Ultrahigh-Purity Process Specification (SC-01)

Specification SCS-00001 Revision D

Scope

This document specifies guidelines used by Swagelok® Company for producing ultrahigh-purity (UHP) electropolished stainless steel products as well as ultrahigh-purity plastic products. This document must be used in conjunction with product catalogs, technical bulletins, and reports for complete product information.

Design

When product literature identifies moisture, hydrocarbon, or ionic cleanliness analysis, the following standards are applicable:

Stainless Steel Products

- Moisture analysis in accordance with ASTM F1397, "Standard Test Method for Determination of Moisture Contribution by Gas Distribution System Components"
- Hydrocarbon analysis in accordance with ASTM F1398, "Standard Test Method for Determination of Total Hydrocarbon Contribution by Gas Distribution System Components"
- Ionic cleanliness in accordance with ASTM F1374, "Standard Test Method for the Determination of Ionic/Organic Extractables of Internal Surfaces—IC/GC/FTIR for Gas Distribution Systems Components"

Plastic Products

- All plastic products are designed in accordance with SEMI F57, "Provisional Specification for Polymer Components Used in Ultrapure Water and Liquid Chemical Distribution Systems"

Materials Guidelines

Stainless Steel

Stainless steel is the industry-preferred material for UHP products used in gas systems due to the inherent properties of corrosion and oxidation resistance. AISI type 316L (UNS S31603), low-carbon stainless steel is most commonly used in industry due to the resistance to intergranular corrosion following welding or stress relieving. Valve seats, diaphragms, gaskets, and O-rings may be available in a variety of materials in order to meet end-customer requirements for chemical compatibility.

- Stainless steel bar stock conforms to the following standards:
  - ASTM A479, "Stainless and Heat-Resisting Bars and Shapes for Use in Boilers and Other Pressure Vessels"
  - ASTM A484, "Specification for General Requirements for Stainless and Heat-Resisting Bars, Billets, and Forgings"
  - ASTM A276, "Stainless and Heat-Resisting Bars and Shapes"
- Primary steel processing is either argon oxygen decarburization (AOD) or vacuum induction melting (VIM). A secondary remelt operation such as vacuum arc remelt (VAR) may be used for additional cleanliness of wetted components.
- Key requirements of certain elements within the chemical make-up have been tightened by Swagelok for more consistency of chemical make-up throughout UHP products; see Table 1.
- Verifications of stainless steel products include but are not limited to the following:
  - Material conformity is verified in accordance with Practice A of ASTM A262, "Standard Practices for Detecting Susceptibility to Intergranular Attack in Austenitic Stainless Steels."
  - Chemical composition is verified in accordance with ASTM A751, "Test Methods, Practices, and Terminology for Chemical Analysis of Steel Products."
  - Surface quality is verified through ultrasonic testing in accordance with ASTM E214, "Practice for Immersed Ultrasonic Testing by the Reflection Method Using Pulsed Longitudinal Waves", or through an eddy current test performed in accordance with Swagelok standards.
  - Inclusions are detected by performing a JK Test in accordance with ASTM E45, "Standard Practice for Determining the Inclusion Content of Steel, Method A," with ratings based on Plate I-r.

Table 1: Swagelok Specifications, wt %

Element	Swagelok 316 AOD	Swagelok 316L AOD	Swagelok 316L VAR	Swagelok 316L VIM-VAR
C (carbon)	0.035 to 0.050	0.015 to 0.030	0.015 to 0.030	0.015 to 0.030
S (sulfur)	0.020 to 0.030	0.005 to 0.030	0.005 to 0.012	0.005 to 0.010
Mn (manganese)	1.50 to 2.00	1.00 to 1.50	1.00 to 1.50	0.15 to 0.40

Materials Guidelines, cont.

Plastic Materials

Plastics are the industry-preferred material for use in UHP liquid service. Swagelok uses a modified PTFE (polytetrafluoroethylene) material for its inherent properties of chemical resistance and purity. Plastic material chemical composition is in accordance with:

- ASTM D3294, "Standard Specification for PTFE Resin Molded Sheet and Molded Basic Shapes"
- ASTM D4894, "Standard Specification for Polytetrafluoroethylene (PTFE) Granular Molding and Ram Extrusion Materials" for Type I, Grade 1 polytetrafluoroethylene

Manufacturing and Surface Finish

During manufacturing, dimensions and surface finishes are monitored closely. Each machined component has extremely fine surface finishes, smooth transitions, fully swept flow paths, and square weld ends to minimize the number of entrapped or generated particles.

Surface roughness/finish criteria are based on:

- Stainless Steel Product—criteria of SEMI F19, "Specification for the Surface Condition of the Wetted Surfaces of Stainless Steel Components" and the procedures of SEMI F37, "Method for Determination of Surface Roughness Parameters for Gas Distribution System Components"
- Plastic Product – SEMI F57, "Provisional Specification for Polymer Components Used in Ultrapure Water and Liquid Chemical Distribution Systems"

The roughness measurement, R_a, is defined by ASME B46.1, "Surface Texture (Surface Roughness, Waviness and Lay)," as the arithmetic average of the absolute values of the profile height deviations recorded within the evaluation length and measured from the mean line.

