Preparing Activity: NASA

Superseding
UFGS-22 05 83.63 (November 2016)
UFGS-22 15 09 (August 2010)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated July 2023
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DIVISION 22 - PLUMBING

SECTION 22 15 09.00 40

GENERAL SERVICE COMPRESSED-AIR SYSTEMS CLEANING PROCEDURES

05/22

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-- End of Section Table of Contents --

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SECTION 22 15 09.00 40

GENERAL SERVICE COMPRESSED-AIR SYSTEMS CLEANING PROCEDURES
05/22

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NOTE: This guide specification covers the requirements of four classes of cleanliness for process piping systems, components, and tanks.

Adhere to UFC 1-300-02 Unified Facilities Guide Specifications (UFGS) Format Standard when editing this guide specification or preparing new project specification sections. Edit this guide specification for project specific requirements by adding, deleting, or revising text. For bracketed items, choose applicable item(s) or insert appropriate information.

Remove information and requirements not required in respective project, whether or not brackets are present.

Comments, suggestions and recommended changes for this guide specification are welcome and should be submitted as a Criteria Change Request (CCR).

****

PART 1 GENERAL

1.1 REFERENCES

****

NOTE: This paragraph is used to list the publications cited in the text of the guide specification. The publications are referred to in the text by basic designation only and listed in this paragraph by organization, designation, date, and title.

Use the Reference Wizard's Check Reference feature when you add a Reference Identifier (RID) outside of the Section's Reference Article to automatically

place the reference in the Reference Article. Also use the Reference Wizard's Check Reference feature to update the issue dates.

References not used in the text will automatically be deleted from this section of the project specification when you choose to reconcile references in the publish print process.

****

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM B479	(2006) Standard Specification for Annealed Aluminum and Aluminum-Alloy Foil for Flexible Barrier, Food Contact, and Other Applications
ASTM D4635	(2016) Standard Specification for Plastic Films Made from Low-Density Polyethylene for General Use and Packaging Applications
ASTM D6368	(2006; R 2012) Standard Specification for Vapor-Degreasing Grade, and General Grade Normal - Propyl Bromide
ASTM E1146	(2023) Standard Specification for Muriatic Acid (Technical Grade Hydrochloric Acid)
ASTM F312	(2008; R 2016) Standard Test Methods for Microscopical Sizing and Counting Particles from Aerospace Fluids on Membrane Filters
ASTM F331	(2013; R 2020) Standard Test Method for Nonvolatile Residue of Solvent Extract from Aerospace Components (Using Flash Evaporator)

COMPRESSED GAS ASSOCIATION (CGA)

CGA G-10.1	(2023) Commodity Specification for Nitrogen; 7th Edition

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION (NASA)

RCBEA GUIDE	(2004) NASA Reliability Centered Building and Equipment Acceptance Guide

SEMICONDUCTOR EQUIPMENT AND MATERIALS INTERNATIONAL (SEMI)

SEMI C28	(2011) Specifications for Hydrofluoric Acid
SEMI C35	(2008) Specifications and Guidelines for Nitric Acid

1.2 DEFINITIONS

1.2.1 Cleanliness-Level Terms

"Particle" includes all foreign matter except fibers, whether metallic or nonmetallic.

"Particle size" is the largest particle dimension, in microns.

"Fiber" includes all foreign matter having a length greater than 100 microns and a length-to-diameter ratio of at least 10-to-1.

"Significant surfaces" are component surfaces that may come in contact with the service medium.

1.2.2 Cleanliness-Level Classifications

****
NOTE: Edit the following paragraphs, deleting Classifications not required for the project.
****

1.2.2.1 Class I - Oxidizers and Oxidizer Pressurants

Significant surfaces of [liquid and gaseous oxygen] [nitrogen] [helium] [chlorine trifluoride (CTF)] [_____] Systems are subject to Class I cleanliness requirements.

1.2.2.2 Class II - Fuels, Fuel Pressurants and Hydraulics

Significant surfaces of [liquid and gaseous hydrogen] [hydraulic] [high purity air] [_____] systems are subject to Class II cleanliness requirements.

1.2.2.3 Class III - Air Control and Instrument Pneumatics

Significant surfaces of [air-pneumatic control and instrument systems, downstream of regulatory panels to the control units] [_____] are subject to Class III cleanliness requirements.

