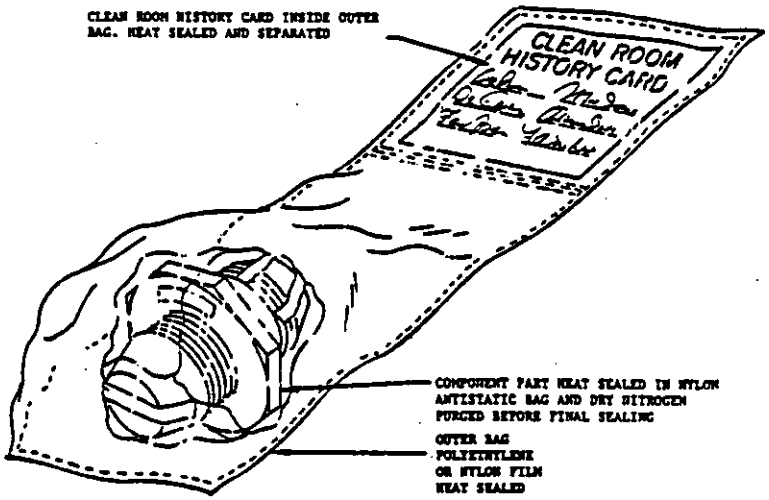


FIGURE 4. Typical Packaging of Single Items

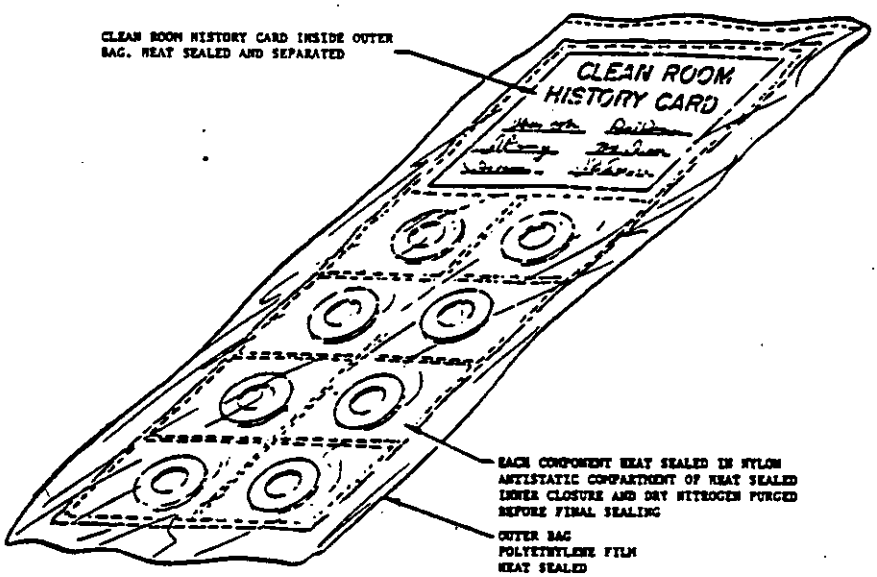


FIGURE 5. Typical Packaging of Small Multiple Items

5.7.2 Proper enclosure and sealing materials. A piece 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 4 and 5 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 per MIL-B-22191, Type III, placed over the opening and held in place with tape. (Plastic screw-type closures are not acceptable.)

5.7.3 Film sheet or bag closures (inner). Each cleaned 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 (5.5.6.1) and finally, completely heat sealed. Nylon anti-static closures, consisting of bags and sheet per MIL-B-22191, Type III, stock, shall be precleaned and shall meet the cleanliness requirements of Table I. Cleaned tubing and hoses shall be protected by enclosing each end with nylon materials, and then if possible, enclosing the entire item in an outer bag.

5.7.4 Film overwrap (outer). Each component part, or component, sealed in accordance with 5.7.3, 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.

5.8 Documentation. Results of all cleanliness verification tests performed shall be recorded on the cleaned part history card (5.8.1) with an indelible pen. Examples of results to be recorded are particle count, ultraviolet, NVR, and pH test results.

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5.8.1 Cleaned part history card. The cleaned part history card or equal shall be fabricated of non-shedding material. The card shall be sealed in bagging material and permanently attached to, but not inside, the inner bag (Figures 4 and 5). The information contained on either or both sides of the card should include the following applicable information:

a. Card registration or job number.

b. Cleaning specification and paragraphs used.

c. Control area cleanliness level in which final rinsing and assembly took place.

d. For small items, list quantity of cleaned items pertaining to the card.

e. Item(s) part number.

f. Item(s) serial number.

g. Next assembly part number.

h. Quality Assurance approval (stamp or signature).

i. Quantity of final rinse solution used.

j. Name of final rinse solution.

k. Number of grid squares counted.

l. Magnification used.

m. Type of propellant service.

n. Lubricant used.

o. Required maximum particle count spectrum (size vs. quantity).

p. Actual final count spectrum (separating metallics, non-metallics, and 10:1 or greater fibers).

