

7.2.1 An example of the apparatus is shown in Figure 1. The input particle concentration is measured by CNC-B, while the output particle concentration is measured by CNC-A. The pressure and flow rates in both legs should be carefully balanced (by maintaining an identical differential pressure in both legs) to insure that the challenge level is the same.

7.2.2 Set the first and subsequent challenge particle sizes per Section 6.6.

7.2.3 Particle challenge concentrations should be set to the maximum output of the electrostatic classifier for each of the particle size tests (Section 6.6). This will determine the test volume and the duration of the test. Generally this requires generating a polydispersed aerosol having a mean size close to the desired monodispersed aerosol size. Any difference between the flow rate exiting the electrostatic classifier and the test flow rate specified in Section 6.5 will be made up by dilution gas as shown in Figure 1.

7.2.4 The total particle challenge must be limited to 1×10^9 particles per liter of filter rated flow in slm. This is done to limit the effects of a particle cake build-up which would enhance the efficiency of the test filter. The test should be concluded upon exposure to 1×10^9 particles per liter of rated flow or after 10 downstream counts are observed, whichever occurs first.

7.2.4.1 As an example, a 10 liter per minute filter would be challenged in one minute with $(10 \text{ slm}) \times (1 \text{ minute}) \times (1 \times 10^9 \text{ particles/liter})$ or 1×10^{10} particles. If the challenge concentration is 1×10^8 particles per liter and the flow rate is 10 slm, then the test would need to last 10 minutes or when 10 downstream particles were observed.

7.2.4.2 The sample interval shall be 1 minute in duration. The sample interval in the penetration test is equivalent to the sample interval in the system background test (Section 7.1.2).

7.2.5 Measure the input and output particle concentration.

7.2.6 Calculate the ratio of output to input particle concentration.

8 Reporting of Test Results

8.1 Raw data shall be reported for each test in the format of a table, including the number of sample intervals, the sampling volume of each interval, the sampling time of each interval, and the total number of particles registered in each interval. In addition, the relevant parameters for each test described in Sections 8.2 and 8.3 should be identified.

8.2 *Static Background Test* — Identify the period of time required to obtain 45 consecutive sampling intervals without a particle being detected for the spool piece and test filter.

8.3 *Penetration Test* — Identify the input concentration, the output concentration, the ratio of output to input concentration (fractional penetration), and the challenge particle size. The most penetrating particle size is the challenge particle at the largest fractional penetration. Care must be taken to distinguish between true penetration and system background counts (see Section 8.5) as measured in Section 7.1.2.

8.4 Efficiency Class

8.4.1 If no penetration is observed then report the POU Gas Filter passed a X LRV efficiency test, where X = the maximum detectable efficiency for the test (as defined in Section 2.2). No penetration is defined as when the filter output is not statistically different from the system background (as defined in Section 8.5).

8.4.2 If penetration is observed , then report that the POU Gas Filter failed a X LRV efficiency test, where X is the maximum detectable efficiency for the test (as defined in Section 2.2). Penetration is defined as when the filter output is statistically different from the system background (as defined in Section 8.5).

8.4.2.1 The LRV defines the number of nines in the efficiency.

8.4.2.2 Example: A filter with a fractional penetration of 0.00001 has a LRV of 5 and an efficiency of 99.999%

8.5 Data Reduction

8.5.1 The statistical analysis is based on the assumption that the particles generated are randomly distributed and are statistically independent of each other. The background counts are independent of the particle performance of the component. The particle counts observed from the test include the counts from the component and the background count.

Let:

$$\overline{X_B} = \text{average background particle count}$$

$$\overline{X_t} = \text{average total particle count from test}$$

$$\overline{X_c} = \text{average particle count generated by the test component}$$

Therefore,

$$\overline{X_t} = \overline{X_c} + \overline{X_B}$$

8.5.2 A statistical analysis of the data is performed to

determine the mean, standard deviation, and the standard error for each particle size range.

8.5.3 The sample mean, X , or average of the data for each state is given by:

$$\bar{X} = \sum_{i=1}^n \frac{X_i}{n}$$

where X_i

is the observed counts for the state and n is the number of samples.

8.5.4 The sample standard deviation is a measure of the variability of the data about the mean. The standard deviation, s , for each state is expressed as:

$$s = \sqrt{\frac{\sum_{i=1}^n (X_i - \bar{X})^2}{n-1}}$$

8.5.5 The standard error, Se or standard deviation of the sampling distribution of the mean for each state is given below:

$$Se = \frac{s}{\sqrt{n}}$$

8.5.6 The average particle count for the total number of particles generated, or the sample mean, is an estimation of the population mean. For a 95% confidence level, the population mean, μ_p , will be within two standard errors of the sample mean, or:

$$\mu_p = \bar{X} \pm 2 Se$$

8.5.7 In order to determine if there is statistical evidence of the component having an effect on the observed particle count, a test must be conducted to see if the actual difference between the average background count, X_B , and the average test count, X_t , exceeds two standard errors in a distribution of differences between means. The average particle count generated by the test component, X_c , is given by:

$$\bar{X}_c = \bar{X}_t - \bar{X}_B$$

8.5.8 The standard error in a distribution of differences between means is expressed as:

$$S_{ec} = \sqrt{S_{et}^2 + S_{eB}^2}$$

8.5.9 The 95% confidence interval of the test component itself is then determined by:

$$\bar{X}_c \pm 2 S_{ec}$$

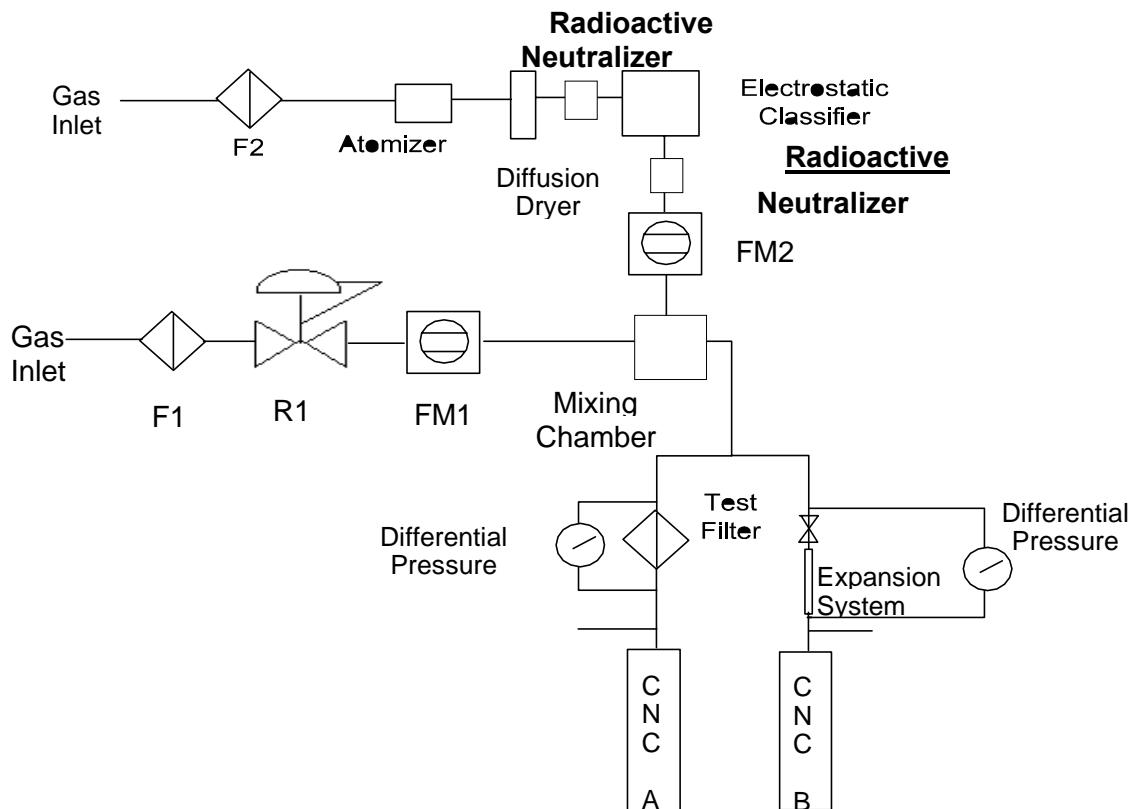
8.5.10 If this confidence interval includes 0, then this implies that there is not strong statistical evidence of the component having an effect on the observed particle count. If this interval does not include 0, then this implies there is strong statistical evidence that the component does have an effect on the observed particle count.

8.5.11 Present in tabular form the average particle count and the associated 95% confidence limits (as calculated in Section 8.5.9) for each test state. In addition, present the background test data separately as a distinct element.

8.5.12 Calculation of the Efficiency Class

8.5.12.1 The efficiency class shall be calculated in such a fashion that that:

$$LRV = \log [\text{Input Concentration} / \bar{X}_B + 2S_{eB}]$$



^{#1} F1, F2 = 10" PTFE Membrane Filter or Equivalent Filter with Sufficient Flow Capacity (LRV ≥ 9)

^{#2} R1 = @ 0 - 100 psig Outlet Regulator

^{#3} FM1, FM2 = Low Flow (0 - 50 slm) Flowmeter

Figure 1
Schematic Diagram of Filter Test System

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SEMI F39-0699

GUIDELINE FOR CHEMICAL BLENDING SYSTEMS

This guideline was technically approved by the Global Facilities Committee and is the direct responsibility of the North American Facilities Committee. Current edition approved by the North American Regional Standards Committee on December 18, 1998. Initially available on www.semi.org January 1999; to be published June 1999.

1 Purpose

1.1 This guideline establishes terminology, classification, performance characterization, and qualification methods for chemical blending equipment.

2 Scope

2.1 This guideline applies to chemical blending equipment interfaced with Bulk Chemical Distribution Systems (BCDS).

3 Limitations

3.1 This guideline does not cover subject matter concerning chemical distribution capability of some chemical blending equipment, chemical blending methodology, or materials of construction used in this equipment.

4 Referenced Documents

4.1 SEMI F31 — Guide for Bulk Chemical Distribution Systems

5 Terminology

5.1 *accuracy* — A quantity describing the deviation of the mean blend ratio produced by the chemical blending equipment from the desired constituent ratio.

5.2 *assay* — A term used to determine the amount of a chemical constituent in a blend.

5.3 *baseline contamination level* — The level of impurity measured in the source fluids, including UPW and chemical.

5.4 *batch* — The end quantity of chemical resulting from the blending of the chemical constituents.

5.5 *blending* — Combination of two or more chemicals to create a mixture which contains a desired ratio of constituents. A dilution process by this definition is also a blending process. However, blending is a more general case where UPW is not always one of the constituents. Therefore, the term blending will be used in the remainder of the document.

5.6 *Central Limit Theorem (CLT)* — The CLT is a probability theorem which allows the approximation of normality for any distribution. The CLT applied to

chemical blending states that if a sufficient number of random samples are taken from the distribution of all chemical produced by chemical blending equipment, then the average measurement of these samples can be approximated to follow a normal distribution. A rule of thumb for the “sufficient number of batches” is thirty or greater.

5.7 *dilution* — Combination of a concentrated chemical and UPW to create a lower concentration of the aqueous chemical.

5.8 *duty cycle* — The normal percentage of time that the chemical blending equipment is operating.

5.9 *mixing* — Mechanical energy imparted to a combination of two or more chemical constituents used to create a homogenous solution.

5.10 *on-site blending* — Chemical blending equipment used for blending chemical on location of the semiconductor manufacturing facility

5.11 *precision or repeatability* — A quantity describing the degree of achieving the same ratio of chemical constituents in the blend over time.

5.12 *production rate* — The volume of chemical able to be blended and provided to the BCDS per day.

6 Classification

6.1 *Batch Blending* — The process of chemical blending where the chemical constituents are combined and mixed in a tank before being made available for use.

6.2 *Feed-forward Controlled Blending* — Blending process which uses information (i.e. incoming chemical assay) of the chemical constituents as the basis for combining these constituents. Examples of feed-forward blending processes include, but are not limited to, those processes that use weight or volume for control.

6.3 *Feedback Controlled Blending* — Blending process which combines constituents based on measurements of the blended chemical. Examples of feedback controlled blending process include, but are not limited to, those processes controlled by measurements of density, conductivity, and chemical assay (by titration).

6.4 In-line Blending — The process of chemical blending where the chemical constituents are combined in line and are immediately available for use.

7 Performance Characterization

7.1 Blending Repeatability :

7.1.1 Batch Blending

7.1.1.1 Sample Collection: A sample of at least thirty batches of blended chemical is taken. Assay of this chemical is measured.

7.1.1.2 Calculations: The mean and standard deviation of the batches are computed.

7.1.1.3 Reporting: When reporting repeatability, either of two methods is acceptable. Both methods quote precision in terms of the chemical assay.

7.1.1.3.1 Repeatability at one concentration = mean \pm 3σ (where σ is in units of concentration)

7.1.1.3.2 Repeatability in range of concentrations: Individually calculate percent relative standard deviation at 3σ = $(3\sigma / \text{mean}) \times 100\%$ for representative concentrations within the desired range (30 samples for each concentration, calculate a standard deviation and mean for each concentration). Repeat largest percent relative standard deviations at 3σ and concentration range examined or report percent relative standard deviation at 3σ for each individual concentration.

7.1.1.3.3 Multiple Components: If more than one non-aqueous chemical constituent exists in the blend, the precision for each must be quoted individually.

7.1.2 In-Line Blending

7.1.2.1 Sample Collection: At least thirty samples of blended chemical are taken. The time interval between samples must be at least one hour. Assay of this chemical is measured.

7.1.2.2 Calculations: The mean and standard deviation of the samples are computed.

7.1.2.3 Reporting: When reporting repeatability one of two methods is acceptable. Both methods quote precision in terms of the chemical assay.

7.1.2.3.1 Repeatability at one concentration = mean \pm 3σ (where σ is in units of concentration)

7.1.2.3.2 Repeatability in range of concentrations: Individually calculate percent relative standard deviation at 3σ = $(3\sigma / \text{mean}) \times 100\%$ for representative concentrations within the desired range (30 samples for each concentration, calculate a standard deviation and mean for each concentration). Repeat largest percent relative standard deviations at 3σ and concentration

range examined or report percent relative standard deviation at 3σ for each individual concentration.

7.1.2.3.3 Multiple Components: If more than one non-aqueous chemical constituent exists in the blend, the precision for each must be quoted individually.

7.2 Blending Accuracy

7.2.1 Since calculation of accuracy takes into account both equipment operational parameters (calibration frequency and drift) and also changes in chemical input (feed forward blending), calculation of blend accuracy will not be standardized. However, by definition, a reported accuracy can not be less than blend precision.

7.2.2 Reporting of Accuracy

7.2.2.1 Accuracy at one concentration = desired concentration $\pm 3\sigma$

7.2.2.2 Accuracy in range of concentrations: Report range of concentrations where this accuracy applies and the accuracy in terms of a percentage of the chemical concentration. Report accuracy with statistical significance of 3σ .

7.3 Production Rate

7.3.1 All production rates described should reference the duty cycle, i.e. the percentage of time that the equipment is operating to achieve the quoted production rate.

7.3.2 Batch Production Rate = batch volume / time to produce one batch (hours) \times 24 hours \times duty cycle

7.3.3 In-line Production Rate = flow rate (volume /day) of blended chemical \times duty cycle

7.4 Purity

7.4.1 Particles — Particle performance should be expressed in the same manner as BCDS (i.e. $\leq x$ particles / ml @ $\geq 0.5 \mu\text{m}$)

7.4.2 Trace Metals — Metallic purity performance should be expressed in a similar manner as BCDS. However, blending systems, by definition, have several source materials, which could include water. Each source material contributes to the “baseline contamination level” (equivalent to drum contamination level in BCDS). A volumetric combination (based on the volumetric combination of source materials) of the contamination levels should be used to construct the baseline contamination level.