1.2.2.4 Class IV - Standard Industrial Cleaning

Significant surfaces of [potable water] [industrial water] [vacuum] [_____] systems are subject to Class IV cleanliness requirements.

1.3 SUBMITTALS

****
NOTE: Review Submittal Description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list, and corresponding submittal items in the text, to reflect only the submittals required for the project. The Guide Specification technical editors have classified those items that require Government approval, due to their complexity or criticality, with a "G." Generally, other submittal items can be reviewed by the Contractor's Quality Control System. Only add a “G” to an item, if the submittal is sufficiently important or

complex in context of the project.

For Army projects, fill in the empty brackets following the "G" classification, with a code of up to three characters to indicate the approving authority. Codes for Army projects using the Resident Management System (RMS) are: "AE" for Architect-Engineer; "DO" for District Office (Engineering Division or other organization in the District Office); "AO" for Area Office; "RO" for Resident Office; and "PO" for Project Office. Codes following the "G" typically are not used for Navy, Air Force, and NASA projects.

The "S" classification indicates submittals required as proof of compliance for sustainability Guiding Principles Validation or Third Party Certification and as described in Section 01 33 00 SUBMITTAL PROCEDURES.

Choose the first bracketed item for Navy, Air Force and NASA projects, or choose the second bracketed item for Army projects.

****

Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are [for Contractor Quality Control approval.][for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Prequalification Statement; G[, [____]]

SD-03 Product Data

Demineralized Water; G[, [____]]

Drying or Preservation Gas; G[, [____]]

Filter Discs; G[, [____]]

Nitric Acid; G[, [____]]

Citric Acid; G[, [____]]

Muriatic Acid; G[, [____]]

Hydrofluoric Acid; G[, [____]]

Normal - Propyl Bromide; G[, [____]]

Tape;G[, [____]]

Polyethylene Film; G[, [____]]

Low Water-Vapor Transmission Film; G[, [____]]

Aluminum Foil; G[, [____]]

SD-04 Samples

Polyethylene Film; G[, [____]]

Certification Tags; G[, [____]]

Low Water-Vapor Transmission Film; G[, [____]]

SD-06 Test Reports

Inspection Records; G[, [____]]

SD-07 Certificates

Cleaning Procedures; G[, [____]]

1.4 QUALITY CONTROL

1.4.1 Preconstruction Qualifications

Before contract work begins, submit a Prequalification Statement verifying previous work experience and containing references, and a statement of selected laboratory and testing entities.

1.4.2 Process Approval

Submit [6] [_____] copies of the Cleaning Procedures describing precleaning, cleaning, handling, preservation, and quality assurance processes for approval before use.

Include the following in the Cleaning Procedures:

a. Trade names and manufacturer's names, specifications, and chemical and physical properties.

b. Estimates of the amounts of waste generated from cleaning for each processing material used.

c. Processing equipment required, including manufacturer, type or model, and size.

d. In-process control procedures to prevent contamination or latent corrosion, and installation procedures for components in cleaned systems.

e. Methods and materials used to preserve cleaned components before installation, and of cleaned systems after acceptance.

1.4.3 Cleaning Certification Tags

Apply Certification Tags, as specified, to all cleaned systems, assemblies, and components to certify the cleanliness level of the tagged item.

1.4.4 Predictive Testing and Inspection Technology Requirements

****
NOTE: The Predictive Testing and Inspection (PT&I) tests prescribed in Section 01 86 12.07 40 RELIABILITY CENTERED ACCEPTANCE FOR MECHANICAL SYSTEMS are MANDATORY for all [NASA] [_____] assets and systems identified as Critical, Configured, or Mission Essential. If the system is non-critical, non-configured, and not mission essential, use sound engineering discretion to assess the value of adding these additional test and acceptance requirements. See Section 01 86 12.07 40 RELIABILITY CENTERED ACCEPTANCE FOR MECHANICAL SYSTEMS for additional information regarding cost feasibility of PT&I.
****

This section contains systems and equipment components regulated by NASA's Reliability Centered Building and Equipment Acceptance Program. This program requires the use of Predictive Testing and Inspection (PT&I) technologies in conformance with the RCBEA GUIDE to ensure building equipment and systems have been installed and contain no identifiable defects that shorten the design life of a system and its components. Satisfactory completion of all acceptance requirements is required to obtain Government acceptance of the work.