Custodians:
Army - MI
Navy - AS
Air Force - 12

Review Activities:
Army - MI
Navy - AS
Air Force - 68

Preparing Activity:
Air Force - 12

Other Agency Interest:
NASA

Project No. 9135-0100

APPENDIX

10. PROVISIONS

10.1 Responsibdlity for inspection. Unless otherwise specified in the contract or purchase order, the supplier shall be responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified, the supplier may use his own facilities or any commercial laboratory acceptable to the Government. The Government shall reserve the right to request or perform any of the inspections set forth in this standard where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements.

10.2 Tests. The schedule of tests specified in Table XIII shall be performed to assure conformance with the requirements of this specification. (Table XIII is located at the back of this standard, for the purpose of convenience.)

10.3 Acceptance criteria. Acceptable criteria are specified in Table I, specific sections of this standard or the applicable controlling specification.

10.4 Cleanliness verification. All items shall be verified clean by performing one or more of the following tests as specified in Table XIII. Results of the particle event performed shall be recorded on the cleaned part history card.

10.4.1 Particle count test. Particulate contamination of cleaned items shall be determined by particle sampling with a precision membrane filtration apparatus or equivalent. Automatic counting instruments may be used.

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

10.4.1.2 Equipment. All equipment involved in the evaluation of particle cleanliness shall be of non-particle shedding materials and shall be verified before the start of cleaning to be at least as clean as the test fluid (Level E). Background particle counts of equipment other than the membrane filter pad shall not be factored out of the final particle count.

10.4.1.3 Test fluid.

10.4.1.3.1 Liquid. The amount of the test fluid used for liquid sampling 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 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.

10.4.1.3.2 Gas. Items may be sampled for particulate contamination by passing gaseous nitrogen or helium through the item at the rate of 141.5 ±14 liters/minute (5 ±0.5 std ft^3/min) for 7 minutes (990 liters or 35 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 990 liters (35 ft^3) of gas.

10.4.1.4 Maximum allowable particulate contamination. Particle counts obtained shall be compared with Table I for maximum allowable counts. The total particle count shall be divided by fluid quantity to obtain the particle count per 100 ml as follows:

Liquid:

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

Gas:

$$\frac{\text{Particle count - filter background}}{\text{Quantity flowed, liters } (ft^3)} \times \frac{(35 \text{ std } ft^3)}{990 \text{ liters}} = \text{particles per 990 liters } (35 \text{ std } ft^3)$$

No silting shall be allowed (Note 9 of Table I).

10.4.1.4.1 Propulsion systems. The applicable propulsion system class (1, 2 or 3) shall be determined according to Table I. The level within the class shall be one of the system or support equipment items of the first column of Table I.

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

10.4.1.5.1 Liquid flush or rinse method. Piece, component and related parts shall be sampled by flowing or force flushing the final rinse fluid per 5.5.5.2 as follows:

Step

1. Verify all sampling and related equipment is clean (10.4.1.2).
2. Precount a 1.2, µm gridded-membrane filter or equivalent using a 100 power magnification microscope.

Step

3. Sample the item with the required volume of fluid per 10.4.1.3. Catch the sample fluid in a clean flask or beaker.

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

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

6. Count the particles in the size ranges specified in Table I 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 for items with particulate limits of 140 particles or less. Statistical sampling may be used where the maximum acceptable particle counts exceed 140 particles. Evaluate contamination level per 10.4.1.4.

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.

10.4.1.5.2 Filter bomb method. Components, assemblies and subsystems of flight, support, or facility equipment may be sampled in place at a remote location using a precision-membrane filter or equivalent to flow the required gas through the filter. The filter is then disassembled and evaluated in the cleaning facility. The procedure should be as follows:

Step

1. Clean the disassembled filter holder (or equivalent) to Level B of the desired cleaning class (Table I).

2. Assemble filter with a 1.2 µm absolute or less element.

3. Flow the filter with nitrogen (5.5.6.1) at 141 liters/minute (5 ft^3/min) for 7 minutes.

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

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

Step

5. Carefully reassemble the filter. Seal the inlet and outlet ports. Double bag per Figure 4 if transportation to another facility is required.

6. Carefully install the filter in the system to be sampled. Test gas shall be flowed in the subject system at a rate equal to or greater than 141.5 liter/minute (5 ft^3/min) for 7 minutes, or the expected system flow rate, for a total of 990 liters (35 ft^3). Liquid systems shall be flowed at the maximum expected rate for a total volume of at least 1 liter. Record the volume of flow. Remove the filter from the system, bag, and return to the clean facility.