7.4.3 Ionic Contamination / TOC — Should be expressed in a similar manner as BCDS.

7.5 Uptime

7.5.1 MTBA — Mean Time Between Assists should



be expressed in the same manner as BCDS

7.5.2 MTBF — Mean Time Between Failures should be expressed in the same manner as BCDS

8 Qualification Methods

8.1 Purity — The purity of the equipment will be qualified in a similar manner to that of BCDS.

8.2 Assay — The assay of each of the chemical constituents ($c_{mean,blend}$) should be compared to that of the customers upper ($UCL_{specification}$) and lower ($LCL_{specification}$) control limits for the chemical assay. The customer specification must be expressed as their desired 3σ limits. The standard deviation for the blend (σ_{blend}) should be determined by the same method described for determining blending repeatability. The number of batches or samples to determine this standard deviation should be agreed upon by the equipment supplier and the customer. The blending unit shall be deemed qualified when both of the following are satisfied for all constituents.

8.2.1 $UCL_{specification} > C_{mean,blend} + 3\sigma_{blend}$

8.2.2 $LCL_{specification} < C_{mean,blend} - 3\sigma_{blend}$

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PRACTICE FOR PREPARING LIQUID CHEMICAL DISTRIBUTION COMPONENTS FOR CHEMICAL TESTING

This practice was technically approved by the Global Facilities Committee and is the direct responsibility of the North American Facilities Committee. Current edition approved by the North American Regional Standards Committee on December 18, 1998. Initially available on www.semi.org January 1999; to be published June 1999.

1 Purpose

1.1 This document defines component preparation and pretreatment procedures for chemical test methods used to evaluate liquid chemical distribution system components.

2 Scope

2.1 This document includes preparation procedures that can be applied to components such as tubing, piping, valves, regulators, fittings, gaskets, O-rings, and filter housings.

2.2 This document defines and specifies all of the component pretreatment and analyze preparation procedures for liquid chemical distribution system components common to the test methods listed (see Table 3). Each type of component should be pretreated and prepared according to the procedures of this document before it can be tested using the identified chemical test methods.

2.3 This document defines preparation and pretreatment procedures used for the evaluation of liquid chemical distribution system components in test fluids. This practice is intended for use with 49% HF, 30% H₂O₂, 29% NH₄OH, IPA and ultrapure water. The document defines the purity of chemicals that can be used for leaching and rinsing liquid chemical distribution system components.

3 Limitations

3.1 Although ozonated water is commonly used in ultrapure water systems, no provisions are made in this document for evaluations using ozonated water. Therefore, some of the procedures may not be directly applicable to ozonated water.

3.2 The preparation procedures described in this practice primarily involve static testing including agitation. Dynamic testing, i.e., continuous flow, may alter the chemical test results. Static component preparation procedures are not directly applicable to dynamic testing.

3.3 This preparation procedure applies to ambient temperature only with the exception of ultrapure water which may be tested at ambient temperature and up to 85°C.

3.4 Filter cartridges are not covered in this document due to the requirement for dynamic testing.

4 Referenced Documents

4.1 None.

5 Terminology

5.1 Acronyms and Abbreviations

5.1.1 *DSC* — differential scanning calorimetry

5.1.2 *FEP* — fluorinated ethylene-propylene

5.1.3 *FTIR* — Fourier transform infrared spectroscopy

5.1.4 *H₂O₂* — hydrogen peroxide

5.1.5 *HF* — hydrofluoric acid

5.1.6 *IPA* — Isopropyl alcohol

5.1.7 *NH₄OH* — ammonium hydroxide

5.1.8 *NVR* — nonvolatile residue

5.1.9 *PE* — polyethylene

5.1.10 *PFA* — perfluoroalkoxy

5.1.11 *PP* — polypropylene

5.1.12 *PVDF* — polyvinylidene fluoride

5.1.13 *TGA* — thermal gravimetric analysis

5.1.14 *TOC* — total organic carbon

5.1.15 *UPW* — ultrapure water

5.2 Definitions

5.2.1 *blank extraction* — A container of test fluid which does not see the component under test. It follows the entire procedure and is handled in the same manner in order to show the background of the lab or test area.

6 Summary of Practice

6.1 This document describes two different component preparation procedures (see Figure 1):

- a) procedure for preparing components and collecting a sample for extraction analyses
- b) procedure for pretreating or preparing components for bulk polymer analysis.

6.2 Table 1 specifies the flush time, soak time, and container material for extracting leachable contaminants. Sample size requirements for bulk analyses are listed in Table 2.

6.3 This practice should be performed before analysis by industry standard extraction and bulk test methods used to evaluate liquid chemical distribution component. Available industry standard test methods are listed in Table 3 and the Related Documents section.

7 Apparatus and Materials

7.1 *Containers*, as defined in Table 1.

7.1.1 All containers and caps used in component and blank extraction should be thoroughly cleaned. A typical recommended cleaning procedure is outlined in Section 11.3. However, any cleaning procedure is acceptable as long as the subsequent blank extraction yields impurity concentrations that do not exceed 10% of the specification for the material being tested. For example, if a given impurity is specified for a maximum of $1.0 \text{ }\mu\text{g}/\text{cm}^2$, the blank extraction concentration should not exceed $0.1 \text{ }\mu\text{g}/\text{cm}^2$.

NOTE: In situations where the detection limit is greater than 10% of the specification for the polymer material, the detection limit of the instrument converted into $\mu\text{g}/\text{cm}^2$ will suffice, provided it does not exceed the specification for the material being tested.

7.2 Test Fluids

7.2.1 For purposes of this practice, references to water shall be understood to mean ultrapure water as defined by maximum individual metal and anion impurity levels of 0.1 parts per billion by weight 1×10^{-9} (ppbw) or less, total organic carbon (TOC) levels of 10 ppbw or less, nonvolatile residue levels of 0.1 parts per million by weight 1×10^{-6} (ppmw) or less, resistivity of 18 megohm-cm or greater, and reactive silica impurity of less than 1.0 ppb.

7.2.2 References to HF, NH₄OH and H₂O₂ shall be understood to refer to chemicals with a minimum of a semiconductor grade purity and meet the criteria in section 7.1.1. The impurity concentrations of the

chemical must not exceed 10% of the lowest anticipated concentration for the analyte(s) of interest.

7.2.3 *Ultrapure Nitric Acid*, less than 1 ppb for each trace metal.

7.2.4 *Ultrapure Hydrochloric Acid*, less than 1 ppb for each trace metal.

7.2.5 *Ultrapure Isopropyl Alcohol*, less than 1 ppb for each trace metal.

8 Precautions

8.1 Safety Precautions

8.1.1 This practice may involve hazardous materials, operations, and equipment. This practice does not purport to address the safety considerations associated with its use. It is the responsibility of the user to establish appropriate safety and health practices and to determine the applicability of regulatory limitations before using this practice.

8.2 Technical Precautions

8.2.1 The component preparations must be conducted in clean environments that prevent contamination of the components and containers at the parts per trillion level for the analyte(s) of interest. A clean environment may require the use of a cleanroom (for those procedures which can be performed in a cleanroom).

8.2.2 For all testing other than differential scanning calorimetry (DSC), thermal gravimetric analysis (TGA), and Fourier transform infrared spectroscopy (FTIR), the component preparation should take place in a controlled environment to minimize contamination.

9 Sampling and Test Specimens

9.1 The components selected for testing should reflect the current manufacturing capabilities of the supplier.

10 Procedure for Preparing Components and Collecting an Extraction Sample for Analysis

10.1 Component preparation for contaminants that can be leached from liquid chemical distribution components is different from component preparation for bulk polymer analysis. Components are flushed and then soaked to extract surface contamination. Refer to Table 1 for procedures for handling specific components.

10.2 The liquid chemical distribution system components described in this section are divided into two groups:

- a) Components that require capping (see Section 9.5).

- b) Components that require a container (see Section 9.6).

10.3 Each group is discussed individually. Use Table 1 to determine the appropriate group for each component.

10.4 General Procedure

10.4.1 The blank extraction is a container of test fluid without a component which follows the entire procedure and is handled in the same manner. Please consult the specific test method for the number of test fluid samples to be prepared and the statistical treatment. This would include a number of containers for both component and blank extractant. Use cleaned containers that meet the criteria specified in Section 7.1.1. An example of a cleaning procedure is outlined in Section 11.3.

10.4.2 Use UPW to fill and then drain the component or container 10 times. After each fill, leave the water in the component or container for two minutes before draining.

10.4.3 Fill an 11th time with the appropriate test fluid (see Section 2.3); use this fill for the test. Refer to Table 1 to determine the soak time for each component or container.

10.4.4 Agitate once a day for one minute. Orbital shakers or manual agitation can be used, but no foreign materials may contact the test fluid; therefore, stir bars cannot be used. Components and/or containers are to remain sealed during agitation to prevent splashing or spilling. Components in containers (such as gaskets) should remain completely submerged throughout the extraction.

10.5 Components that Require Capping (Tubing, Piping, Valves, Regulators, and Filter Housings)

10.5.1 This practice is appropriate for static samples with one end permanently sealed and one end loosely capped. Since the sealing process may contaminate the sample, one end should be sealed prior to precleaning. Use cleaned caps meeting the criteria specified in Section 7.6.1. The cap must be manufactured from the same material as the component or from a compatible material that will not contaminate the sample.

10.5.2 As surfactants and solvents may leave a residue that could alter the test results, do not use them for precleaning.

10.5.3 During sample collection for metal analysis, the components must be acid stabilized to a pH of 2 (approximately 3 drops of concentrated nitric acid per 250 mL of UPW) to stabilize for certain trace metals (i.e., iron and chromium).

10.5.4 *Tubing and piping:* Fill the component with test

fluid to within one inch of the top of the component to allow free space for agitation. In the case of tubing or pipes, to maximize the exposed surface area of the pipe to the volume of fluid and to minimize the surface area of the end cap, it is recommended that the ratio of the surface area of the pipe to the surface area of the end cap be 10 or greater. The equation to determine the ratio is $4L/D$, where L is the length of the pipe or tubing and D is the diameter.

10.5.5 *Valves, regulators, and fittings:* To allow for maximum fluid volume, fill valves, regulators, and fittings with the appropriate test fluid to within five mL of the top to allow for agitation. Multiple components may be required to obtain the necessary volume for the test. Valves, regulators, and fittings must be capped at both ends. In the case of valves, this practice assumes that normally opened valves will be used.

10.5.6 *Filter housings:* Fill the component with the appropriate test fluid to within one inch of the top of the housing to allow free space for agitation. The inlet and outlet of the housing must be capped.

10.5.7 Example of procedure for components that require capping

10.5.7.1 Clean and prepare 8 covered containers per Sections 10.4.1 and 7.1.1.

10.5.7.2 Flush component and blank extraction containers (3 components and 5 blank extraction containers) according to Section 10.4.2 (rinse 10 times for 2 minutes per Table 1).

10.5.7.3 Fill all components and blank extraction containers with the test media of choice (see Section 2.3 for definition of test media).

10.5.7.4 Soak according to Section 10.4.3 (soak one week per table 1), agitate all components and blank extraction containers once a day for one minute per Section 10.4.4.

10.5.7.5 Decant the contents of the component into 3 remaining empty containers.

10.5.7.6 At completion of this practice analytical tests should be performed on test fluid from each container see test methods noted in Table 3 and related documents section.

10.6 Components that Require a Container (Gaskets, and O-Rings)

10.6.1 Containers must have sufficient internal volume to perform the required test. Often, 100 mL of extracted test fluid will be required per test.

10.6.2 Surfactants and solvents may leave a residue that could alter the test results; do not use them for precleaning.

10.6.3 During sample collection for metal analysis, the components must be acid stabilized to a pH of 2 (approximately 3 drops of concentrated nitric acid per 250 mL of UPW) to stabilize for certain trace metals (i.e., iron and chromium).

10.6.4 *Gaskets and O-rings:* A minimum of two grams of component per 100 mL of test fluid is required to perform any of the tests. To concentrate a sample and lower the detection limit of the test method, increase the amount of component per 100 mL of fluid.

10.6.5 Example of procedure for components that require a container

10.6.5.1 Clean and prepare 8 covered containers per Section 10.4.1 and 7.1.1.

10.6.5.2 Place the component into 3 containers per Section 10.6.

10.6.5.3 Flush all containers (3 with components and 5 as blanks) according to Section 10.4.2 (rinse 10 times for 2 minutes per Table 1).

10.6.5.4 Fill all containers with the test media of choice (see Section 2.3 for definition of test media).

10.6.5.5 Soak according to Section 10.4.3 (soak one week per table 1), agitate all containers once a day for one minute per Section 10.4.4.

10.6.5.6 At completion of this practice analytical tests should be performed on test fluid from each container see test methods noted in Table 3 and related documents section.

11 Procedure for Preparing Components for Bulk Polymer Analysis

11.1 Table 2 lists the amount of material required to achieve the indicated level of detection. Obtaining the amount may require using 1) an entire component, 2) a segment of a large component (such as piece of piping or valve), or 3) an appropriate quantity of smaller components (such as O-rings).

11.2 No further pretreatment is required except for inorganic analysis. See Section 11.3.

11.3 Additional Pretreatment for Inorganic Bulk Analysis

11.3.1 If the intent of the inorganic analysis is to examine the as-received material from a supplier, no further pretreatment is required.

11.3.2 After the proper amount of the material is obtained, place it in a clean container and clean it using the procedure outlined below.

NOTE: This procedure may also be used to pre-clean containers and caps to meet the criteria specified in

Section 7.1.1. If pre-cleaning performance criteria is not achieved with this procedure another procedure should be used or the concentrations, times, and temperatures noted in this procedure could be varied to achieve required result.

11.3.3 Agitate the material in ultrapure IPA for 2 minutes. Drain the IPA from the material and replenish with ultrapure IPA. Allow the material to soak for 30 minutes.

11.3.4 Drain the IPA from the material and replace with UPW. Agitate the material for 2 minutes.

11.3.5 Soak the material in 1:1 ultrapure nitric acid : UPW for 2–4 hours.

11.3.6 Drain the nitric acid from the material and replace with UPW. Agitate the material for 2 minutes.

11.3.7 Soak the material in 1:1 ultrapure HCl : UPW for 2–4 hours.

11.3.8 Drain the HCl from the material and replace with the test fluid. Agitate the material for 2 minutes. Drain the material and replenish with test fluid and agitate for an additional two minutes.

12 Data Presentation

12.1 See Table 3 for a list of the units to report for individual component types. Record the following:

- a) Report the test fluid used and test temperature.
- b) Report if the components were prepared for testing as received or after the rinse pretreatment.
- c) Report the volume of test fluid used.
- d) Report the soak time
- e) Report the wetted surface area of the component. If the precise wetted surface area is not known please record the assumed or estimated wetted surface area and note it is estimated.
- f) If multiple components (such as gaskets, or O-rings) were used, report the total wetted surface area of the components.
- g) Report the manufacturer, model number, and lot number (if known) for each component tested.

13 Related Documents

13.1 ASTM Standards¹

¹ American Society for Testing and Materials (ASTM). 1916 Race St. Philadelphia, PA 19103.