Perform PT&I tests and provide submittals as specified in Section 01 86 12.07 40 RELIABILITY CENTERED ACCEPTANCE FOR MECHANICAL SYSTEMS.

PART 2 PRODUCTS

2.1 MATERIALS

2.1.1 Demineralized Water

Use demineralized water with a pH between 6.0 to 8.0 and a specific resistance greater than 50 ohms per cubic millimeter for rinsing or operations. Filter water to remove all particles larger than 175 microns in any dimension and yielding not more than 5 particles sized between 100 microns and -175 microns per 500-millimeter sample.

2.1.2 Drying or Preservation Gas

Filter air and nitrogen gas conforming to CGA G-10.1, Grade E, to a 100-micron level (absolute). Ensure that the oil content is no greater than 3 parts per million (ppm) by weight and that the moisture content not greater than 24 ppm by volume.

2.1.3 Filter Discs

Provide polytetrafluoroethylene (PTFE)-fiber filter discs with 5-microns pores.

2.1.4 Nitric Acid

Conform technical-grade nitric acid to SEMI C35.

2.1.5 Citric Acid

Provide industrial-grade citric acid.

2.1.6 Muriatic Acid (Hydrochloric)

Conform Muriatic acid to ASTM E1146.

2.1.7 Hydrofluoric Acid

Conform hydrofluoric acid to SEMI C28.

2.1.8 Normal - Propyl Bromide

****
NOTE: Do not use normal - propyl bromide for vessel cleaning where tank entry is required or with oxygen-related services.
****

Do not use normal - propyl bromide with oxygen service.

Ensure that the solvent used for testing or for immersion cleaning conforms to ASTM D6368, with no particle over 175 microns in any dimension and no more than 5 particles from 100 to 175 microns in size.

Ensure that the solvent used for vapor degreasing cleaning processes of stainless steel components conforms to ASTM D6368.

2.1.9 Tape

Provide waterproof, pressure-sensitive tape, with plastic-film backing material, suitable for a temperature range of minus 54 to 71 degrees C minus 65 degrees F to plus 160 degrees F.

2.1.10 Polyethylene Film

Ensure that polyethylene film conforms to ASTM D4635, Type [1] [_____].

2.1.11 Low-Water-Vapor Transmission Film

****
NOTE: Ensure material meets the requirements of MIL B-22191F, Type 1.
****

Provide a transparent, flexible, thermoplastic film material, made from fluorinated-chlorinated resins, highly resistant to chemicals and liquid oxygen. The water-vapor transmission rate cannot be greater than 0.03 grams per 64516 square millimeter 0.03 grams per 100 square inches per 24 hours.

2.1.12 Aluminum Foil

Ensure that aluminum foil conforms to ASTM B479.

2.1.13 Certification Tags

Provide certification tags made of stainless steel, and 300 millimeter 12

inch-long stainless steel chain or wire.

2.1.13.1 Certification Tag Schedule

****
NOTE: Edit list as necessary for tags required for the project.
****

CERTIFICATION TAGS				
Tag Type	Thickness (millimeter)	Note "A" (kilograms)	Note "B" (grams)	[Tie Wire] [millimeter]
20	0.51 to 0.56	91 t0 109	1,130	[0.64]
15	0.38 to 0.43	68 to 86	850	[0.64]
13	0.33 to 0.38	59 to 77	610	[0.46]
Note "A": Basis weight, 500 sheets, 572 by 724 millimeter.				
Note "B": Tearing Resistance. Total of both directions, (minimum).				

CERTIFICATION TAGS				
Tag Type	Thickness (inches)	Note "A" (pounds)	Note "B" (grams)	[Tie Wire] [inches]
20	0.020 to 0.022	200 to 240	1,130	[0.025]
15	0.015 to 0.017	150 to 190	850	[0.025]
13	0.013 to 0.015	130 to 170	610	[0.018]
Note "A": Basis weight, 500 sheets, 22-1/2 inches by 28-1/2 inches.				
Note "B": Tearing Resistance. Total of both directions, (minimum).				

Note "A": Basis weight, 500 sheets, 572 by 724 millimeter 22- 1/2 by 28-1/2 inches.

Note "B": Tearing resistance. Total of both directions, (minimum).