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

8. Evaluate total particulate contamination on the filter element per Step 6 of 10.4.1.5.1.

10.4.1.6 Method of particle counting. The filter element shall be evaluated for particulate contamination in the size ranges of Table I by examination under a minimum of 100 power magnification. The entire 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 (40 power) to examine for obvious defects.

10.4.2 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 completely across the 2500 to 3900 Angstrom range. Eye glasses (not plastic lenses) shall be worn to protect eyes against the longwave portion of the ultraviolet 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 10.4.1. Any fluorescense shall be considered as failure of the test and shall require rejection or recleaning of the item.

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

10.4.4 Silver nitrate test. This test specifically applies to components fabricated by any brazing or other metal joining process in which fluxes or salts are employed. A silver nitrate solution shall be used to determine the presence or verify the absence of brazing salts in a solution in which the brazed item has been boiled. 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, either sulphuric acid conforming to MS-36052 or nitric acid conforming to O-N-350 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.

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

Step

1. Filter 500 ml of solvent with 0.8 µm filter.

2. Transfer the filtered solvent to a clean 800 ml capacity beaker.

3. Evaporate the 500 ml gently on a hot plate until the volume is reduced so that a second 500 ml of filtered solvent may be added. A clean glass stirring rod shall be placed in the 800 ml beaker to prevent bumping during boiling.

4. After the second quantity of 500 ml has been added, reduce the volume of solvent in the beaker to between 50 and 100 ml and add another filtered 490 ml. Evaporate the contents of the beaker down to approximately 20 ml.

5. 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.

Note: The tare weight of the vial (or similar container) shall be taken beforehand.

6. Evaporate 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 vacuum-oven and allow to dry for one hour or until the final 5 to 10 ml of solvent has evaporated.

7. Remove the vial from the oven, allow to cool, then reweigh to the nearest 0.1 mg.

Step

8. 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)

9. 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.

10.4.6 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. The test shall be performed per ASTM D-1293.

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

10.4.8 Chloride test. The water used for cleaning and rinsing purposes shall be tested prior to use for chloride ion content.

10.4.9 Ultrasonic cleaner evaluation test. The activity of the ultrasonic unit shall be qualitatively tested using aluminum foil (annealed) suspended in the ultrasonic bath cavitation 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 (less than 40°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 excitation turned off.

The foil should be exposed to the ultrasonic cavitating 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 sonic cleaning strength of the equipment. This test shall be performed prior to the start of testing and the test solution, which may be an old solution used earlier, shall be replaced before cleaning.

20. PACKAGING

20.1 Packaging. All cleaned hardware shall be packaged in accordance with the requirements specified in 5.7.

20.2 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 location or shifting of the material or hardware within the container during shipping handling.

30. NOTES

30.1 Intended use. This standard covers the cleanliness levels, cleaning, protection, and inspection procedures for surfaces of parts, components, assemblies, systems, or other related equipment in contact with monopropellant hydrazine of spacecraft propulsion systems and associated ground support equipment.

30.2 Ordering data. Procurement documents should specify the following:

a. Title, number, and date of this standard.

b. Cleanliness level required.

c. Whether special cleanliness levels, cleaning methods and procedures, and protection are required beyond the requirements of Section 3.

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Table III. Cleaning Solutions and Sequences for 200 and 300 Series Stainless Steel

Sequence	Paragraph	Purpose	Solution	Specification	Temperature, °C	Temperature, °F	Time, minute	Notes	Sequence
			Operation(1)						
1	5.5.1 5.5.1.2	Degrease	Isopropyl alcohol (IPA)	TT-I-735	Ambient	Ambient	5-10 ultrasonic (30-60 hand agitate, secondary option)		1
8	5.5.2	Detergent clean(3)	1% solution by volume	MIL-D-16791	65-87	170 ±20	5-10		8
3	5.5.3	Alkaline		FED-SPEC P-C-436	71-82	170 ±10	5-10		3
5	5.5.4	Acid(2)	HNO_3, 10% by volume	O-N-350	18-29	75 ±10	10-15		5
6	5.5.5.1	Rinse	H_2O, Type II	ASTM D 1193 (4)	Ambient	Ambient			6
2 4 7, 9			H_2O, Type II, ultrasonic, (performed twice)		Ambient	Ambient	Until pH is within 0.2 of source		2 4 7, 9

For footnotes, refer to next page.