ASTM D859 — Standard Test Method for Silica in Water

ASTM D1068 — Standard Test Method for Iron in Water

ASTM D1353 — Standard Test Method for Nonvolatile Matter in Volatile Solvents for Use in Paint, Varnish, Lacquer, and Related Products

ASTM D4327 — Standard Test Methods for Anions in Water by Ion Chromatography

ASTM D4779 — Standard Test Method for Total, Organic, and Inorganic Carbon in High Purity Water by Ultraviolet (UV) or Persulfate Oxidation or Both, and Infrared Detection

13.2 SEMATECH Documents²

SEMATECH 92010935B-STD — Provisional Test Method for Electrical Resistivity of UPW

SEMATECH 92010936B-STD — Provisional Test Method for the Determining Leachable Trace Inorganics from UPW Distribution System Components

SEMATECH 92010937B-STD — Provisional Test Method for Evaluating Bulk Polymer Samples of UPW Distribution System Components (FTIR Method)

SEMATECH 92010938B-STD — Provisional Test Method for Determining Bulk Trace Metals in Polymer Materials for UPW Distribution System Components

SEMATECH 92010939B-STD — Provisional Test Method for Evaluating Bulk Polymer Samples of UPW Distribution System Components (DSC and TGA Methods)

SEMATECH 92010940B-STD — Provisional Test Method for Determining the Water Retention Capacity of Ion-Exchange Resins Used in UPW Distribution Systems

²SEMATECH, 2706 Montopolis Dr. Austin, TX 78741.

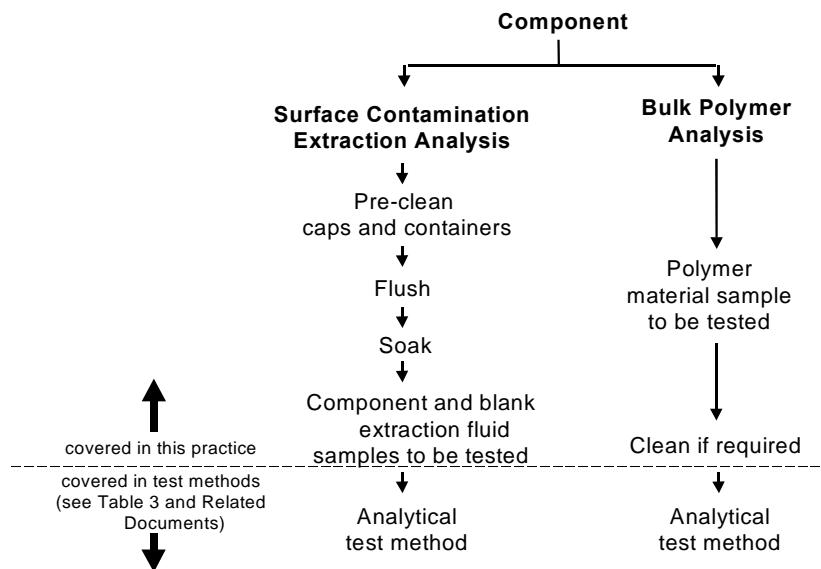


Figure 1
Summary of Practice

Table 1 Component Handling for Extraction Test Preparation

Component	No. of Flushes x Flush Time (min.)	Soak Time	Capped Component or Container	Container Material	Section
Tubing, Piping	10 x 2 min.	1 week	capped component	N/A	9.5.4
Valves, Regulators, Fittings	10 x 2 min.	1 week	capped component	N/A	9.5.5
Filter Housings	10 x 2 min.	1 week	capped component	N/A	9.5.6
O-rings, Gaskets	10 x 2 min.	1 week	container	PFA FEP PP glass (see NOTE*)	9.6.4

* NOTE: The container and transfer vessel materials used depend on the test to be performed. Use the following materials for the noted test methods.

Test Method	Material
TOC, NVR	glass
anions	PP, glass
inorganics, resistivity, silica	PFA, FEP

Table 2 Material Requirements for Bulk Analysis

	Inorganics	FTIR	Thermal Analysis	Water Absorption
Weight (gms)	1–2	< 5	0.007–0.01	10
Detection Limit	0.1 ppm	N/A	N/A	0.1%

Table 3 Reporting Units for Aqueous Liquid Components

Test Method	Aqueous Liquid Component	Reporting Units
Leachable Trace Inorganics, Anions, TOC	tubing, piping, valves, regulators, fittings, gaskets, O-rings, filter housings	µg/cm ²
Bulk Trace Inorganics	tubing, piping, valves, regulators, fittings, gaskets, O-rings, filter housings	µg/cm ²
Nonvolatile Residue	tubing, piping, valves, regulators, fittings, gaskets, O-rings, filter housings	µg/cm ²

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mentioned herein. These standards are subject to change without notice.

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SEMI F41-0699

GUIDE FOR QUALIFICATION OF A BULK CHEMICAL DISTRIBUTION SYSTEM USED IN SEMICONDUCTOR PROCESSING

This Guide was technically approved by the Global Facilities Committee and is the direct responsibility of the North American Facilities Committee. Current edition approved by the North American Regional Standards Committee on December 18, 1998. Initially available on www.semi.org January 1999; to be published June 1999.

1 Purpose

1.1 This Guide sets forth a logical and systematic approach to the qualification of a Bulk Chemical Distribution System that may be used by users and suppliers as a basis for developing site-specific BCDS specifications and performance criteria.

2 Scope

2.1 The qualification process includes evaluation of chemical from the chemical source, the fluid transfer system, the distribution piping, the day tank, as well as other intermediary points of transfer and storage that may be included in the qualification plan.

2.2 This guide assumes that the BCDS has been installed per the BCDS manufacturer's recommendations and the customer's specifications, and has been appropriately leak tested and shown to meet all requirements of mechanical and physical integrity up to the POU.

2.3 BCDS are typically tested for particle levels and trace metal impurities according to specified levels agreed upon in advance. For certain applications or specific chemicals, other testing may become incorporated in the qualification process. These other tests may include assay analysis, anion analysis, TOC analysis, moisture analysis, etc.

3 Limitations

3.1 This guide does not define the test methods that should be used for evaluation of samples taken during the qualification process, or distinguish test methods that will generate accurate and reliable results from those that will not generate accurate or reliable results.

3.2 This guide does not define or describe the sampling methodologies that are required in order to physically take a representative and a non-contaminated batch sample. However, appropriate sampling procedures and equipment must be used consistent with the actual specifications.

3.3 This guide does not define the type of containers that should be used for sampling. Pretreatment of containers is necessary to assure that the data generated

by testing actually measures the chemical being delivered to the process tool and not the impurities in the container itself, from the environment, or from human handling.

3.4 This guide does not address the type, level, or frequency of testing necessary and appropriate for ongoing monitoring of a BCDS.

3.5 This guide does not address the special case of a system designed and used for the generation and distribution of high purity water used in semiconductor processing.

3.6 This guide does not address the testing and prequalification of materials, subassemblies, or components used in a BCDS.

3.7 This guide does not address the protocols and requirements defined by the manufacturer concerning the installation of the BCDS.

3.8 This guide does not define the actual specifications generally negotiated between the user and the manufacturer of the BCDS, against which chemical samples are tested and qualification is passed.

3.9 This guide does not address the qualification process for chemicals through the process tool. While the sampling considerations and timing make the initial tool qualification a natural adjunct to the BCDS qualification, the responsibility for this task generally falls within a different jurisdiction and is generally handled separately.

4 Referenced Documents

4.1 SEMI Documents

4.1.1 *SEMI S-2* — Safety Guideline for Semiconductor Manufacturing Equipment

4.1.2 *SEMI E-4* — Guide for Standard Performance, Practices, and Sub-Assembly for High Purity Piping Systems and Final Assembly for Semiconductor Manufacturing Equipment

4.1.3 *SEMI F31* — Guide for Bulk Chemical Distribution Systems

4.2 Other Document

4.2.1 SIA National Technology Roadmap For Process Chemicals¹

5 Terminology

5.1 Acronyms and Abbreviations

5.1.1 BCDS — Bulk Chemical Distribution System

5.2 Definitions

5.2.1 *pickling* — To condition the BCDS by exposing to an aggressive chemical that extracts impurities from the internal surfaces of the system.

5.2.2 *sample* — Sample taken from a system into a sampling container and measured off-line.

6 Pre-Chemical Qualification

6.1 Advantage of Pre-Chemical Qualification — The pre-chemical qualification is designed to ensure that the piping systems and storage tanks are able to accept chemicals. This step is often initiated after the UPW system is functional and an acceptable resistivity is achieved but before chemicals are authorized to be brought on-site. Although UPW does not extract high levels of metallic and ionic impurities from the BCDS materials of construction, this step can ensure that the BCDS and distribution piping is free of any gross contamination that may have been introduced into the system during installation. In addition, the UPW flush can be effective for the elimination of some types of particles.

6.2 Particle Qualification — The BCDS is flushed with UPW and the levels of particles are measured using an on-line optical particle counter. The steps followed include:

6.2.1 Install an acceptable UPW water filter element(s) per the filter and BCDS manufacturer's specifications.

6.2.2 Fill the BCDS with UPW and recirculate internally to ensure that all piping is filled with UPW.

6.2.3 Begin sampling to a liquid particle counter downstream of the filters either at the outlet of the BCDS, the POU, or both. Follow an approved particle counting sampling procedure.

6.2.4 Continue recirculating and flushing until the particle concentrations in the desired channel or channels are observed at levels below the agreed-upon specification. An example of typical specification is the average of five consecutive ten minute readings of <X particles/ml @ ≥ Y micron.

6.3 Metallic Qualification — After reaching the particle specification for the UPW, a sample of UPW may be taken for trace metal analysis. This sample can be taken at the outlet of the BCDS, at an end point sample station and/or at the POU. An appropriate sample bottle precleaned for this test should be used to collect a sample. The sample bottle should be preconditioned before use and contamination-free techniques used for the actual sampling.

6.3.1 The steps to follow are:

6.3.1.1 Fill the sample bottle with the required volume for the analytical method to be used. The volume varies depending on analytical procedures and lab instrumentation.

6.3.1.2 Send samples to a designated laboratory capable of performing trace metal analysis. Use only a laboratory that has experience with these types of samples and that can test reliably in the sub-ppb range. The number of elements and concentrations that are to be analyzed will vary depending on customers' requirements.

6.3.1.3 Evaluate data and compare to the agreed-upon specification. A typical specification is <X ppb total and <X ppb per element.

6.3.1.4 If the trace metal specification is not met, drain or flush the entire BCDS and distribution piping and repeat the process.

6.3.1.5 If a maximum level of impurities is desired, a sample of the UPW used to charge the system should be tested to establish a baseline and to ensure that the incoming UPW is not the source of high impurities.

6.3.1.6 Once the BCDS has been qualified for particles and trace metals in UPW, the qualification of the BCDS in Chemical may be initiated.

7 Chemical Conditioning of The System

7.1 Advantages of Conditioning the System — Another precleaning step that may be used independently or in conjunction with a UPW flush is to condition the BCDS by actively flushing it with an aggressive chemical that extracts impurities from the internal surfaces of the system. This step is sometimes referred to as "pickling" the system. This extra step can help minimize the amount of time consumed in the qualification process by utilizing a chemical with more aggressive extraction properties than the actual chemical to be used in the line, thereby increasing the rate at which impurities are removed. This can shorten the amount of time needed until the actual chemical can be put into the line and shown to meet the qualification specifications. Since a goal of a well-designed qualification protocol is to minimize the amount of high

¹ Semiconductor Industry Association, 181 Metro Drive, Ste 150, San Jose, CA 95110, USA

purity chemical flushed to drain during the qualification process, this approach may also prove to be more cost effective depending on the cost of the chemical used for pickling, compared to the cost of the process chemical designated for use in the line.

7.2 Conditioning With Same Chemical — A variation on the above approach is to "pickle" the system with the process chemical that is intended to be used in the BCDS line a 24-72 hour soak period and flushing the chemical to drain. While the process chemical may not be as aggressive in cleaning up the line, this approach has the advantage that the extracted metals have the same fingerprint as those that might otherwise be observed during the final qualification testing, and the final qualification may be done immediately following this step, without further preparation.

7.3 Testing the Preconditioning Chemical — Rather than relying on an arbitrary or predetermined lengths of time for preconditioning the BCDS, test samples are often taken and analyzed to ensure that the required level of impurities has actually been obtained. This testing is often commissioned by the equipment manufacturer and not reported to the customer as part of the BCDS qualification. Indicator elements are often analyzed that are either of particular concern in the process chemical, or elements such as Ca, Cr, Cu, Fe, Mg, Na, Ni, and Zn, that are known as common impurities in chemicals and that are also highly detrimental in semiconductor processing.

7.4 Conditioning Procedure — The three most common chemicals (HCl, HF, and HNO₃) used for precleaning the BCDS are aggressive in extracting metallic impurities and particles. The steps followed include:

7.4.1 Install an acceptable chemical filter element(s) per the filter and BCDS manufacturer's specifications.

7.4.2 Fill the BCDS and distribution piping with the chemical of choice and recirculate internally to ensure that all piping is filled. This may include all distribution piping. Let the chemical soak the materials of construction in a static manner for a period of 24 to 72 hours, or continue recirculating the chemical as a closed loop for the same amount of time.

7.4.3 Flush the chemical from the system.

7.4.4 Depending on the chemical used, a UPW rinse step or an inert gas purge step for drying may be required prior to filling the system with the actual chemical for the qualification testing.

Note: The precleaning chemicals used may add undesirable contaminants (i.e. F⁻ from Hydrofluoric acid, Cl⁻ from hydrochloric acid, etc.). Therefore, if

any of these chemicals are used, additional testing may be required to determine that these materials have not added contaminants in excess of any specification. These contaminants may be tested in the UPW rinse step or in the final chemical qualification step.

7.5 Solvent Systems — The type of chemical used for flushing solvent BCDS systems is different than that used for oxidizers and corrosive chemicals since solvent systems can be made from stainless steel and metal materials for reasons of safety and chemical compatibility. Generally, IPA, or the chemical to be used in the system, is used for the aqueous pre-clean step in flushing a system where solvents are to be used.

8 Final Chemical Qualification

8.1 Initial Considerations — Notwithstanding any of the steps taken to prepare the BCDS for qualification testing, certain issues should be considered prior to starting any sampling required in the qualification process:

8.1.1 Determination about the adequacy of the sampling points. — The sampling points are generally coincident with the location of pre-existing sample ports on the Valve Manifold Box, day tank and other distribution points. The adequacy of the sampling points depends on their accessibility, environmental controls, ability to flush prior to sampling, and safety considerations.

8.1.2 Adequacy of data. — Due to sampling error, possibility of environmental contamination, handling problems, and impurities in sampling containers, samples should be taken in duplicate or triplicate, with two samples sent to the lab for testing and one sample retained in case of a dispute.

8.1.3 Use of proper precleaned sampling containers. — Sampling containers must be chemically compatible and precleaned in a manner consistent with the desired specification level for impurities. Sample bottle preparation differs depending on the type of testing to be performed.

8.1.4 Use of a contamination-free sampling device for samples pulled from an open vessel or a drum.

8.1.5 Proper training for personnel assigned to sampling. — The proper training is required to ensure that personnel charged with sampling follow appropriate safety and contamination-free protocols.

8.2 Particle Qualification — For most accurate results, particle levels should be measured on-line with a optical particle counter capable of measuring the size of particle that is included in the guaranteed specification. Batch samples may be taken and measured for particles in a lab, but special care is needed to prequalify containers used for this sampling, and data integrity may be compromised for the smallest sized particles due to various contamination sources. An example of a protocol generally followed to measure particle on-line includes:

8.2.1 Remove all UPW in the BCDS and distribution piping.

8.2.2 Remove UPW filters or replace incompatible chemical filters if present.

8.2.3 Install specified filter element per the BCDS and filter manufacture's specifications.

8.2.4 Commission the BCDS and distribution piping with the process chemical.

8.2.5 Recirculate chemical through the BCDS and through all POU to drain.

8.2.6 Drain all chemicals from the BCDS and distribution piping.

8.2.7 Refill entire system with chemical and begin circulation through filters and out to POU to drain.

8.2.8 Begin sampling to a liquid particle counter downstream of the filters either at the outlet of the BCDS, the POU, or both. Follow a prescribed particle counting sampling procedure.