Provide preprinted spaces for the following information, as applicable. Size tags such that the information is legible when entered with an indelible marking pen:

a. Part or identification number

b. Manufacturer's serial number

c. Contractor identification

d. Cleaning classification and specification identification

e. Date of cleaning

f. Service medium or intended use

g. Pressurizing medium and initial pressure

h. Title, date, and number of this specification

PART 3 EXECUTION

3.1 FIELD QUALITY CONTROL

3.1.1 Test Procedures

****
NOTE: If the specified system is identified as critical, configured, or mission essential, use Section 01 86 12.07 40 RELIABILITY CENTERED ACCEPTANCE FOR MECHANICAL SYSTEMS to establish predictive and acceptance testing criteria, above and beyond that listed below.
****

Perform PT&I tests and provide submittals as specified in Section 01 86 12.07 40 RELIABILITY CENTERED ACCEPTANCE FOR MECHANICAL SYSTEMS.

3.1.1.1 Particle Size Determination

Determine the size distribution, and quantity of solid particles retained on significant surfaces by removing and measuring particles on a minimum 5 percent representative sample of the total surface.

Ensure that solid-particle contamination per 92903 square millimeter 1 square foot of significant surface, when determined by the following procedure, does not exceed the specified amount:

a. Estimate or measure the size of the area to be sampled. Flush the selected sample surface with approximately 500 milliliter 33 ounces of demineralized water per 92903 square millimeter 1 square foot.

b. For individual small components having less than 92903 square millimeter 1 square foot of surface area, use a minimum of 500 milliliter of flushing fluid.

c. For piping and large components having greater than 836127 square millimeter 3 square feet of surface area, collect and analyze 3 separate samples.

d. Sample piping and piping systems at 3 separate locations as directed by the Contracting Officer.

e. During sampling, ensure the flow velocity through the pipe exceeds 2.44 meter 8 feet per second, or is as approved by the Contracting Officer.

f. Catch the entire quantity of the flushing fluid in a precleaned container.

g. Transfer an equal quantity of the unused flushing fluid into a second precleaned container.

h. Filter both samples of flushing fluid through a filter disc and examine the residue under a 10 power to 45-power stereomicroscope. The difference in particle count in each size range represents the solid particle contamination of the entire surface examined. If the allowable limit is exceeded in any range, reclean the entire surface and repeat the test.

After satisfactory completion of the particle-size determination, dry all surfaces and protect the surfaces against corrosion or recontamination in accordance with the procedures identified in this Section, and mark as specified.

3.1.1.2 Moisture Determination

Visually examine small components and assemblies with all significant surfaces exposed for the presence of surface moisture. Determine moisture content of surfaces in tanks, piping sections and systems as follows:

a. Set up a flow of purge gas through the tank or system that contacts all significant surfaces. Several checks may be run covering different portions of the system in order to ensure the flow of purge gas over all significant surfaces.

b. Use a dry, oil-free nitrogen purge gas. While the gas is flowing, do not allow the velocity of purge gas at any point in the system being checked to exceed 0.30 meter per second 60 feet per minute.

c. Maintain the system under a static lockup for at least 8 hours before sampling.

d. Measure the moisture content of the effluent gas using a dew point meter.

e. Rejection and correct moisture-vapor levels above the specification in tanks, systems, or sub-systems. Continue the drying process until a satisfactory moisture-vapor level is measured.

3.1.1.3 Acidity or Alkalinity

Test the external and internal surfaces of cleaned and rinsed components with pH-indicating paper while the component is still wet from the last rinse or after wetting the test surface with a few drops of distilled water. Ensure that the cleaned area registers a pH between [5.0 and 8.0][_____] acidity or alkalinity along the surface.

3.1.2 Quality Assurance Tests

Maintain current inspection records of examinations and tests and provide the inspection records to the Contracting Officer on request.

3.1.2.1 Tests Requirements for Class I Cleanliness

a. Solid-Particle Contamination

Conduct a microscopical particle population analysis in accordance with ASTM F312. Comply with the following criteria to determine cleanliness acceptability:

(1) No particles greater than 500 microns in any dimension.

(2) Not more than 5 particles between 150 and 500 microns.

(3) Not more than 100 particles between 5 and 150 microns.

(4) Fewer than 10 fibers per 92903 square millimeter one square foot of significant surface.

(5) Maximum fiber-length cannot exceed [500] [_____] microns.