Table III. Cleaning Solutions and Sequences for 200 and 300 Series Stainless Steel (contd)

Sequence	Paragraph	Purpose	Solution	Specification	Temperature, °C	Temperature, °F	Time, minute	Notes	Sequence
10	5.5.5.2	Final rinse	Operation(1) IPA	TT-I-735	Ambient	Ambient	As necessary to achieve desired particulate level		10
11 -or- 11	5.5.6	Dry	Purge, nitrogen Purge, nitrogen, hot	MIL-P-27401 MIL-P-27401	Ambient 49-71	Ambient 120-160	5.5.6.1 5.5.6.1	Filtered Filtered	11 -or- 11
13 12			Vacuum, ambient Vacuum, hot		Ambient 43-54	Ambient 120 ±10	1 hr minimum		13 12

NOTES: (1) Table instructions:

See end columns for sequence.

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

(3) Suggested list of detergents

MIL-D-16791

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, Union Carbide

Acceptable substitutes:

Renex, Atlas
Ethefats, Armour
Emulphor VK-730, Antara
Sterox CD, Monsanto
Sterox A J, Monsanto

(4) ASTM D1193

	TYPE I	TYPE II
Conductivity	6×10^{-7} $ohms^{-1}/cm$	1×10^{-6} ohm^{-1}/cm
Particulate	0.1 mg/L	o.1 mg/L
Acidity (pH)	6.00 - 7.50	6.00 - 7.50
Nonvolatile residue (max)	nd	nd

Table IV. Cleaning Solutions and Sequences for Precipitation Hardening and 400 Series Stainless Steel

Sequence	Paragraph	Purpose	Solution	Specification	Temperature, °C	Temperature, °F	Time, minute	Notes	Sequence
			Operation(1)						
	5.5.1	Degrease							
1	5.5.1.2		Isopropyl alcohol (IPA)	TT-I-735	Ambient	Ambient	5-10 ultrasonic (30-60 hand agitate, secondary option)		1
8	5.5.2	Detergent clean(3)	1% solution by volume	MIL-D-16791	65-87	170 ±20	5-10		8
3	5.5.3	Alkaline		FED-SPEC P-C-436	71-82	170 ±10	5-10		3
5	5.5.4	Acid(2)	HNO_3, 21% +22 grams/liter sodium dichromate	O-N-350 O-S-595	16-32	75 ±15	10-15		5
6	5.5.5.1	Rinse	H_2O, Type II	ASTM D 1193(4)		Ambient			6
2 4 7, 9			H_2O, Type II, ultrasonic (performed twice)			Ambient	Until pH is within 0.2 of source		2 4 7, 9

For footnotes, refer to next page.

Table IV. Cleaning Solutions and Sequences for Precipitation Hardening and 400 Series Stainless Steel (contd)

Sequence	Paragraph	Purpose	Solution	Specification	Temperature, °C	Temperature, °F	Time, minute	Notes	Sequence
			Operation (1)						
10	5.5.5.2	Final rinse	IPA	TT-I-735	Ambient	Ambient	As necessary to achieve desired particulate level		10
11	5.5.6	Dry	Purge, nitrogen	MIL-P-27401	Ambient	Ambient	5.5.6.1	Filtered	11
-or-									-or-
11			Purge, nitrogen, hot	MIL-P-27401	49-71	120-160	5.5.6.1	Filtered	11
13			Vacuum, ambient		Ambient	Ambient			13
12			Vacuum, hot		43-54	120 ±10	1 hr minimum		12

NOTES: (1) Table instructions:

See end columns for sequence.

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

(3) Suggested list of detergents:

MIL-D-16791

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, Union Carbide

Acceptable substitutes:

Renex, Atlas
Ethefats, Armour
Emulphor VK-730, Antara
Sterox CD, Monsanto
Sterox A J, Monsanto

(4) ASTM D 1193

	TYPE I	TYPE II
Conductivity	6×10^{-7} ohms^{-1}/cm	1×10^{-6} ohms^{-1}/cm
Particulate	0.1 mg/L	0.1 mg/L
Acidity (pH)	6.00 - 7.50	6.00 - 7.50
Nonvolatile residue (max)	nd	nd

Table V. Cleaning Solutions and Sequences for Free Machining 300 Series Stainless Steel

Sequence	Paragraph	Purpose	Solution	Specification	Temperature, °F	Temperature, °F	Time, minute	Notes	Sequence
			Operation(1)						
1	5.5.1	Degrease	Isopropyl alcohol (IPA)	TT-I-735	Ambient	Ambient	5-10 ultrasonic (30-60 hand agitate, secondary option)		1
7	5.5.2	Detergent clean (3)	1% solution by volume	MIL-D-16791	65-87	170 ±20	5-10		7
3	5.5.3	Alkaline		FED-SPEC P-C-436	71-82	170 ±10	5-10		3
5	5.5.4	Acid(2)	HNO_3, 21% +22 grams/liter sodium dichromate	O-N-350 O-S-595	16-32	75 ±15	10-15		5
4	5.5.5.1	Rinse	H_2O, Type II	ASTM D 1193 (4)		Ambient			4
6			H_2O, Type II		60-83	160 ±20			6
8			H_2O, Type II, ultrasonic, hot (performed twice)		60-71	150 ±10	Until pH is within 0.2 of source		8

For footnotes, refer to next page.