8.2.9 The number of particle samples and sample duration time should be calculated based on the total volume of chemical desired to be examined by the particle counter. A "sufficient" volume of chemical should be examined by the particle counter during the qualification period. As an example, the particle concentration could be measured over at least a five-hour period with thirty consecutive ten-minute samples taken. In this example, the average of the last consecutive 30 samples would be calculated and compared to the specification.

8.2.10 The particle concentration is considered acceptable if the average is less than the specification.

8.3 Metallic Qualification — Metallic impurities are generally specified both in terms of level of impurity by element and total amount of impurities. The customer's specification generally lists each element to be included in the analysis or may refer to the list of elements published by SEMI for each chemical at different purity grades. The maximum impurity levels may be described as an absolute value (e.g. 1ppb maximum

impurity), or in terms of the quantity of impurities that may be added by the BCDS including the distribution piping. This amount of "total adders" is determined by measuring the impurity levels of the incoming chemical from the storage or supply vessel compared to the purity level of the chemical at the end point sample station or POU. The number of samples and location of samples vary depending on the type of specification. When qualifying to a "metallic impurities added" specification, a sample must be taken from the incoming chemical supply drums for an incoming baseline. The testing protocols includes:

8.3.1 Precondition all sampling bottles before use and follow appropriate sampling protocol.

8.3.2 Send samples to a lab for trace metal analysis specifying the level of testing required and the number of elements to be tested. The level of testing required depends on the agreed upon specification. As a rule of thumb, the detection limits of the analysis should be at least 10X's lower than the impurity level to be achieved for each element. In addition, the lab should follow high standards of quality control for trace metal analysis including analysis in duplicate, duplicate blanks, use of internal standards, instrument calibration using primary standards, and QC checks.

8.3.3 Review the data that is reported and compare it to the customer requirement.

8.3.4 If the system does not meet the specification then repeat the procedure until the system is qualified.

8.3.5 Where maximum levels of impurities are specified, a sample of the incoming chemical should either be measured as part of the qualification process, or retained, to ensure that the incoming chemical is not a significant source of contamination.

8.3.6 For purposes of metallic qualification, soak periods similar to those referenced in Section 7.2 are recommended.

9 Other Considerations

9.1 Accelerated Qualification Techniques — Although process chemicals such as hydrofluoric and hydrochloric acid may reach acceptable levels of purity after a few weeks in the BCDS, other chemicals such as sulfuric acid and ammonium hydroxide extract impurities much more slowly and significant levels of impurities are observed even after several months. The BCDS conditioning process described above is one approach to preleaching impurities from the BCDS. Other variations include combinations of static and dynamic rinses and emphasis on the use of dilute HF as the aqueous preclean chemical that is particularly effective for iron removal, however, it contributes high

levels of fluoride which may be a concern for some qualification processes.

9.2 Specialty Chemicals — Certain CVD chemicals have high levels of organics which raise concerns about chemical decomposition, residues and particulate formation. These concerns may require customized approaches to the design of a BCDS qualification. For example, reservoir replacement for these types of chemicals with vapor pressure from 1-5 Torr and above may require the use of vacuum less than the vapor pressure of the chemical whereas low vapor pressure chemicals with vapor pressures from 1-5 Torr, and viscous materials, may require a solvent purge. In addition, purging and pickling of the BCDS and chemical delivery lines should be performed per Sections 7.1 and 7.2. CAUTION: UPW introduced into the lines frequently interacts with the CVD chemicals causing decomposition.

NOTICE: These standards do not purport to address safety issues, if any, associated with their use. It is the responsibility of the user of these standards to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use. SEMI makes no warranties or representations as to the suitability of the standards set forth herein for any particular application. The determination of the suitability of the standard is solely the responsibility of the user. Users are cautioned to refer to manufacturer's instructions, product labels, product data sheets, and other relevant literature respecting any materials mentioned herein. These standards are subject to change without notice.

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SEMI F42-0600

TEST METHOD FOR SEMICONDUCTOR PROCESSING EQUIPMENT VOLTAGE SAG IMMUNITY

This test method was technically approved by the Global Facilities Committee and is the direct responsibility of the North American Facilities Committee. Current edition approved by the North American Regional Standards Committee on March 2 and April 10, 2000. Initially available on www.semi.org May 2000; to be published June 2000. Originally published June 1999.

1 Purpose

1.1 The purpose of this document is to define the test method used to characterize the susceptibility of semiconductor processing, metrology, and automated test equipment to voltage sags.

2 Scope

2.1 This document defines the testing procedures and test equipment required to characterize the susceptibility of equipment to voltage sags by showing voltage sag duration and magnitude performance data for the equipment.

NOTE 1: Characterizing equipment voltage sag immunity allows for the identification of tolerances, if any, that may exist between the actual equipment immunity and any one or more voltage sag performance specifications.

2.2 This test method is intended for, but not limited to, the following equipment types:

- Etch equipment (Dry & Wet)
- Film deposition equipment (CVD & PVD)
- Thermal equipment
- Surface prep and clean
- Photolithography equipment (Stepper & Tracks)
- Chemical Mechanical Polishing equipment
- Ion Implant equipment
- Metrology equipment
- Automated test equipment

2.3 This standard does not purport to address safety issues, if any, associated with its use. It is the responsibility of the users of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

3 Limitations

3.1 This standard does not address testing for over-voltage conditions.

3.2 International, national and local codes, regulations and laws should be consulted to ensure that the

equipment and procedures meets regulatory requirements in each location.

4 Referenced Standards

4.1 SEMI Standard

SEMI S2 — Safety Guidelines for Semiconductor Manufacturing Equipment

4.2 IEEE Standard¹

IEEE 1250 — Guide for Service to Equipment Sensitive to Momentary Voltage Disturbances

NOTE 2: As listed or revised, all documents cited shall be the latest publications of adopted standards.

5 Terminology

5.1 Definitions

5.1.1 *device under test (DUT)* — the semiconductor process, metrology, or automated test equipment intended to be tested, including the equipment mainframe and all subsystems whose electrical power is directly affected by the operation of the equipment's EMO system.

5.1.2 *emergency off circuit (EMO)* — a control circuit which when de-activated, places the equipment into a safe shut down condition and will restrict all hazardous potentials to the main power enclosure. This is a state in which all hazardous voltage has been removed from the equipment, all hazardous production materials flow has been stopped, any radiation sources de-energized or totally contained, any capacitors grounded, all moving parts stopped, internal and external heat sources shut off, and the equipment presents minimum hazard to personnel or the facility. [SEMI S2]

5.1.3 *point of connection (POC)* — the point where the facility utility connects to the exterior of the equipment.

5.1.4 *ride-through capability* — the ability of equipment to withstand momentary interruptions or sags [IEEE 1250]. Also known as voltage sag immunity.

¹ The Institute of Electrical and Electronic Engineers, Inc., 345 East 47th Street, New York, NY 10017-2394, USA

5.1.5 *sag generator* — test apparatus capable of reducing voltage supplied to the device under test for specific time durations.

5.1.6 *voltage sag* — an rms reduction in the ac voltage, at power frequency, for durations from half-cycle to a few seconds [IEEE 1250]. Also known as voltage dip.

6 Test Apparatus

6.1 *Data Acquisition System (DAS)*: The DAS will allow monitoring of the device under test and selected subsystems during the test. The DAS must measure the voltage and current at least two cycles (40/33 ms) before, during, and at least two cycles (40/33 ms) after the voltage sag event. The DAS must have the performance characteristics defined in Table 1.

NOTE 3: (40/33 ms) refers to 40 ms at 50 Hz or 33 ms at 60 Hz.

Table 1 Data Acquisition System Performance Requirements

Parameter	Requirement
Measurement Accuracy	± 3 percent of reading
Minimum Sample Rate	900 Hz
Minimum Number of Analog Inputs	As required by the Test Plan (see Section 10.1.4)

6.2 *Digital Volt Meter (DVM)* — A digital meter with current and voltage measurement probes. Minimum performance requirements of 1% accuracy, true rms, and resolution of 3 1/2 digits.

6.3 *Sag Generator* — The sag generator must be capable of providing voltage sags of controlled magnitude and duration relative to the nominal supply voltage of the DUT. The sag generator must be able to create voltage sags over the range of durations and magnitudes as required. The sag generator must be capable of producing independent output voltages on each phase of the load. The sag generator must have the performance characteristics in Table 2 (see Related Information 1).

Table 2 Sag Generator Performance Requirements

Parameter	Requirement
Insertion loss (the difference between sag generator input and output voltages when set to 100% of nominal)	Less than 1.5%
Change in output voltage as load is varied from 0–100% (steady state load regulation)	$\pm 5\%$
Output current capability	As required by the DUT.
Capability to supply inrush current	Not to be limited by the sag generator.
Under all conditions, the maximum deviation from required voltage (dynamic load regulation)	Less than $\pm 10\%$ for not more than 1 cycle (20/17 ms).

7 Safety Precautions

NOTE 4: The following are safety guidelines for voltage sag testing and as such should be considered only recommendations since regional safety regulations vary. International, national and local codes, regulations and laws should be consulted to ensure that the equipment and procedures meet regulatory requirements in each testing location.

7.1 Work should be conducted in accordance with industry standard safety procedures. Since panels may need to be open in order to connect voltage probes and route power leads to and from the sag generator, this work is classified as Type 2 Energized Electrical Work per SEMI S2. Test equipment manufacturer's safety recommendations should be followed.

7.2 Worker Safety

7.2.1 During testing lock and tag (lockout/tagout) procedures should be followed to control hazardous energy (reference appropriate regional regulations and requirements). No circuit should be connected or wired when electricity is present. This includes power connections as well as the connection of various monitoring probes.

7.2.2 The area immediately surrounding the device under test (DUT) should be cordoned off and appropriate signs like "Test In Progress" should be posted.

7.2.3 Appropriate personal protective equipment should be worn at all times.

7.2.4 Only authorized personnel should be allowed within the cordoned off test area.

7.2.5 Work should be done as described in the test procedure (see Section 10).

7.2.6 Proper connections should be traced and verified before energizing.

7.3 Equipment Safety

7.3.1 The sag generator should have a fail-safe design.

NOTE 5: Subjecting equipment to repeated voltage sags of less than 80% nominal for longer than 3 seconds may damage equipment.

7.3.2 The sag generator should be protected by an appropriately sized branch circuit breaker at the utility power source. This will protect the sag generator and DUT from short circuits and overcurrent conditions.

7.3.3 Every effort should be made to protect the DUT. As with other equipment tests damage to the DUT is possible. Although only a remote possibility, the equipment owner should be made aware of the potential for damage.

8 Sampling and Test Specimens

8.1 Characterization tests are conducted on samples of production articles, not on each item produced. Characterization tests apply to equipment that is manufactured to a single design either in multiple quantities or one-of-a-kind. The equipment selected for testing should reflect current production models of the supplier.

8.2 The intent of this document is to make reasonable efforts to test the semiconductor process, metrology, and automated test equipment as a complete operating

system under the actual intended conditions of end use. To simulate the worst-case condition, the tests described in this document should be performed during the most sensitive process mode of the equipment as determined by the equipment supplier.

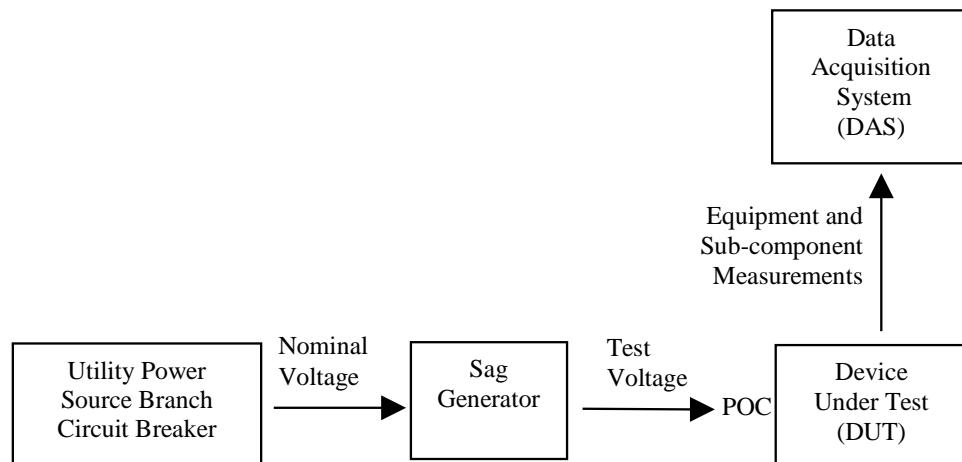
9 Test Setup

9.1 The test setup should consist of a sag generator and a data acquisition system as shown in Figure 1.

9.2 When the current required by the DUT is within the sag generator's rating, the sag generator shall be connected between the incoming utility power source and the point of connection (POC) on the DUT. If the current required by the DUT is greater than the rating of the sag generator, then individual subsystems of the DUT can be tested separately.

9.2.1 If DUT subsystem testing is required due to the limitation of the sag generator, each subsystem must be tested independently with the other parts of the DUT operating. Tested in this manner, any interlocks or alarms that might activate during the test will be apparent. Testing the DUT main power module may require providing power to only the main power module, leaving the subsystems turned off. After the characteristics of the DUT main power module EMO circuit are known, testing of DUT subsystems can begin as described.

9.2.2 Power down the DUT.



NOTE: Single-phase test fixture is shown for clarity.

Figure 1
Test Setup

- 9.2.3 De-energize and lockout/tagout the DUT POC.
- 9.2.4 De-energize and lockout/tagout the voltage supply at the DUT utility power source branch circuit breaker.

- 9.2.5 Identify the utility power source branch circuit breaker to be used to power the sag generator, then, turn off and lockout/tagout this device.

- 9.2.6 Following the sag generator manufacturer's instructions, connect the input of the sag generator for each phase, ground, and neutral (if required) to the utility power source branch circuit breaker identified in Section 9.2.5.

- 9.2.7 Following the sag generator manufacturer's instructions, connect the output of the sag generator to the DUT POC.

- 9.2.8 Following the DAS manufacturer's instructions, connect the DAS channels to the appropriate measurement points on the DUT. The data acquisition measurement points should be defined in the test plan (see Section 10.1.4). Typical data acquisition measurement points for semiconductor equipment are listed in Table 3.

Table 3 Typical Data Acquisition Measurement Points

No	Data Acquisition Measurement Points
1	I _a , phase A current
2	I _b , phase B current
3	I _c , phase C current
4	V _{a-n} , phase a-n voltage
5	V _{b-n} , phase b-n voltage
6	V _{c-n} , phase c-n voltage
7	Instrument Power Supplies output voltage
8	Emergency Off Relay contact
9	Equipment power contactor contact
10	Equipment controller power supplies output voltage

- 9.2.9 During all voltage sag tests, the output of the sag generator must be monitored by the DAS system. The magnitude of the DAS monitored sag waveform must be used to determine the magnitude of the actual event since the magnitude may vary from the pre-sag setting on the test equipment.

- 9.2.10 Visually inspect all connections.

- 9.2.11 Remove the lockout/tagout at the sag generator utility power supply branch circuit breaker.

- 9.2.12 Energize the sag generator's utility power source branch circuit.

- 9.2.13 Initialize the sag generator system and set the output for 100% of the DUT nameplate nominal voltage.