- Wetted surfaces of Swagelok ultrahigh-purity stainless steel products are produced with an R_a of 5 µin. (0.13 µm) with the exception of the following products, which have an R_a of 8 µin. (0.20 µm):
  - BN and HB series bellows valves
  - DL and DS series diaphragm valves
- Wetted surfaces of Swagelok ultrahigh-purity plastic products are machined to a maximum surface finish R_a of 25 µin. (0.62 µm) in accordance with SEMI F57.

Swagelok roughness numbers published in product catalogs refer to the process mean, or the roughness value that represents the arithmetic average for a given production process in accordance with SEMI F37.

Surface roughness/finish is verified by using a suitable profiling instrument in accordance with ASME B46.1. Measurements are taken over the maximum available length of the fitting or valve bore, excluding tapered surfaces, intersections, or welds.

Electropolishing and Passivation (Stainless Steel Only)

The wetted surfaces of fittings and valve bodies are electropolished to improve surface conditions and to form a corrosion resistant surface layer of chromium oxide. After electropolishing, all surfaces are passivated to remove free iron.

- Electropolishing processes are based on ASTM E1558, "Electrolytic Polishing of Metallographic Specimens" and are processed using custom fixturing.
- Passivation processes are based on ASTM A380, "Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems."
- Verification of electropolishing and passivation is performed in accordance with Table 2.

Table 2: Verification Methods and Specifications

Parameter	Specification	Test Method
Chromium-to-Iron (Cr/Fe)	Ratio ≥ 2.0	ESCA (electron spectroscopy for chemical analysis) based on SEMI F60
Chromium oxide-to-iron oxide (CrO/FeO)	Ratio ≥ 2.0	
Oxide thickness	≥ 15Å①	AES (Auger electron spectroscopy) based on SEMI F72
Surface defect analysis	Maximum of 40 defects, over 5 sample areas②	SEM (scanning electron microscopy) based on SEMI F73
Appearance	All parts will be highly reflective, mirror-like, with consistent roughness and a uniform, lustrous finish③	Finished parts are visually inspected by the unaided eye using additional bright light

① Process average.
② Does not apply to HB, BN, DS, DL, or LD series bodies.
③ Does not apply to "special" configurations or HB, BN, DS, DL, or LD series bodies.

IMPORTANT PROCESS NOTE:
All electropolished ultrahigh-purity products are processed in accordance with the guidelines in the preceding sections *(Design, Materials Guidelines, Manufacturing and Surface Finish,* and *Electropolishing and Passivation)* of this document. Product ordering numbers that contain a "P1" designator refer to Swagelok Special Cleaning and Packaging (SC-11), for cleaning, assembly and testing, and packaging requirements. Product ordering numbers that contain only a "P" designator will follow the remainder of this document for cleaning, assembly and testing, and packaging requirements.

Electrochemical Critical Pitting Temperature (Stainless Steel Only)

The electrochemical critical pitting temperature (CPT) test, based on ASTM G150, "Standard Test Method for Electrochemical Critical Pitting Temperature of Stainless Steels," is used to determine resistance to localized pitting corrosion. The CPT test measures the temperature at which the current density increases rapidly beyond a set limit at a set electrical potential. Sodium chloride solution is used, and electrical potential is held constant in the passivation region.

Table 3: Critical Pitting Temperature

Parameter	Specification	Test Method
Critical pitting temperature	>13°C (55°F)	ASTM G150

Cleaning and Drying

The DI water cleaning system is closed to the outside environment and thereby limits particle contamination. Products move through a series of ultrasonic washing and multistage DI water rinse tanks to a drying chamber. The DI water characteristics are based on the guidelines of:

- Stainless steel components—SEMI E49.6, "Guide for Subsystem Assembly and Testing Procedures—Stainless Steel Systems"
- Plastic components—SEMI E49.7, "Purity Guide for the Design and Manufacture of Ultrapure Water and Liquid Chemical Systems in Semiconductor Process Equipment"

Table 4: DI Water Characteristics

Characteristic	Swagelok Capabilities
Resistivity	≥ 17.5 MΩ·cm at 25°C (77°F)
Total organic carbon (TOC)	< 20 ppb
Silica	< 5 ppb
Bacteria	< 10 colonies per 100 milliliters
Hot DI water temperature	140°F (60°C) minimum

Assembly and Testing

To protect parts from airborne contamination, parts are protected and transported directly from the established cleaning system to a clean environment for assembly and testing.

- Clean areas are particle tested and classified in accordance with ISO 14644-1, "Cleanrooms and Associated Controlled Environments." The particle count values listed represent maximum concentration limits (particles per cubic meter of air) of particles ≥ 0.5 µm.
- Swagelok classification in accordance with ISO 14644-1 is shown in Table 5.