Table V. Cleaning Solutions and Sequences for Free Machining 300 Series Stainless Steel(contd)

Sequence	Paragraph	Purpose	Solution	Specification	Temperature, °C	Temperature, °F	Time, minute	Notes	Sequence
			Operation(1)						
9	5.5.5.2	Final rinse	IPA	TT-I-735	Ambient	Ambient	As necessary to achieve desired particulate level		9
2	5.5.6	Dry	Purge, nitrogen	MIL-P-27401	Ambient	Ambient	5.5.6.1	Filtered	2
-or-									-or-
2			Purge, nitrogen, hot	MIL-P-27401	49-71	120-160	5.5.6.1	Filtered	2
10			Vacuum, hot		43-54	120 ±10	1 hr minimum		10

NOTES: (1) Table instructions:

See end columns for sequence.

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

(3) Suggested list of detergents:

MIL-D-16791
- 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
- Nutronyx, Onyx
- Turgetol, Union Carbide

Acceptable substitutes:
- Renex, Atlas
- Ethefats, Armour
- Emplphor, VK-730, Antara
- Sterox CD, Monsanto
- Sterox A J, Monsanto

(4) ASTM D 1193

	TYPE I	TYPE II
Conductivity	6 x 10^{-7} $ohms^{-1}/cm$	1 x 10^{-6} ohm^{-1}/cm
Particulate	0.1 mg/L	0.1 mg/L
Acidity (pH)	6.00 - 7.50	6.00 - 7.50
Nonvolatile residue (max)	nd	nd

Table VI. Cleaning Solutions and Sequences for Titanium Alloys

Sequence	Paragraph	Purpose	Solution	Specification	Temperature, °C	Temperature, °F	Time, minute	Notes	Sequence
			Operation(1)						
1	5.5.1 5.5.1.2	Degrease	Isopropyl alcohol (IPA)	TT-I-735	Ambient	Ambient	5-10 ultrasonic (30-60 hand agitate secondary option)		1
8	5.5.2	Detergent clean (3)	1% solution by volume	MIL-D-16791	65-87	170 ±20	5-10		8
3	5.5.3	Alkaline		FED-SPEC P-C-436	71-82	170 ±10	5-10		3
5	5.5.4	Acid.(2)	HNO_3, 45% by volume	O-N-350	18-29	75 ±10	20-30		5
6	5.5.5.1	Rinse	H_2O, Type II	ASTM D 1193 (4)	Ambient	Ambient			6
2 4 7,9			H_2O, Type II, ultrasonic (performed twice)			Ambient	Until pH is within 0.2 of source		2 4 7,9

For footnotes, refer to next page.

Table VI. Cleaning Solutions and Sequences for Titanium Alloys (contd)

Sequence	Paragraph	Purpose	Solution	Specification	Temperature, °C	Temperature, °F	Time, minute	Notes	Sequence
			Operation (1)						
10	5.5.5.2	Final rinse	IPA	TT-I-735	Ambient	Ambient	As necessary to achieve desired particulate level		10
11	5.5.6	Dry	Purge, nitrogen	MIL-P-27401	Ambient	Ambient	5.5.6.1	Filtered	11
13			Vacuum, ambient		Ambient	Ambient			13
12			Vacuum, hot		43-54	120 to 160	1 hr minimum		12

NOTES: (1) Table instructions:

See end columns for sequence.

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

(3) Suggested list of detergents:

MIL-D-16791

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, Union Carbide

Acceptable substitutes:

Renex, Atlas
Ethefats, Armour
Emulphor VK-730, Antara
Sterox CD, Monsanto
Sterox A J, Monsanto

(4) ASTM D 1193

	TYPE I	TYPE II
Conductivity	6×10^{-7} ohms^{-1}/cm	1×10^{-6} ohm^{-1}/cm
Particulate	0.1 mg/L	0.1 mg/L
Acidity (pH)	6.00 - 7.50	6.00 - 7.50
Nonvolatile residue (max)	nd	nd

Table VII. Cleaning Solutions and Sequences for Aluminum and Aluminum Alloys

Sequence	Paragraph	Purpose	Solution	Specification	Temperature, °C	Temperature, °F	Time, minute	Notes	Sequence
			Operation(1)						
	5.5.1	Degrease							
1	5.5.1.2		Isopropyl alcohol (IPA)	TT-I-735A	Ambient	Ambient	5-10 ultrasonic (30-60 hand agitate, secondary option)		1
3	5.5.2	Detergent clean(4)	1% solution by volume	MIL-D-16791	65-87	170 ±20	5-10		3
	5.5.5.1	Rinse		ASTM D 1193 (3)					
2 4			H_2O, Type II, ultrasonic (performed twice)		Ambient	Ambient	Until pH is within 0.2 of source		2 4

For footnotes, refer to next page.