- 9.2.14 Using a digital voltmeter, measure and record the phase voltage(s) at the output of the sag generator.

- 9.2.15 Remove lockout/tagout at the DUT POC.

- 9.2.16 Energize the DUT.

- 9.2.17 Bring the DUT on-line in an idle state.

- 9.2.18 Using a digital voltmeter, measure and record the phase voltage(s) at the output of the sag generator. If needed, adjust the output of the sag generator for 100% of the DUT nameplate nominal voltage.

- 9.2.19 Set the sag generator for a 95% of DUT nominal, 10 cycle (200/167 ms) sag voltage on one phase.

- 9.2.20 From the sag generator controller, trigger the sag event.

- 9.2.21 From the DAS, verify that the test sag event is within the specified tolerance.

- 9.2.22 From the DAS, verify that all monitoring points are recording the expected status information.

10 Test Procedure

- 10.1 In order to arrive at meaningful and comparable results from voltage sag immunity testing on semiconductor equipment the following steps should be followed.

- 10.1.1 The test engineer should first study and understand the DUT power flow and safety interlocking systems of the DUT.

- 10.1.2 The test engineer should then determine the purpose of the test (e.g. To characterize the susceptibility of the DUT to voltage sags within a defined duration range and to a defined minimum voltage magnitude).

- 10.1.2.1 The test engineer should define the duration range minimum and maximum over which the test voltage sag should be applied to the DUT (e.g. 0.05 seconds to 1.0 seconds, as described in voltage sag ride-through specification, etc.).

- 10.1.2.2 The test engineer should define the voltage magnitude minimum(s) that should be applied to the DUT over the test duration range (e.g. 0 volts nominal for maximum duration, as described in voltage sag ride-through specification, etc.).

- 10.1.3 The test engineer should define that testing is complete for each phase mode when either an equipment interrupt occurs at the minimum test

duration regardless of the voltage magnitude, or, the test is conducted at the defined minimum voltage magnitude without equipment interrupt.

10.1.4 Based on the knowledge gained in the study of the DUT and the purpose of the test, the test engineer should prepare a specific Test Plan that references this test method with date of issue and includes, at a minimum:

- identify the most sensitive process mode and the process mode(s) to be used during tests
- minimum sag voltage to be applied (e.g. 0%, 50%, etc.)
- sag voltage incremental change not greater than 5% (e.g. 5%)
- maximum sag duration at each sag voltage (e.g. determined by voltage sag ride-through specification, potential for DUT damage, etc.)
- sag test durations (e.g. 0.05, 0.2, 0.5, 1.0 seconds)
- phase modes required (e.g. phase-to-neutral, phase-to-phase)
- point-on-wave of the sags (location on the sine wave where voltage sag begins): if controllable, set at 0°. If not controllable, noted as such.
- data acquisition measurement points (e.g. Table 3).

10.2 The following test procedure should be conducted in both the DUT idle state and the DUT's most sensitive process mode (see Section 8.2).

10.3 The following test procedure should be conducted with the sags applied in each phase mode identified in the Test Plan (see Section 10.1.4).

10.3.1 For single-phase loads, the sags should be applied from phase-to-neutral, for a total of one mode.

10.3.2 For three-phase loads without a neutral conductor, the sags should be applied from phase-to-phase between each pair of phases, for a total of three modes.

10.3.3 For three-phase loads with a neutral conductor, the sags should be applied from phase-to-neutral for each phase, and from phase-to-phase between each pair of phases, for a total of six modes.

10.4 Using a DVM, measure and record the actual test site voltages at the line side of the sag generator, phase-to-neutral (if available) and phase-to-phase (if available).

10.5 Verify that the test setup is complete (see Section 9).

10.6 Set the sag generator to 100% of the DUT nameplate nominal voltage. Cycle through the following test procedure.

10.6.1 Set the sag generator to the next lower sag voltage based on the sag voltage increment determined in the Test Plan, not greater than 5% (see Section 10.1.4).

10.6.2 Set the sag generator to the minimum sag duration for this sag voltage in the Test Plan (see Section 10.1.4).

10.6.3 Trigger the sag event. Record the results, including the magnitude (sag depth) and duration.

NOTE 6: It is advantageous to record additional detail, such as DAS waveforms, if a DUT interruption occurs.

10.6.4 Set the sag generator to the next longer sag duration for this sag voltage in the Test Plan (see Section 10.1.4)

10.6.5 Trigger the sag event. Record the results, including the magnitude (sag depth) and duration.

10.6.6 Repeat Sections 10.6.4 thru 10.6.5 until all durations are complete for this sag voltage magnitude per the Test Plan, then, continue to Section 10.6.7.

10.6.7 Repeat Sections 10.6.1 thru 10.6.6 until all sag voltage magnitudes are complete for this phase mode per the Test Plan, then, continue to Section 10.6.8.

10.6.8 If required, reconfigure the test setup for the next phase mode and repeat Sections 10.6.1 thru 10.6.7 until the test is complete for all phase modes, then, continue to Section 10.6.9.

10.6.9 If required, return the test setup to the original phase mode and repeat Sections 10.6.1 thru 10.6.8 until the test is complete for all process modes (e.g. idle state, most sensitive process mode).

11 Interpretation of Test Results

11.1 The injection of voltage sags into semiconductor equipment can lead to numerous shutdown mechanisms. Typical semiconductor equipment voltage sag shutdown mechanisms include EMO circuitry, instrument and controller power supplies, motion control drives, and voltage monitoring relays.

11.2 The shutdown or dropout of equipment components is best identified when monitored by a DAS that is tightly coupled to the control of the sag generator. Figures 2 and 3 display the shutdown of a power supply during a 55% of nominal 10-cycle (200/167 ms) voltage sag.

11.3 Figure 2 displays the actual voltage sag output from the sag generator and Figure 3 displays the output of the power supply. With the DAS it can be seen that

the power supply output begins to decay 3 cycles (60/50 ms) into the 55% of nominal sag event, causing the DUT to interrupt.

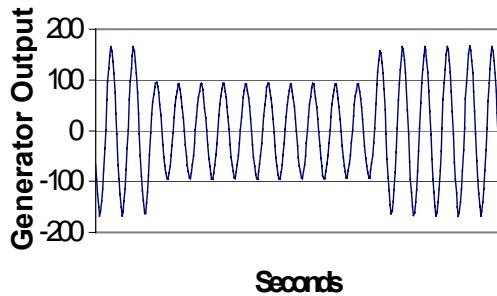


Figure 2
Sag Generator Output

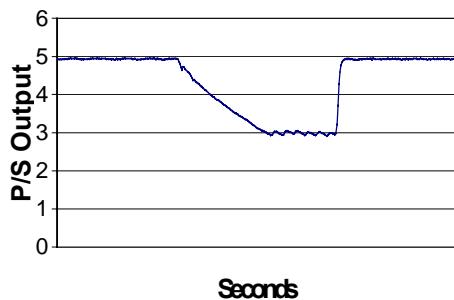


Figure 3
Power Supply Voltage Sag Shut Down Example

12 Reporting Test Results

12.1 Report the specific test plan used and, if used, the voltage sag ride-through specification.

12.2 Report the manufacturer, model number, revision (if known) and process application for the DUT.

12.3 Report the type of sag generator and the accuracy of the test apparatus.

12.4 Report the outcome of the voltage sag testing in both a tabular form (see Tables 4 and 5) and plotted on a graph(s), voltage magnitude (Y axis) and duration (X axis). Separate graphs should be plotted in order to represent the results of the single-phase testing and the phase-to-phase testing. If used, overlay a plot of the voltage sag ride-through specification onto the voltage sag testing outcome graph(s) (see Figures 4 and 5).

12.5 Report the outcome of the sag event including the cause of the DUT interrupt (e.g., EMO relay dropped out, power supply shutdown, etc.).

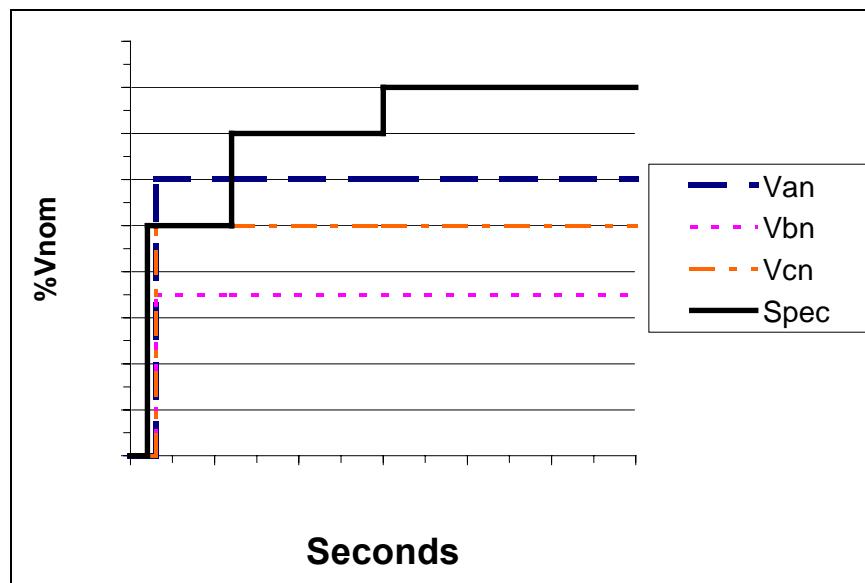
12.6 Report conclusions of voltage sag immunity testing of the DUT (e.g., Key immunity data points, compliance/non-compliance with voltage sag ride-through specification, corrective actions taken, etc.).

Table 4 Example of Test Data Sheet for Characterizing to Voltage Sag Ride-Through Specification Limits

Event	% Va-n	% Vb-n	% Vc-n	DUT Mode (Idle or Processing)	Voltage Sag Duration	Result	
						Actual Time to Interrupt (Seconds)	Comments
1	95	100	100	Processing	0.05	OK	Equipment OK.
2	95	100	100	Processing	0.20	OK	Equipment OK.
3	95	100	100	Processing	0.50	OK	Equipment OK.
4	95	100	100	Processing	1.00	OK	Equipment OK.
5	90	100	100	Processing	0.05	OK	Equipment OK.
6	90	100	100	Processing	0.20	OK	Equipment OK.
7	90	100	100	Processing	0.50	OK	Equipment OK.
8	90	100	100	Processing	1.00	OK	Equipment OK.
↓	↓	↓	↓	↓	↓	↓	↓
34	55	100	100	Processing	0.20	0.16	Equipment Shutdown: EMO Relay CR1 dropout
35	55	100	100	Processing	0.50	INT	No Test - Beyond Interrupt
36	55	100	100	Processing	1.00	INT	No Test - Beyond Interrupt
37	50	100	100	Processing	0.05	OK	Equipment OK.
38	50	100	100	Processing	0.20	0.16	Same result as event 34.
↓	↓	↓	↓	↓	↓	↓	↓
77	100	50	100	Processing	0.05	OK	Equipment OK.
78	100	50	100	Processing	0.20	OK	Equipment OK.
79	100	50	100	Processing	0.50	OK	Equipment OK.
80	100	50	100	Processing	1.00	OK	Equipment OK.
↓	↓	↓	↓	↓	↓	↓	↓
117	100	100	50	Processing	0.05	OK	Equipment OK.
118	100	100	50	Processing	0.20	OK	Equipment OK.
119	100	100	50	Processing	0.50	OK	Equipment OK.
120	100	100	50	Processing	1.00	OK	Equipment OK.

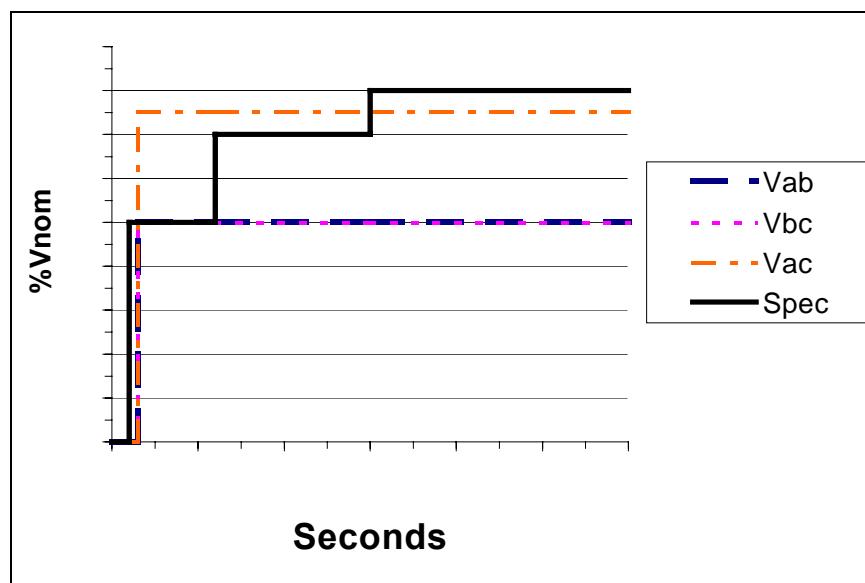
Table 5 Example of Test Data Sheet for Characterizing Equipment Susceptibility to Voltage Sags

Event	% Va-n	% Vb-n	% Vc-n	DUT Mode (Idle or Processing)	Voltage Sag Duration	Result	
						Actual Time to Interrupt (Seconds)	Comments
1	95	100	100	Processing	0.05	OK	Equipment OK.
2	95	100	100	Processing	0.20	OK	Equipment OK.
3	95	100	100	Processing	0.50	OK	Equipment OK.
4	95	100	100	Processing	1.00	OK	Equipment OK.
↓	↓	↓	↓	↓	↓	↓	↓
53	30	100	100	Processing	0.05	OK	Equipment OK.
54	30	100	100	Processing	0.20	0.16	Equipment Shutdown: EMO Relay CR1 dropout
55	30	100	100	Processing	0.50	INT	No Test - Beyond Interrupt
56	30	100	100	Processing	1.00	INT	No Test - Beyond Interrupt
↓	↓	↓	↓	↓	↓	↓	↓
129	100	35	100	Processing	0.20	OK	Equipment OK.
130	100	35	100	Processing	0.50	OK	Equipment OK.
131	100	35	100	Processing	1.00	OK	Equipment OK.
132	100	30	100	Processing	0.05	OK	Equipment OK.
133	100	30	100	Processing	0.20	0.16	Power Supply PS1 dropout
↓	↓	↓	↓	↓	↓	↓	↓
233	100	100	5	Processing	0.05	OK	Equipment OK.
234	100	100	5	Processing	0.20	0.16	Equipment Shutdown: EMO Relay CR1 dropout
235	100	100	5	Processing	0.50	INT	No Test - Beyond Interrupt
236	100	100	5	Processing	1.00	INT	No Test - Beyond Interrupt
237	100	100	0	Processing	0.05	OK	Equipment OK.
238	100	100	0	Processing	0.20	0.16	Same result as event 234.
239	100	100	0	Processing	0.50	INT	No Test - Beyond Interrupt
240	100	100	0	Processing	1.00	INT	No Test - Beyond Interrupt
.	.	.	.				



NOTE: Equipment did not meet standard during A to neutral sag events.

Figure 4
Example of Single-Phase Test Results



NOTE: Equipment did not meet specification during A-C to sag events.

Figure 5
Example of Phase-to-Phase Test Results

13 Related Documents

13.1 IEC Standard²

13.1.1 *IEC 61000-4-11* — Electromagnetic Compatibility (EMC) - Part 4: Testing and Measuring Techniques - Section 11: Voltage Dips, Short Interruptions and Voltage Variations Immunity Tests.