Particle population analysis (Automatic Particle Counters) may be used for the final verification of cleanliness, provided the individual counters have demonstrated accuracy and repeatability, which correlates with the accepted analytical methods, and are approved by the Contracting Officer.

b. Moisture Content

If the influent air at the point of delivery has a dew point of minus 62 degrees C 80 degrees F or colder, ensure the effluent dew point is minus 51 degrees C 60 degrees F or colder, as measured in effluent purge gas.

If the dew point of the furnished gas is warmer than minus 62 degrees C 80 degrees F, ensure the dew point of the effluent is within minus 7 degrees C 20 degrees F of the influent.

c. Acidity or Alkalinity

[As specified.] [_____]

d. Nonvolatile Residue Contamination

Perform Nonvolatile Residue Contamination (NVRC) solvent flush testing as a final flush and cleanliness verification test. Ensure that test procedures conform to the following accepted method:

(1) Gravimetric NVR Analysis Method - Evaporate the filtered solvent sample to determine the NVR content in accordance with ASTM F331.

(2) Solvent Purity Meter - Use solvent purity meter Model SP-1000, which is manufactured by the Virtis Co., Gardiner, New York; and which correlates with accepted analytical methods for demonstrated accuracy and repeatability, and is approved by the Contracting Officer.

(3) Infrared Spectrophotometric NVR Analysis Method - Infrared (IR) spectrophotometric NVR analysis of solvent samples may be used if the following apply:

(a) The method quantifies hydrocarbons and other contaminants that are reactive with liquid oxygen.

(b) The analysis method has demonstrated accuracy and repeatability and is approved by the Contracting Officer.

NVRC cannot exceed 0.001 grams per 92903 square millimeter 0.001 grams per square foot of surface area.

3.1.2.2 Tests Requirements for Class II Cleanliness

a. Solid Particle Contamination

Comply with the following criteria to determine cleanliness acceptability:

(1) No particles greater than 500 microns in any dimension.

(2) Not more than 5 particles between 150 microns and 500 microns.

(3) Not more than 100 particles between 5 microns and 150 microns.

(4) Fewer than 10 fibers per 92903 square millimeter 1 square foot of significant surface.

(5) Maximum fiber length cannot exceed [500] [_____] microns.

b. Moisture Content

If the influent air has a dew point of minus 54 degrees C 65 degrees F or colder at the point of delivery, ensure the effluent dew point are minus 43 degrees C 45 degrees F or colder, as measured in the effluent purge gas.

If the dew point of the furnished gas is warmer than minus 54 degrees C 65 degrees F, ensure the dew point of the effluent gas is within minus 7 degrees C 20 degrees F of the influent.

3.1.2.2.1 Acidity or Alkalinity

As specified.

3.1.2.3 Tests Requirements for Class III Cleanliness

3.1.2.3.1 Solid Particle Contamination

Comply with the following criteria to determine cleanliness acceptability:

a. No particles greater than 1500 microns in any dimension.

b. Not more than 50 particles between 150 microns and 1500 microns.

c. Not more than 500 particles between 5 microns and 150 microns.

d. Fewer than 50 fibers per 92903 square millimeter 1 square foot of significant surface.

e. Maximum fiber length cannot exceed [_____] microns.

3.1.2.3.2 Moisture Content

Ensure that total quantity of moisture solvents, and products, including both absorbed surface film and vapor present in the entire system subject to Class III cleanliness requirements, does not exceed 150 ppm by volume as measured in the effluent purge gas.

3.1.3 Inspection Procedures

The Government reserves the right to perform any inspections set forth in the specification where such inspections are deemed necessary to ensure

that the work conforms to the prescribed requirements.

3.1.3.1 Visual Examination

Visually inspect significant surfaces of cleaned components for moisture and foreign material such as corrosion, scale, dirt, hydrocarbons, crayon, and similar materials. Use a flashlight or borescope to examine internal surfaces. The presence of visible contamination will result in rejection by the Contracting Officer and necessitate recleaning of the item. Scale-free discoloration caused by welding and passivation is permitted.

3.1.3.2 Ultraviolet Light Examination

Examine significant surfaces of cleaned components using an ultra-violet light of at least 100 watts and producing a wavelength of approximately 366 nanometer 3660 angstrom units. Presence of fluorescent particles on areas of any surface, metallic or nonmetallic, will result in rejection by the Contracting Officer and necessitate recleaning of the item. Any component or material, either metallic or nonmetallic, from which fluorescence cannot be eliminated will be rejected and replaced at no further cost to the Government.