Table VII. Cleaning Solutions and Sequences for Aluminum and Aluminum Alloys (contd)

Sequence	Paragraph	Purpose	Solution	Specification	Temperature, °C	Temperature, °F	Time, minute	Notes	Sequence
			Operation(1)						
5	5.5.5.2	Final rinse	IPA	TT-I-735	Ambient	Ambient	As necessary to achieve desired particulate level		5
6	5.5.6	Dry	Purge, nitrogen	MIL-P-27401	Ambient	Ambient	5.5.6.1	Filtered	6
8			Vacuum, ambient		Ambient	Ambient			8
7			Vacuum, hot		43-54	120 ±10	1 hr minimum		7

NOTES: (1) Table instructions:

See end columns for operation.

(2) Suggested list of detergents:

MIL-D-16791	Acceptable substitutes:
Triton X-100, Rhom and Haas	Renex, Atlas
Triton X-102, Rhom and Haas	Ethefats, Armour
Triton X-114, Rhom and Haas	Emulphor VK-730, Antara
Igepal CA-630, Antara	Sterox CD, Monsanto
Igepal CA-716, Antara	Sterox A J, Monsanto
Igepal CO	
Synthetics B-29, Hercules	
Neutronyx, Onyx	
Turgetol, Union Carbide	

(3)

ASTM D 1193	TYPE I	TYPE II
Conductivity	6×10^{-7} $ohms^{-1}/cm$	1×10^{-6} ohm^{-1}/cm
Particulate	0.1 mg/L	0.1 mg/L
Acidity (pH)	6.00 - 7.50	6.00 - 7.50
Nonvolatile residue (max)	nd	nd

Table VIII. Cleaning Solutions and Sequences for Nickel and Nickel Alloys

Sequence	Paragraph	Purpose	Solution	Specification	Temperature, °C	Temperature, °F	Time, minute	Notes	Sequence
			Operation(1)						1
1	5.5.1 5.5.1.2	Degrease	Isopropyl alcohol (IPA)	TT-I-735	Ambient	Ambient	5-10 ultrasonic (30-60 hand agitate, secondary option)		1
3	5.5.2	Detergent clean (3)	1% solution by volume	MIL-D-16791	65-87	170 ±20	5-10		3
2,4,7	5.5.5.1	Rinse	H_2O, Type II, ultrasonic (performed twice)	ASTM D 1193 (4)		Ambient	Until pH is within 0.2 of source		2,4,7
6			H_2O, Type II			Ambient			6
5	5.5.4	Acid(2)	HNO_3, 21% +22 grams/ liter, Sodium Dichromate	O-N-350 O-S-595	16-32	75±15	10-15		5

For footnotes, refer to next page.

Table VIII. Cleaning Solutions and Sequences for Nickel and Nickel Alloys (contd)

Sequence	Paragraph	Purpose	Solution	Specification	Temperature, °C	Temperature, °F	Time, minute	Notes	Sequence
			Operation (1)						
8	5.5.5.2	Final rinse	IPA	TT-I-735	Ambient	Ambient	As necessary to achieve desired particulate level		8
9 -or- 9	5.5.6	Dry	Purge, nitrogen	MIL-P-27401	Ambient	Ambient	5.5.6.1	Filtered	9 -or- 9
			Purge, nitrogen, hot	MIL-P-27401	49-71	120-160	5.5.6.1	Filtered	
11			Vacuum, ambient		Ambient	Ambient			11
10			Vacuum, hot		43-54	120 ±10	1 hr minimum		10

NOTES: (1) Table instructions:

See end columns for sequence.