NOTICE: SEMI makes no warranties or representations as to the suitability of the test method set forth herein for any particular application. The determination of the suitability of the test method is solely the responsibility of the user. Users are cautioned to refer to manufacturer's instructions, product labels, product data sheets, and other relevant literature respecting any materials mentioned herein. These test methods are subject to change without notice.

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² International Electrotechnical Commission, 3, rue de Varembé PO Box 131, 1211 Geneva 20 Switzerland

RELATED INFORMATION 1 SAG GENERATORS

NOTE: This related information is not an official part of SEMI F42 and has been derived from the work of the originating task force. This related information was approved for publication by full letter ballot procedures on December 18, 1998. Determination of the suitability of the material is solely the responsibility of the user.

R1-1 Types of Sag Generators

R1-1.1 As defined in the test instrumentation section of IEC-61000-4-11, there are two common types of voltage sag generator devices – variable transformer-switch type and the power amplifier type.

R1-1.2 Both units shown in this section can inject phase-shifting into the output waveform. All units except the contactor based transformer-switch type are capable of some point-on-wave controllability.

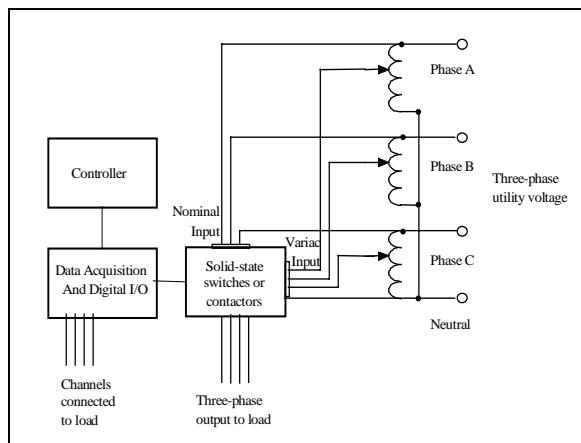


Figure R1-1
Transformer-Switch Type Sag Generator

R1-2 Transformer-Switch Type

R1-2.1 This type of sag generator has been built with either insulated gate bipolar transistor (IGBT), silicon control rectifier (SCR), or contactors used as the switching devices. The IGBT based switch is the most controllable with the ability to precisely control the point on the waveform in which the voltage sag starts and finishes (0-360 degrees). With an SCR switch, the point on wave of the voltage sag starts can be controlled, but the cutoff point of the voltage sag will be fixed at zero degrees. In real power systems, the point-on-wave in which the voltage sag occurs is somewhat random and unpredictable. A contactor based unit simulates the randomness of a real power system in that the point-on-wave in which the voltage sag begins is not controllable, but is dependent on the lag time between energizing the coil of the contactor and contactor closure. Figure R1-1 below displays a

three-phase sag generator test fixture with data acquisition.

R1-2.2 As shown in Figure R1-1, voltage sags are injected into the load referenced to the neutral. Since the three variable transformers shown only need to carry current during the voltage sag, they do not need to be rated for continuous current.

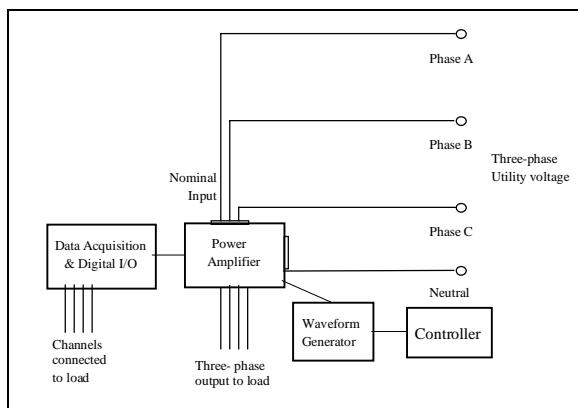


Figure R1-2
Power Amplifier Type Sag Generator

R1-3 Power Amplifier Type

R1-3.1 This type of system utilizes a controller, waveform generator, data acquisition systems, and power amplifier section. Since this type of amplifier can be highly configurable, it can simulate most any point-on-wave or phase-shift desired. The power amplifier-based sag generator will be typically heavier and less portable than its transformer-switch counterpart. A conceptual three-phase version of this type of sag generator test fixture is shown in Figure R1-2.

NOTICE: SEMI makes no warranties or representations as to the suitability of the test method set forth herein for any particular application. The determination of the suitability of the test method is solely the responsibility of the user. Users are cautioned to refer to manufacturer's instructions, product labels, product data sheets, and other relevant literature respecting any materials mentioned herein. These test methods are subject to change without notice.



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SEMI F43-0699

TEST METHOD FOR DETERMINATION OF PARTICLE CONTRIBUTION BY POINT-OF-USE PURIFIERS

This Test Method was technically approved by the Global Facilities Committee and is the direct responsibility of the North American Facilities Committee. Current edition approved by the North American Regional Standards Committee on December 18, 1998. Initially available on www.semi.org February 1999; to be published June 1999.

1 Purpose

1.1 The purpose of this document is to define a method for testing POU purifiers intended for installation into a high-purity gas distribution system and semiconductor manufacturing process equipment. Application of this test method is expected to yield comparable data among POU purifiers tested for the purposes of qualification for its installation.

2 Scope

2.1 This document describes a test method designed to draw comparisons of particulate generation performance of POU purifiers tested under standard conditions. The procedure utilizes a condensation nucleus counter (CNC) applied to in-line gas purifiers typically used in semiconductor applications. It applies to purifiers of various media and up to 5 cm (~ 2 in.) i.d. in size and for room temperature operation. The purifier's rated flow should be in the range of 0-50 standard liter per minute (slpm). For applications of this method to larger purifiers, the testing flow rate should be higher than specified in this method.

2.2 The experimental set up described in this method can be used for testing either POU purifiers or stand-alone POU filters.

3 Limitations

3.1 This procedure addresses total particle count greater than the minimum detection limit (MDL) of the condensation nucleus particle counter and does not consider classifying data into various size ranges.

3.2 This methodology specifies flow and mechanical stress conditions in excess of those considered typical. These conditions shall not exceed those recommended by the manufacturer. Actual performance under normal operating conditions may differ.

3.3 The test medium is limited to nitrogen and argon. Performance with other gases may vary.

3.4 This method does not include extended particle count testing or testing under challenging conditions.

3.5 The accuracy of the data generated by this method is limited to the accuracy of the particle measuring instruments utilized.

3.6 This method is written with the assumption that the operator understands the use of the apparatus at a level equivalent to six months of experience.

4 Referenced Documents

4.1 FED-STD-209. Federal Standard Airborne Particulate Cleanliness Classes in Cleanrooms and Clean Zones. General Services Administration.

5 Terminology

5.1 Acronyms

CNC – condensation nucleus counter

DUT – device under test

EP – electropolished

kPa – kiloPascal

LPC – laser particle counter

POU – point of use

psi – pounds per square inch

psia – pounds per square inch absolute

psid – pounds per square inch differential

psig – pounds per square inch guage

Ra – roughness average

Rmax – roughness maximum

scfm – standard cubic feet per minute

slpm – standard liters per minute

5.2 Definitions

5.2.1 *background counts* — counts contributed by the test apparatus (including counter electrical noise) with the spool piece in place of the test object.

5.2.2 *CNC* — condensation nucleus counter. A light scattering instrument that detects particles in a gaseous stream by condensing supersaturated vapor on the particles.

5.2.3 *control product* — a sample component that gives consistent, stabilized counts at or below the expected counts from the test components. The product is run periodically in accordance with the test protocol to assure that the system is not contributing particles significantly different from expected levels. In the absence of a control product, a spool piece can be used as a control product of low particle emission rate.

NOTE 1: The control product may have to be changed periodically if its performance degrades with testing. Between tests, the control product must be bagged in accordance with the original manufacturer's packaging and stored in a clean manner. The control product is used to allow the system to consider the disruption caused by changes in flow due to the actuation of any valve, such as significant fluctuations in flow, pressure, turbulence, and vibration.

5.2.4 *dynamic test* — a test performed to determine particle contribution as a result of pulsing flow through the DUT.

5.2.5 *impact test* — a test performed to determine particle contribution as a result of mechanical shock applied to the DUT.

5.2.6 *Nine-log retention* — number of particles upstream of the purifier or filter are 1,000,000,000; number of particles down-stream of the purifier or filter is 1.

5.2.7 *sample flow rate* — the volumetric flow rate drawn by the counter for particle detection. The counter may draw higher flow for other purposes (e.g., sheath gas).

5.2.8 *sampling time* — the time increment over which counts are recorded.

5.2.9 *spool piece* — a null component consisting of a straight piece of electropolished tubing and appropriate fittings used in place of the DUT to establish the baseline.

5.2.10 *static test* — a test performed to determine particle contribution under steady flow condition through the DUT.

5.2.11 *test duration* — total time required to complete the test procedure. (See Section 7.3)

5.2.12 *test flow rate* — mass flow through device under test.

5.2.13 *test pressure* — pressure immediately downstream of the test component. (See Figure 1.)

5.2.14 *test temperature* — ambient temperature at which the experiment is being conducted.

6 Safety Precautions

6.1 This test method may involve hazardous materials,

operations, and equipment. This test method does not purport to address the safety considerations associated with its use. It is the responsibility of the user to establish appropriate safety and health practices and determine the applicability of regulatory limitations before using this method.

6.2 Exhaust from the CNC may contain hazardous and/or flammable vapors and should be properly vented.

6.2.1 Only inert gases like nitrogen and argon should be used for purifier testing. **No air is allowed in the purifier testing procedure described in this document.**

6.3 Care should be taken to minimize the purifier's exposure to room air during and after testing.

7 Test Protocol

7.1 Test Conditions

7.1.1 The test is to be conducted at a normal indoor temperature of between 18°C (64°F) and 26°C (78°F). Environmental temperature within this range is not expected to have any measurable effect on particle detection. Follow manufacturer's recommended handling procedures.

7.1.2 Test apparatus must be enclosed in a Class 100 environment (per current revision of Federal Standard 209). If a clean hood is used, the hood should be located within a clean environment. Use procedures necessary to maintain Class 100 when handling test apparatus and test component.

7.1.3 Care should be taken to protect the test apparatus from excessive vibration. For example, vacuum pumps and compressors should be isolated from the system.

7.2 Apparatus

7.2.1 Materials

7.2.1.1 *Test gas* — Nitrogen of minimum dryness of <10 PPM moisture at 790.57 kPa (100psig) with <10 ppm of total hydrocarbons.

7.2.1.2 *Filters* — Electronics grade filters are required to provide "particle-free" test gas. Each filter must be nine-log retentive per manufacturer's specifications to 0.02 µm. The filter must be capable of achieving less than 2 particles ≥ 0.02 µm per cubic foot of test gas under test conditions.

7.2.1.3 *Pressure regulator* — Made of electropolished 316L with an internal surface finish of 0.18 µm (7 µin.) Ra and 0.25 µm (10 µin.) Rmax to maintain system pressure.

7.2.1.4 *Pressure gauge* — made of electropolished 316L stainless steel, with an internal surface finish of 0.18 μm (7 $\mu\text{in.}$) Ra and 0.25 μm (10 $\mu\text{in.}$) Rmax, to monitor system test pressure.

7.2.1.5 *Standard testing flow control device* — Use flow meters with ranges appropriate for testing from 0-50 slpm.

7.2.1.6 *Tubing* — Made of electropolished 316L stainless steel, with an internal surface finish of 0.18 μm (7 $\mu\text{in.}$) Ra and 0.25 μm (10 $\mu\text{in.}$) Rmax.

7.2.1.7 *Sampler* — The sampler is to be constructed according to the drawing and sampler design criteria given in Appendix 1 Sampler Design Criteria. The sampler collects gas from the stream exiting the test device, where the sample is near-isokinetic in design.

7.2.1.8 *Upstream adapter* — The upstream adapter piece connects 12.7 mm (1/2-in.) tubing to the test device. For 12.7 mm (1/2-in.) test devices, the adapter is a simple face-seal connector. For 6.35 mm (1/4-in.) test devices, the adapter is a tapered cone between 6.35 mm and 12.7 mm (1/4- and 1/2-in.) face-seal connections.

7.2.1.9 *Downstream adapter* — The downstream adapter piece connects 12.7 mm (1/2-in.) tubing of the sampler to the test device. For 12.7 mm (1/2-in.) test devices, the adapter is a simple face seal connector. For 6.35 mm (1/4-in.) test devices, the adapter is a tapered cone between 6.35 mm (1/4-in.) and 12.7 mm (1/2-in.) face-seal connections.

7.2.1.10 *Spool Pieces* — Spool pieces shall be the same diameter as the fittings on the test piece and be 15 cm (6 in.) in length. The spool piece is to be installed in the system in place of the DUT while obtaining background counts for the system.

7.2.1.11 *Fittings* — Face seal connectors or compression fittings dependent on test component end connections. The end connection fittings of each DUT being compared must be of the same type.

7.2.1.12 *Gaskets* — Use metal gaskets for attaching the test device and adapter pieces. New gaskets should be used for each new connection. The use of metal gaskets is recommended in order to minimize the particles that may be generated by installation of the test piece. The use of silver plated metal gaskets should be avoided because they shed particles after installation.

7.2.1.13 *Mechanical shock device* — To provide mechanical shock by impact to the test device (see Figure 2).

7.2.1.14 *Actuator* — A gas (compressed air or nitrogen) operated device connected to the valve stem to open and close the valve.

7.2.1.15 *Actuator pressure* — Minimum actuator gas line pressure required to fully open and close the valve during the dynamic test.

7.2.2 *Instrumentation*

7.2.2.1 A CNC whose counting efficiency characteristics fall within the envelope defined in FED STD 209 for counting ultrafine particles is to be used for particle counting. Test durations in this test method have been established based on a sampling flow rate of 0.05 scfm.

7.2.2.2 Instruments should be calibrated regularly, according to manufacturer's recommendations. For the CNC, this includes routine checks of instrument operation as specified by the manufacturer.

7.2.2.3 The CNC and data collection equipment must have power surge suppression.

7.2.3 *Setup and Schematic*

7.2.3.1 Assemble the test apparatus according to the schematic drawing of the test apparatus used shown in Figure 1. Install the test apparatus inside a class 100 clean room. Adjust the inlet gas pressure to the required pressure of 30 psig using the pressure regulator R1 as indicated by an electronics grade pressure gauge P1. The filtered gas flow is then diverted to flow through either of the two flowmeters located downstream of the valve V1.

7.2.3.1.1 The test gas delivered from the flow meters is filtered again by an electronics grade filter F2. The test gas pressure at this point is measured by another electronics grade pressure gauge P2 installed upstream of filter F2. A pneumatic valve PV1 is installed downstream of the filter F2 for obtaining the particle counts for the dynamic test portion (including the background) of the test method. The test gas is filtered once again by another electronics grade filter F3 before it is delivered to the spool piece and the test component.

7.2.3.1.2 Particles released from the spool piece and the test component are measured by a CNC located downstream of these components. A representative sample of the gas flow is sampled by the CNC through an isokinetic sampler located downstream of the test devices. The CNC measures particle concentration every minute, sampling at a flow rate of 0.05 scfm, to provide a continuous measurement of particle counts for the static, dynamic, and impact tests on the test pieces. The particle data can also be collected and stored in a computer using a data acquisition program.

7.2.3.1.3 A schematic drawing of a recommended test apparatus is given in Figure 1. A list of parts used in the construction of the recommended test stand is presented in Table 1. The dimensions of the tubing and

components used for the construction of the recommended test apparatus are given because they have been found to be critical to the proper operation of the test apparatus as required by the specification. Deviations from these dimensions have resulted in some lab facilities not meeting the requirements of the specification.