Table 5: Cleanroom and Work Area Classifications

Location of Testing	Federal Standard 209E	ISO 14644-1 (Particles per Cubic Meter)
Stainless Steel		
Cleanroom	Class 100	Class 5 (3520)
Work areas, laminar flow hoods, and receiving room	Class 10	Class 4 (352)
Plastics		
Materials storage areas, gowning areas, staging areas, and assembly areas	Class 10 000	Class 7 (352 000)

- Specific product performance test requirements and results may be obtained from the product catalog.

Packaging and Identification

Swagelok products are packaged to keep products free from outside contaminants during shipping. Identification and traceability information is visible without opening the product package to reduce the chances for contamination of the product and the system to which it is being assembled.

Packaging and identification procedures meet the requirements of:

- SEMI E49.6, "Guide for Subsystem Assembly and Testing Procedures—Stainless Steel Systems" for stainless products
- SEMI F57, "Provisional Specification for Polymer Components Used in Ultrapure Water and Liquid Chemical Distribution Systems" for plastic components

Referenced Documents

ASME

ASME B46.1, “Surface Texture (Surface Roughness, Waviness and Lay)”

ASTM

ASTM A262, “Standard Practices for Detecting Susceptibility to Intergranular Attack in Austenitic Stainless Steels”

ASTM A276, “Stainless and Heat-Resisting Bars and Shapes”

ASTM A380, “Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems”

ASTM A479, “Stainless and Heat-Resisting Bars and Shapes for Use in Boilers and Other Pressure Vessels”

ASTM A484, “Specification for General Requirements for Stainless and Heat-Resisting Bars, Billets, and Forgings”

ASTM A751, “Test Methods, Practices, and Terminology for Chemical Analysis of Steel Products”

ASTM D3294, “Standard Specification for PTFE Resin Molded Sheet and Molded Basic Shapes”

ASTM D4894, “Standard Specification for Polytetrafluoroethylene (PTFE) Granular Molding and Ram Extrusion Materials” for Type I, Grade 1 Polytetrafluoroethylene

ASTM E45, “Standard Practice for Determining the Inclusion Content of Steel, Method A”

ASTM E214, “Practice for Immersed Ultrasonic Testing by the Reflection Method Using Pulsed Longitudinal Waves”

ASTM E1558, “Electrolytic Polishing of Metallographic Specimens”

ASTM F1374, “Standard Test Method for the Determination of Ionic/Organic Extractables of Internal Surfaces—IC/GC/FTIR for Gas Distribution System Components”

ASTM F1397, “Standard Test Method for Determination of Moisture Contribution by Gas Distribution System Components”

ASTM F1398, “Standard Test Method for Determination of Total Hydrocarbon Contribution by Gas Distribution System Components”

ASTM G150, “Standard Test Method for Electrochemical Critical Pitting Temperature of Stainless Steels”

ISO

ISO 14644-1, “Cleanrooms and Associated Controlled Environments”

SEMI

SEMI E49.6, “Guide for Subsystem Assembly and Testing Procedures—Stainless Steel Systems”

SEMI E49.7, “Purity Guide for the Design and Manufacture of Ultrapure Water and Liquid Chemical Systems in Semiconductor Process Equipment”

SEMI E49.9, “Guide for Ultrahigh Purity Gas Distribution Systems in Semiconductor Manufacturing Equipment” (pending adoption of SEMI E49.8 revision)

SEMI F19, “Specification for the Surface Condition of the Wetted Surfaces of Stainless Steel Components”

SEMI F37, “Method for Determination of Surface Roughness Parameters for Gas Distribution System Components”

SEMI F57, “Provisional Specification for Polymer Components Used in Ultrapure Water and Liquid Chemical Distribution Systems”

SEMI F60, “Test Method for ESCA Evaluation of Surface Composition of Wetted Surfaces of Passivated 316L Stainless Steel Components”

SEMI F72, “Test Method for Auger Electron Spectroscopy (AES) Evaluation of Oxide Layer of Wetted Surfaces of Passivated 316L Stainless Steel Components”

SEMI F73, “Test Method for Scanning Electron Microscopy (SEM) Evaluation of Wetted Surface Condition of Stainless Steel Components”

About this document

Thank you for downloading this electronic catalog, which is part of General Product catalog Swagelok published in print. This type of electronic catalog is updated as new information arises or revisions, which may be more current than the printed version.

Swagelok Company is a major developer and provider of fluid system solutions, including products, integration solutions and services for industry research, instrumentation, pharmaceutical, oil and gas, power, petrochemical, alternative fuels, and semiconductor. Our manufacturing facilities, research, service and distribution facilities support a global network of more than 200 authorized sales and service centers in 57 countries.

Visit www.swagelok.com to locate your Swagelok representative and obtain any information on features, technical information and product references, or to learn about the variety of services available only through authorized sales centers and service Swagelok.

Safe Product Selection

When selecting a product, the total system design must be considered to ensure safe, trouble-free performance. Function, material compatibility, adequate ratings, proper installation, operation, and maintenance are the responsibilities of the system designer and user.

Warranty Information

Swagelok products are backed by The Swagelok Limited Lifetime Warranty. For a copy, visit your Swagelok Web site or contact your authorized Swagelok representative.