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

(3) Suggested list of detergents:

MIL-D-16791

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, Union Carbide

Acceptable substitutes:

Renex, Atlas
Ethefats, Armour
Emulphor VK-730, Antara
Sterox CD, Monsanto
Sterox A J, Monsanto

(4) ASTM D 1193

	TYPE I	TYPE II
Conductivity	6×10^{-7} $ohms^{-1}/cm$	1×10^{-6} ohm^{-1}/cm
Particulate	0.1 mg/L	0.1 mg/L
Acidity (pH)	6.00 - 7.50	6.00 - 7.50
Nonvolatile residue (max)	nd	nd

Table IX. Cleaning Solutions and Sequences for Polymeric Materials

Sequence	Paragraph	Purpose	Solution	Specification	Temperature, °C	Temperature, °F	Time, minute	Notes	Sequence
			Operation (1)						
1	5.5.1 5.5.1.2	Degrease	Isopropyl alcohol (IPA)	TT-I-735	Ambient	Ambient	5-10 ultrasonic (30-60 hand agitate, secondary option)		1
3	5.5.2	Detergent clean (2)	1% solution by volume	MIL-D-16791	65-87	170 ±20	5-10		3
2 4	5.5.5.1	Rinse	H_2O, Type II, ultrasonic, hot (performed twice)	ASTM D 1193 (3)	60-71	150 ±10	Until pH is within 0.2 of source		2 4

For footnotes, refer to next page.

Table IX. Cleaning Solutions and Sequences for Polymeric Materials (contd)

Sequence	Paragraph	Purpose	Solution	Specification	Temperature, °C	Temperature, °F	Time, minute	Notes	Sequence
			Operation (1)						
5	5.5.5.2	Final rinse	IPA	TT-I-735	Ambient	Ambient	As necessary to achieve desired particulate level		5
6	5.5.6	Dry	Purge, nitrogen	MIL-P-27401	Ambient	Ambient	5.5.6.1	Filtered	6
8			Vacuum, ambient		Ambient	Ambient	8 hrs minimum		8
7			Vacuum, hot		43-54	120 ±10	1 hr minimum		7

NOTES: (1) Table instructions:

See end columns for sequence.

(2) Suggested list of detergents:

MIL-D-16791	Acceptable substitutes:
Triton X-100, Rhom and Haas	Renex, Atlas
Triton X-102, Rhom and Haas	Ethefats, Armour
Triton X-114, Rhom and Haas	Emulphor VK-730, Antara
Igepal CA-630, Antara	Sterox CD, Monsanto
Igepal CA-716, Antara	Sterox A J, Monsanto
Igepal CO	
Synthetics B-29, Hercules	
Neutronyx, Onyx	
Turgetol, Union Carbide	

(3)

ASTM D 1193	TYPE I	TYPE II
Conductivity	6×10^{-7} ohms^{-1}/cm	1×10^{-6} ohm^{-1}/cm
Particulate	0.1 mg/L	0.1 mg/L
Acidity (pH)	6.00 - 7.50	6.00 - 7.50
Nonvolatile residue (max)	nd	nd

Table X. Cleaning Solutions and Sequences for Elastomeric Materials

Sequence	Paragraph	Purpose	Solution	Specification	Temperature, °C	Temperature, °F	Time, minute	Notes	Sequence
			Operation (1)						
1 -or-	5.5.1 5.5.1.2	Degrease	Isopropyl alcohol (IPA)	TT-I-735	Ambient	Ambient	5-10 ultrosonic (30-60 hand agitate, secondary option)		1 -or-
1	5.5.2	Detergent clean (2)	1% solution by volume	MIL-D-16791	65-87	170 ±20	5-10		1
2 -or- 2	5.5.5.1	Rinse	H_2O, Type II H_2O, Type II	ASTM D1193 (3)	60-83	Ambient 160 ±20	Until pH is within 0.2 of source		2 -or- 2

For footnotes, refer to next page.

Table X. Cleaning Solutions and Sequences for Elastomeric Materials (contd)

Sequence	Paragraph	Purpose	Solution	Specification	Temperature, °C	Temperature, °F	Time, minute	Notes	Sequence
			Operation (1)						
3	5.5.5.2	Final rinse	H_2O, Type II	ASTM D1193 (3)	Ambient	Ambient	As necessary to achieve desired particulate level	General use	3
4	5.5.6	Dry	Purge, nitrogen, hot	MIL-P-27401		120-160	5.5.6.1	Filtered	4
5 -or- 5			Vacuum, ambient		Ambient	Ambient	8 hrs minimum		5 -or- 5
			Vacuum, hot		43-54	120 ±10	1 hr minimum		

NOTES: (1) Table instructions:

See end columns for sequence.