7.2.3.2 The spool piece is to be installed when the test stand is not in use. A continuous low flow (0.1 scfm) is to be maintained to purge the system. The particle counter may be turned off. For an extended shutdown, the system (excluding the CNC) should be pressurized and capped.

7.2.3.3 After initial construction, the spool piece should be installed and the test apparatus (except the CNC) should be pressurized and tested for leaks in the system. It is recommended that a helium leak detector or a pressure decay method be used to detect leaks in the system. The system should then be cleaned by running a high flow rate of test gas with simultaneous gentle tapping of all components (except the CNC) downstream of the final filter F3. This procedure should be followed by a start-up phase which characterizes system cleanliness by conducting the entire test protocol with the control product installed. This start-up phase should continue and be repeated as necessary until the counts from the control product have stabilized at or below the expected number of counts from the test components.

7.3 Test Procedures

NOTE: Ensure the counter is counting continuously and reporting data every minute. For the duration of the test, the counter should be continuously counting, except where noted in the test protocol.

7.3.1 Background Test

7.3.1.1 Ensure that the spool piece and proper adapters are in place on the test apparatus.

7.3.1.2 *Static Test* — Close the pneumatic valve (PV1). Set regulator R1 to 30 psig. Open the pneumatic valve (PV1) to establish flow. Using the flow control device, set the test flow to manufacturer's recommended maximum flow. Measure the static background count. Background count is established when the counter has sampled a minimum of 3 scf, and the arithmetic average during the last 3 scf of gas sampled is <2 particles/scf. At a sample flow rate of 0.05 scfm, the time required is one hour. Ensure that the background counts are stable or decreasing. If background cannot be achieved after 6 scf have been sampled, there may be a problem with the counter or test apparatus.

7.3.1.3 *Dynamic Test* — Set the actuator pressure of PV1 to its minimum pressure recommended by the manufacturer to fully open the valve. Actuate the pneumatic valve PV1 at 30 cycles per minute to measure the background counts under dynamic test conditions. Dynamic background count is established when the counter has sampled a minimum of 3 scf, and the arithmetic average during the last 3 scf of gas sampled is < 3 particles/scf. (Estimated dynamic background count will be verified and altered if necessary during the validation phase of this test method.) At a sample flow rate of 0.05 scfm, the time required is 1 hour. If dynamic background cannot be achieved after 6 scf have been sampled, there may be a problem with the counter or test apparatus.

7.3.1.4 Stop the pneumatic valve cycling. Flush the system for 10 minutes under static test conditions.

7.3.1.5 *Purifier Impact Test* — Impact the spool piece once per minute for ten minutes with the mechanical shock device (See Figure 2). The impact background count should be <4 particles/scf over the ten minutes of the test. (Estimated impact background count will be verified and altered if necessary during the validation phase of this test method.) If impact background cannot be achieved, repeat the shock a second time. If the impact background count specification still cannot be met, there may be a problem with the counter or test apparatus.

7.3.1.6 Flush the system for 30 minutes at the test flow rate. Record the resulting count.

7.3.1.7 Turn the CNC pump off while leaving the CNC power on.

7.3.2 Purifier Static Test

7.3.2.1 Using the flow control device, decrease the flow rate to 0.1–0.2 scfm, so that some flow remains in the system while the test purifier is installed.

7.3.2.2 Remove the spool piece by first disconnecting the downstream fitting and then the upstream fitting. Immediately install the test component in a fully open position by first connecting the upstream fitting and then the downstream fitting. Removal of the spool piece and installation of the test component to minimize reactions of the purifier with room air and extraneous contamination and prevent the counter from cooling off should take no longer than 3 minutes. Extreme care should be taken to minimize contamination of the test apparatus during this operation. The test component is to be removed from its inner bag in the Class 100 test area. If the test component has mechanical fittings, these fittings are to be properly connected. If the test component has tube ends, the component is to be installed with clean compression fittings. Do not

permanently crimp any ferrules onto the tube stubs. Nylon ferrules are acceptable.

7.3.2.3 Using the flow control device, set the test flow to manufacturer's recommended maximum flow.

7.3.2.4 Turn on the counter pump and conduct the static test. The purifier is to be tested with the valve PV1 in the fully open position until 85 standard liters (3 scf) of gas have been sampled. Cumulative data should be recorded at one-minute intervals.

7.3.3 Purifier Dynamic Test

7.3.3.1 This test is to immediately follow the static test. To conduct the dynamic test, set the actuator pressure of the actuator attached to valve PV1 to its minimum actuator pressure as recommended by the manufacturer to fully open the valve. Actuate valve PV1 at the rate of 30 cycles/minute for 60 minutes. A cycle consists of off *and* on actuation of the valve. The off and on cycles should be of equal duration.

7.3.4 Purifier Impact Test

7.3.4.1 This test is to immediately follow the dynamic test. Maintain the test flow rate for 10 minutes, with the valve PV1 in the fully open position. Impact the purifier once a minute for 10 minutes, using the mechanical shock device. Purge the test component by maintaining the test flow rate for 30 minutes.

7.3.5 Turn the counter pump off and then decrease the test gas flow rate to ~ 5 slpm.

7.3.6 Remove the test purifier by first disconnecting the downstream fitting and then the upstream fitting, and immediately install the spool piece by connecting the upstream fitting followed by the downstream fitting. The removed purifier should be immediately valved off or capped to prevent its exposure to room air.

7.4 Data Presentation

7.4.1 The following test conditions are to be reported in the data presentation:

- Date and time of test
- Operator
- Test flow rate (scfm)
- Test pressure (psig)
- Test temperature (°C)
- Purifier type, manufacturer, serial number, lot number, and model number
- CNC manufacturer, serial number, sample flow rate (scfm), model number, and calibration date
- Test gas type and dew point (°C)

- A schematic of the test apparatus, including manufacturer's and model numbers of all test apparatus components
- Calibration dates for the flow meters and the test date

7.4.2 Graph the static, dynamic and impact portions of the test separately as counts/minute (measured by the counter) versus time, including the appropriate background (measured with the spool piece in place) with each. Also graph the entire data set as counts per minute versus time. If different filters are to be compared, graph their entire data sets together.

7.4.3 Present the entire raw data set in tabular form.

8 Related Documents

8.1 The appropriate particle counter manufacturer's operating and maintenance manuals should be consulted when using this test method.

8.2 On particle counter efficiencies: Agarwal, J. K. and Sem, G. J. "Continuous Flow, Single Particle Counting Condensation Nucleus Counter." *Journal of Aerosol Science*, v.11.4. July 1980:343–357.

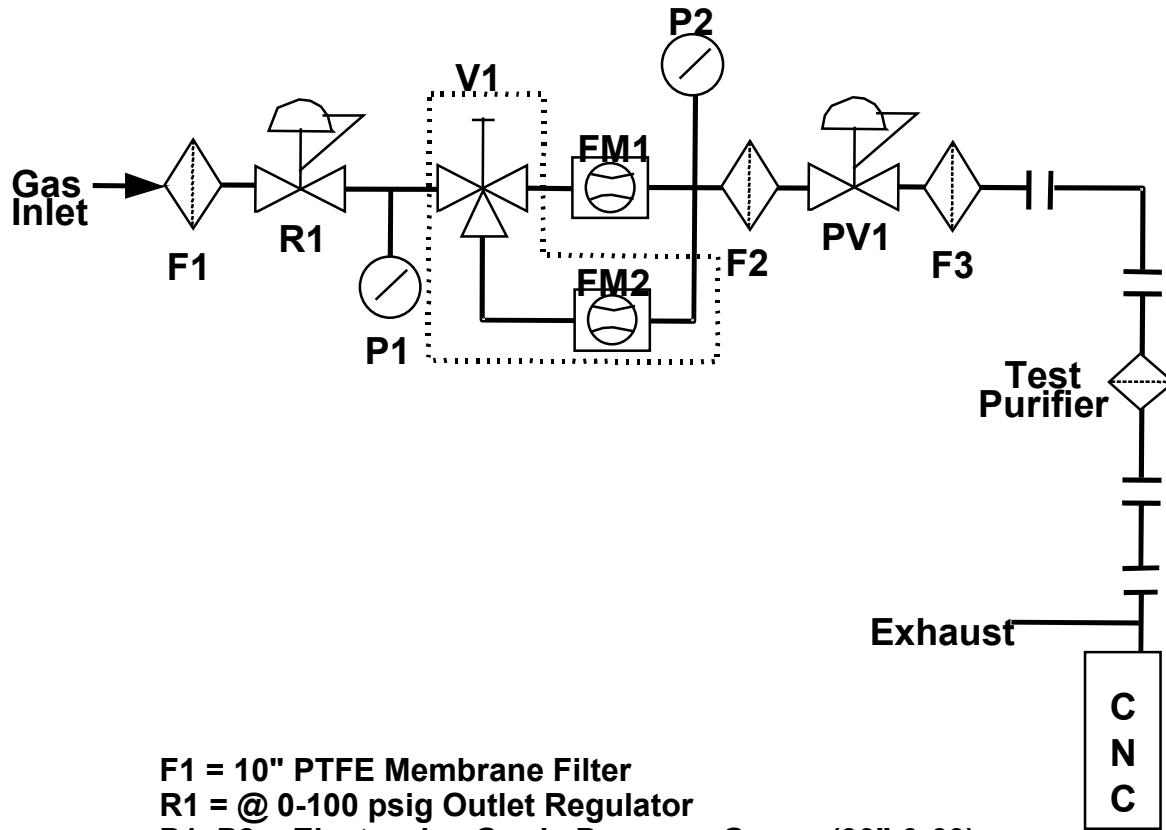
8.3 On flow calculations: D. E. Dickie, ed. *Crane Handbook*. Construction Safety Association of Toronto. Ontario, Canada. 1975.

8.4 Statistical reference: Van Slooten, R. A., "Statistical Treatment of Particle Counts in Clean Gases." *Microcontamination*, v.4.2. Feb. 1986:32–38.

8.5 Hinds, W. C. *Aerosol Technology: Properties, Behavior, and Measurement of Airborne Particles*. John Wiley & Sons. 1982:187–194.

8.6 Fissan, H. and Schwientek. "Sampling and Transport of Aerosols." *TSI Journal of Particle Instrumentation*, v.2.2. July–December 1987:3–10.

8.7 SEMI F1-96, Specification for Leak Integrity of High Purity Gas Piping Systems and Components.



F1 = 10" PTFE Membrane Filter
R1 = @ 0-100 psig Outlet Regulator
P1, P2 = Electronics Grade Pressure Gauge (30"-0-60)
V1 = Three-Way Valve
FM1 = Low Flow (0-2 scfm) Flowmeter
FM2 = High Flow (0-20 scfm) Flowmeter
F2, F3 = Electronics Grade Filter
PV1 = Electronics Grade Pneumatic Valve

Figure 1
Schematic of Particle Test Loop

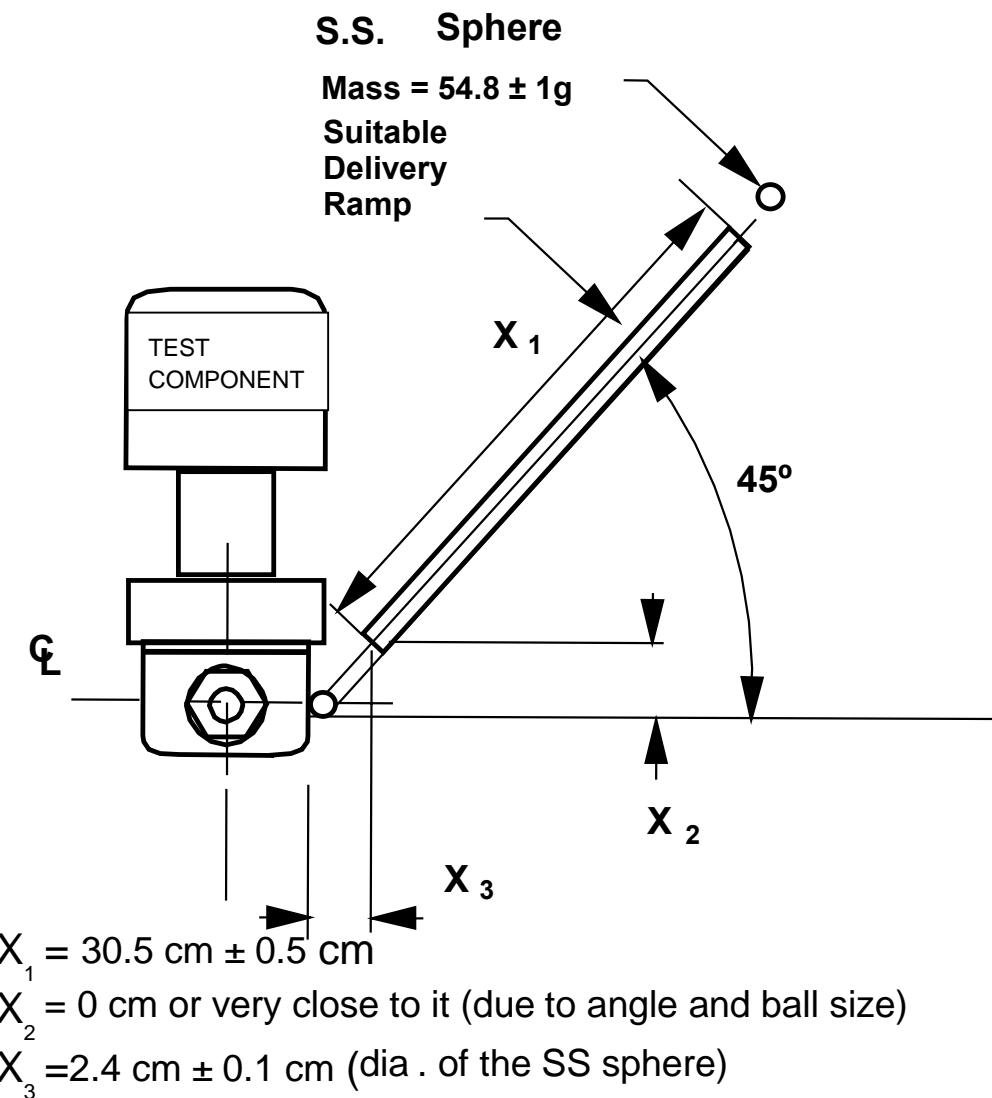


Figure 2
Mechanical Shock Device

NOTE 1: X3 will change with a change on sphere size.

NOTE 2: Position the delivery ramp so that the position of impact is at the midpoint of the axial centerline of the device under test.

Table 1 Parts List for the Recommended Particle Test Apparatus

Item number	Description
1	1/4 in. diameter electropolished (EP) SS tube
2	1/4 in. to 1/2 in. tube reducing union
3	1/2 in. diameter EP SS tube
4	PTFE membrane filter with 3/8 in. face seal
5	Pressure regulator, 0-300 inlet pressure, 0-100 outlet pressure
6	1/2 in. butt weld tee
7	1/2 in. tube to 3/8 in. NPT female connector
8	0-60 psig electronics grade pressure gauge
9	1/2 in. to 1/2 in. union
10	1/2 in. 3-way SS ball valve
11	1/4 in. tube to 1/2 in. port reducer
12	0.2-2 std ft ³ flowmeter
13	1-15 std ft ³ flowmeter
14	1/2 in. SS union
15	1/2 in. dia, 3-ft flexible SS tube
16	1/2 in. union elbow
17	1/2 in. pneumatic valve
18	1/2 in. to 1/4 in. SS reducer gland
19	Test component
20	3-way normally closed solenoid air valve
21	Solenoid valve cycle controller
22	1/2 in. welded tee
23	1 1/2 in. dia., 4-ft long exhaust tube
24	1/2 in. tube to 1/4 in. NPT adapter
25	1/8 in. dia., 17 in. long SS sample tube
26	1/4 in. to 1/8 in. reducer union
27	1/4 in. dia., 30 in. long SS sample loop
28	1/4 in. to 3/8 in. reducer union
29	Condensation Nucleus Counter

APPENDIX 1

SAMPLER DESIGN CRITERIA

A-1.1 The average velocity of gas flowing through the sampler should approximate the average velocity in the tubing in which the sampler is inserted. The sample flow rate used to calculate the sampler diameter is the total flow drawn by the counter.