3.1.4 Quality Assurance Inspections

Except as specified herein, perform the following inspections on all components, assemblies, and systems.

3.1.4.1 Inspections for Class I Cleanliness Requirements

a. Visual Examination: As specified, under a strong white light.

b. Ultraviolet Light Examination: As specified.

3.1.4.2 Inspections for Class II Cleanliness Requirements

a. Visual Examination: As specified, under a strong white light.

b. Ultraviolet Light Examination: As specified.

3.1.4.3 Inspections for Class III Cleanliness Requirements

a. Visual Examination: As specified, under a strong white light.

b. Ultraviolet Light Examination: As specified.

3.1.4.4 Inspections for Class IV Cleanliness Requirements

Visual Examination: As specified, under normal shop lighting conditions.

3.2 ADJUSTING AND CLEANING

Notify the Contracting Officer at least 48 hours before the time Government-furnished air, gaseous nitrogen, and demineralized water are required for cleaning purposes.

Remove all gross contamination by mechanical processes, flushing, or high-velocity blowdown before final cleaning. Accomplish mechanical and electrical testing after precleaning and before final cleaning. Preclean all lengths of pipe, fittings, and piping system components before welding

and assembly.

Treat corrosion-resistant steel assemblies using pickling and passivating processes to prevent latent corrosion or contamination.

Disassemble and clean assemblies (or clean before original assembly) not suitable for cleaning as assembled. This applies to assemblies composed of materials requiring different cleaning procedures, or assemblies from which cleaning solutions cannot be adequately drained.

Loosen flanged joints as required during the cleaning procedure to ensure complete drainage of cleaning and rinsing solutions.

3.3 CLOSEOUT ACTIVITIES

3.3.1 Waste Disposal

****
NOTE: Furnish specific waste collection criteria, defining waste management guidelines for the Contractor to follow in the contract documents.
****

Determination as to whether waste fluids or materials generated during cleaning operations are hazardous, controlled, non-hazardous, or non-controlled is made by the [_____].

Coordinate waste-generation activities with the [Hazardous Waste Section] [_____]. As a minimum, furnish suitable containers and tankage to collect, transport, and offload the collected waste in designated [tankage] [_____]. Store the waste for a minimum of [7] [30] [_____] calendar days after the storage container is filled to capacity.

[The Government will dispose of hazardous waste and controlled waste.

] Dispose nonhazardous wastes and noncontrolled wastes at no additional cost to the Government. Dispose of nonhazardous or noncontrolled waste [offsite as approved by the Government] [_____]. [Disposal of these fluids or materials is not permitted at [_____].]

3.4 PROTECTION

For [Class I,] [and] [Class II,] [and] [Class III] cleaning levels, place protected components that are not installed in a clean polyethylene bag. Purge the bag with dry, oil-free gas and heat-seal the ends of the bag to ensure an inert package during storage. Place the bagged component in a second heat-sealed and purged polyethylene bag with a cleaning certification tag placed in the second bag. Give equivalent protection to components that cannot be placed in a polyethylene bag and place a tag near each sealed opening used in the cleaning procedure.

3.4.1 Protection for Class I Cleanliness Requirements

Immediately after precleaning, cleaning, and drying, protect significant surfaces subject to Class I cleanliness requirements from recontamination by covering the surfaces or openings with a minimum of two layers of Low Water-vapor transmission film. Secure the film and reinforce it with pressure-sensitive tape.

3.4.2 Protection for Class II Cleanliness Requirements

Immediately after cleaning and drying, protect significant surfaces subject to Class II cleanliness requirements from recontamination by covering the surfaces or openings with [aluminum foil] [or] [a minimum of two layers of polyethylene film] [or] [precleaned dry covers], secured and reinforced with pressure-sensitive tape.

3.4.3 Protection for Class III Cleanliness Requirements

Immediately after cleaning and drying, protect significant surfaces subject to Class III cleanliness requirements from recontamination by covering the surfaces or openings with [aluminum foil] [or] [a minimum of two layers of polyethylene film] [or] [precleaned dry covers], secured and reinforced with pressure-sensitive tape.

3.4.4 Protection for Class IV Cleanliness Requirements

Drain liquids from all parts of the system and seal openings with [aluminum foil] [or] [polyethylene bags] [or] [approved devices].

-- End of Section --