(2) Suggested list of detergents:

MIL-D-16791

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, Union Carbide

Acceptable substitutes:

Renex, Atlas
Ethefats, Armour
Emulphor VK-730, Antara
Sterox CD, Monsanto
Sterox A J, Monsanto

(3) ASTM D 1193

	TYPE I	TYPE II
Conductivity	6×10^{-7} ohms^{-1}/cm	1×10^{-6} ohm^{-1}/cm
Particulate	0.1 mg/L	0.1 mg/L
Acidity (pH)	6.00 - 7.50	6.00 - 7.50
Nonvolatile residue (max)	nd	nd

Table XI. Cleaning Solutions and Sequences for Thermoplastic Materials

Sequence	Paragraph	Purpose	Solution	Specification	Temperature, °C	Temperature, °F	Time, minute	Notes	Sequence
			Operation(1)						
1	5.5.2	Detergent clean(2)	1% solution by volume	MIL-D-16791	65-87	170 ±20	5-10		1
2	5.5.5.2	Final rinse	H_2O, Type II	ASTM D1193	Ambient	Ambient	As necessary to achieve desired particulate level	General use	2
3	5.5.6	Dry	Purge, nitrogen	MIL-P-27401	Ambient	Ambient	5.5.6.1	Filtered	3

NOTES: (1) Table instructions:

See end columns for sequence.

(2) Suggested list of detergents:

MIL-D-16791	Acceptable substitutes:
Triton X-100, Rhom and Haas	Renex, Atlas
Triton X-102, Rhom and Haas	Ethefats, Armour
Triton X-114, Rhom and Haas	Emulphor VK-730, Antara
Igepal CA-630, Antara	Sterox CD, Monsanto
Igepal CA-716, Antara	Sterox A J, Monsanto
Igepal CO	
Synthetics B-29, Hercules	
Neutronyx, Onyx	
Turgetol, Union Carbide	

(3) ASTM D1193

	TYPE I	TYPE II
Conductivity	6×10^{-7} ohms^{-1}/cm	1×10^{-6} ohm^{-1}/cm
Particulate	0.1 mg/L	0.1 mg/L
Acidity (pH)	6.00 - 7.50	6.00 - 7.50
Nonvolatile residue (max)	nd	nd

Table XII. Cleaning Solutions and Sequences for Glass

Sequence	Paragraph	Purpose	Solution	Specification	Temperature, °C	Temperature, °F	Time, minute	Notes	Sequence
			Operation (1)						
4	5.5.1 5.5.1.2	Degrease	Isopropyl alcohol (IPA)	TT-I-735	Ambient	Ambient	5-10 ultrasonic (30-60 hand agitate, secondary option)		4
1	5.5.2	Detergent clean (2)	1% solution by volume	MIL-D-16791	65-87	170 ±20	5-10		1
2	5.5.5.1	Rinse	H_2O, Type II	ASTM D1193 (3)	60-83	160 ±20			2

For footnotes, refer to next page.

Table XII. Cleaning Solutions and Sequences for Glass (contd)

Sequence	Paragraph	Purpose	Solution	Specification	Temperature, °C	Temperature, °F	Time, minute	Notes	Sequence
			Operation (1)						
5 -or- 5	5.5.5.2	Final rinse	IPA H_2O, Type II	TT-I-735 ASTM D1193 (3)	Ambient Ambient	Ambient Ambient	As necessary to achieve desired particulate level		5 -or- 5
3,6 7	5.5.6	Dry	Purge, nitrogen Vacuum, hot	MIL-P-27401	Ambient 60-71	Ambient 150 ±10	5.5.6.1 2 hrs minimum	Filtered	3,6 7

NOTES: (1) Table instructions:

See end columns for sequence.

(2) Suggested list of detergents:

MIL-D-16791

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, Union Carbide

Acceptable substitutes:

Renex, Atlas
Ethefats, Armour
Emulphor VK-730, Antara

(3) ASTM D1193

	TYPE I	TYPE II
Conductivity	6×10^{-7} ohms^{-1}/cm	1×10^{-6} ohm^{-1}/cm
Particulate	o.1 mg/L	0.1 mg/L
Acidity (pH)	6.00 - 7.50	6.00 - 7.50
Nonvolatile residue (max)	nd	nd

Table XIII. Test Frequency Requirements

	10.4.6 pH	10.4.1 Particle count	10.4.2 Ultra-violet	10.4.4 Silver nitrate, flux-brazed parts	10.4.5 Non-volatile residue	5.5.6.1 Dewpoint hydrocarbon (gas analysis) purge gas source	10.4.3 Wipe	5.6.1 Solution certification	5.5.6.1 Residual gas analyzer or dewpoint purge gas drying method only	10.4.8 Chloride	10.4.7 Conductance	10.4.9 Ultrasonic bath test
Every item	X(1)	X	X	X					X(3)			
Daily		Work area (2)				X (Dewpoint)						
Quality assurance/ quality control/ engineering 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 hydrocarbon content)		X		X	X	
Monthly											X	X
Weekly								X				

NOTES: (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 5.2.1.2

(3) Items rinsed with water and dried per 5.5.6.1

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