A-1.2 Gradual expansion to atmospheric pressure is recommended for sampling. Critical orifice expansion may alter the particle level of the sample.

A-1.3 The tip of the sampling probe should have a 30 degree taper on the outside diameter.

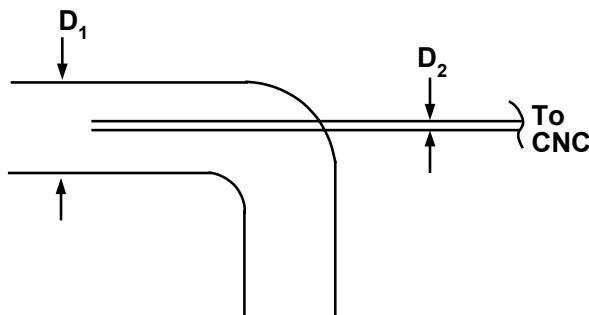
A-1.4 The pick-off point should be approximately centered within the flow stream.

A-1.5 The pick-off point should be approximately 15 diameters of the primary flow tube upstream or downstream of any connection.

A-1.6 There should be enough volume in the exhaust portion of the sampler to supply the CNC for one minute. This volume represents 60 times the volume that will be drawn by the CNC while the valve is closed during the dynamic testing. Minimum sample flow through the CNC is 5 slpm.

A-1.7 State the minimum volume after the probe or generate a sample blank using the stated volume until background counts are reached.

Under static flow conditions, the sampler size is within 50% of the size required to achieve isokinetic sampling. For particles of interest <0.5 um, Hinds¹ and Fissan² indicate that any unlikely isokinetic sampling biases are significant. During dynamic testing, isokinetic sampling is compromised regardless of the sample tube size.



Isokinetic Sampler Calculation

To establish isokinetic sampling condition:

$$V_1 = V_2$$

$$Q = AV \text{ or } V = Q/A$$

$$\text{so } Q_1/A_1 = Q_2/A_2$$

$$\text{therefore, } A_2 = A_1 (Q_2/Q_1) \text{ or } D_2 = D_1 (Q_2/Q_1)^{1/2}$$

where:

Q = flow rate (volumetric)

A = area (internal cross section)

V = velocity (average)

D = diameter (internal)

subscripts:

1 = main flow line

2 = sample flow line

If pressure correction at point of flow control device is needed, then:

$$Q_s = [(P + 14.7)/14.7]^{1/2} \times Q_A$$

where:

Q_A = actual flow rate

Q_s = standard flow rate

P = pressure, psig

Temperature variances are assumed to be negligible.

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SEMI F44-0699

GUIDELINE FOR STANDARDIZATION OF MACHINED STAINLESS STEEL WELD FITTINGS

This guideline was technically approved by the Global Facilities Committee and is the direct responsibility of the Japanese Facilities Committee. Current edition approved by the Japanese Regional Standards Committee on March 17, 1999. Initially available on www.semi.org May 1999; to be published June 1999.

1 Purpose

1.1 The purpose of this guideline is to prevent confusion among the manufacturers of stainless steel weld fittings, piping fabricators and end users and to standardize the dimensions of weld fittings.

2 Scope

2.1 This guideline applies to 6.35 mm (1/4in.), 9.53 mm (3/8in.) and 12.7 mm (1/2in.); the machined stainless steel weld fittings elbows and tees made for use in the semiconductor industry.

3 Referenced Documents

3.1 None.

4 Terminology

4.1 *elbow weld fittings* — machined fittings shaped like the letter "L", for welding tubes in a right angle. (see Figure 1)

4.2 *tee weld fittings* — machined fittings shaped like the letter "T", for welding tubes in a T-shape. (see Figure 2)

4.3 *weld fittings* — machined fittings to be welded or welded fittings.

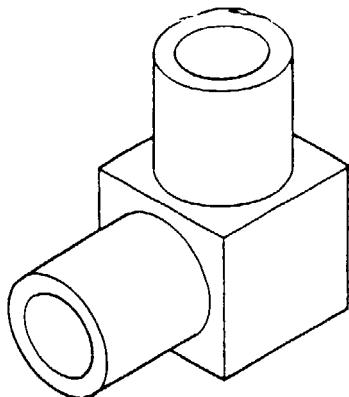


Figure 1
Elbow Weld Fittings

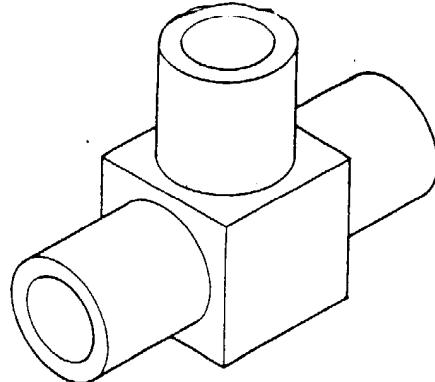


Figure 2
Tee Weld Fittings

5 Dimensions of Weld Fittings

5.1 *Elbow Weld Fittings* (see Figures 3A and 3B)

5.2 *Tee Weld Fittings* (see Figures 4A and 4B)

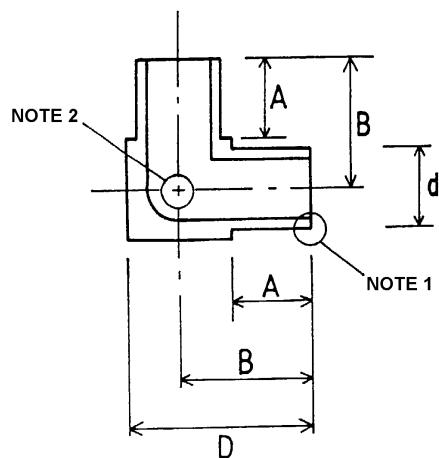


Figure 3A
Dimensions of Elbow Weld Fittings

NOTE 1: Machined tube weld ends shall be square tolerance $\pm 0.5^\circ$.

NOTE 2: Intersection shall be square tolerance $\pm 0.5^\circ$.

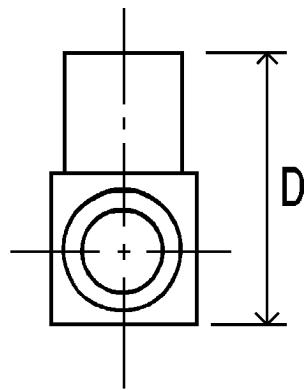


Figure 3B
Dimensions of Elbow Weld Fittings

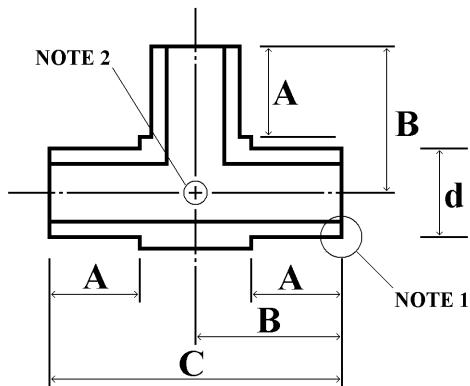


Figure 4A
Dimensions of Tee Weld Fittings

NOTE 1: Machined tube weld ends shall be square tolerance $\pm 0.5^\circ$.

NOTE 2: Intersection shall be square tolerance $\pm 0.5^\circ$.

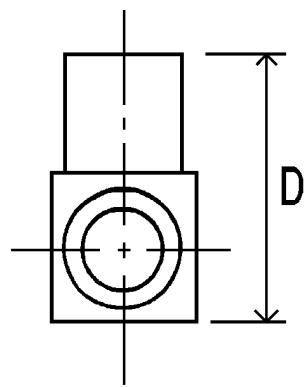


Figure 4B
Dimensions of Tee Weld Fittings

6 Marking The Weld Fittings

6.1 Marks include 1), 2), 3), 4), 5), 6) and 7). Marks 1) through 4) shall be made on the weld fittings body. Marks 5) - 7) shall be made on weld fittings body or its package (both individual bagging and box).

- 1) Manufacturer's name
- 2) Material designator
- 3) Surface finish designator
- 4) Heat Number (optional)
- 5) Lot Number
- 6) Model (Part Number)
- 7) Wall thickness of tube end

6.2 To be agreed upon between supplier and user for marking items and marking locations. The example below explains marking applications. (see Figures 5A and 5B)

6.3 Manufacturer's name, Material designator, Surface finish designator and Heat Number should be marked on the body. The Heat Number shall be marked either on the body of the cube along with the other information, but if space is limited, then the Heat Number marked on the tube Outside Diameter close to the body block is permissible.

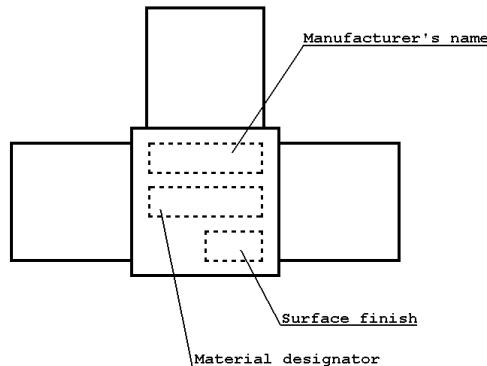


Figure 5A
Marking Application Example

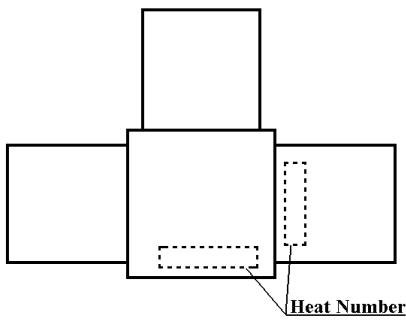


Figure 5B
Marking Application Example

7 Outside Diameter Tolerance

7.1 The Outside Diameter tolerance of 6.35 mm (1/4 in.), 9.53 mm (3/8 in.) and 12.7 mm (1/2 in.) is + 0.1 mm, - 0.0 mm (+ 0.004 in., - 0.000 in.).

8 Wall Thickness of Tube End

8.1 Wall thickness of tube end should be either 1 mm (0.039 in.) or 0.89 mm (0.035 in.), 1.24 mm (0.049 in.) and the thickness should be marked on the weld fitting body or its package. Wall thickness tolerance is $\pm 8\%$.

Table 1 Dimensions and Tolerance

Nominal Diameter	<i>d</i>	A	B	C	D
6.35 (1/4)	6.35 (0.25)	$6.35 + 0.1 / - 0.05$ $(0.25 + 0.004 / - 0.002)$	10.3 ± 0.1 (0.4055 ± 0.004)	20.6 ± 0.1 (0.811 ± 0.004)	14.25 ± 0.1 (0.561 ± 0.004)
9.53 (3/8)	9.53 (0.375)	$6.35 + 0.1 / - 0.05$ $(0.25 + 0.004 / - 0.002)$	11.9 ± 0.1 (0.4685 ± 0.004)	23.8 ± 0.1 (0.937 ± 0.004)	17.45 ± 0.1 (0.687 ± 0.004)
12.7 (1/2)	12.7 (0.5)	$6.35 + 0.1 / - 0.05$ $(0.25 + 0.004 / - 0.002)$	13.5 ± 0.1 (0.5315 ± 0.004)	27.0 ± 0.1 (1.063 ± 0.004)	20.65 ± 0.1 (0.813 ± 0.004)

Dimensions : mm (in.)

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SEMI F45-0699

GUIDELINE FOR STANDARDIZATION OF MACHINED STAINLESS STEEL REDUCING WELD FITTINGS

This guideline was technically approved by the Global Facilities Committee and is the direct responsibility of the Japanese Facilities Committee. Current edition approved by the Japanese Regional Standards Committee on March 17, 1999. Initially available on www.semi.org May 1999; to be published June 1999.

1 Purpose

1.1 The purpose of this guideline is to prevent confusion among the manufacturers of stainless steel reducing weld fittings, piping fabricators and end users and to standardize the dimensions of weld fittings.

2 Scope

2.1 This guideline applies to 6.35 mm (1/4 in.), 9.53 mm (3/8 in.) and 12.7 mm (1/2 in.); the machined stainless steel reducing weld fittings elbows and tees made for use in the semiconductor industry.

3 Referenced Documents

3.1 None.

4 Terminology

4.1 *reducing elbow weld fittings* — machined fittings shaped like the letter "L", for welding tubes in a right angle. (see Figure 1)

4.2 *reducing tee weld fittings* — machined fittings shaped like the letter "T", for welding tubes in a T-shape. (see Figure 2)

4.3 *reducing weld fittings* — machined fittings to be welded or welded fittings.

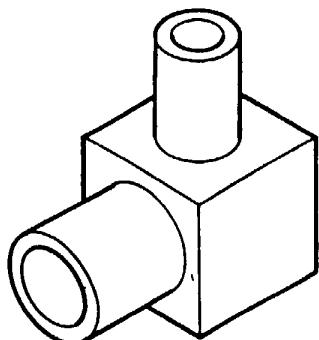


Figure 1
Reducing Elbow Weld Fittings

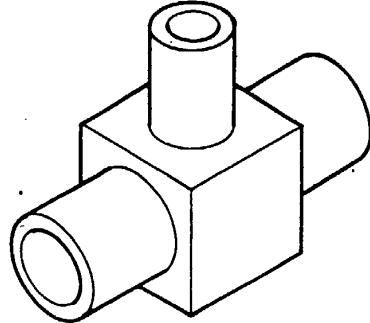


Figure 2
Reducing Tee Weld Fittings

5 Dimensions of Reducing Weld Fittings

5.1 *Reducing Elbow Weld Fittings* (see Figures 3A and 3B)

5.2 *Reducing Tee Weld Fittings* (see Figures 4A and 4B)

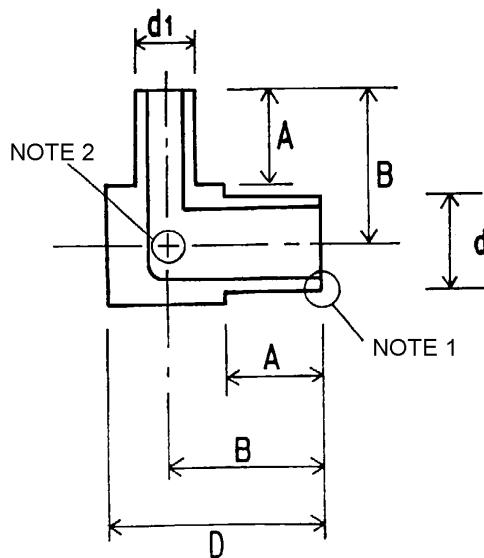


Figure 3A
Dimensions of Reducing Elbow Weld Fittings

NOTE 1: Machined tube weld ends shall be square tolerance $\pm 0.5^\circ$.

NOTE 2: Intersection shall be square tolerance $\pm 0.5^\circ$.

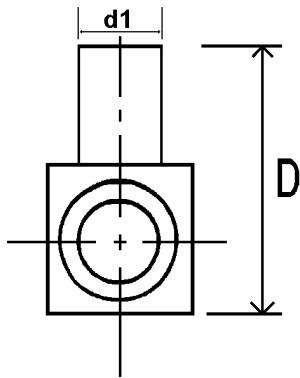


Figure 3B
Dimensions of Reducing Elbow Weld Fittings

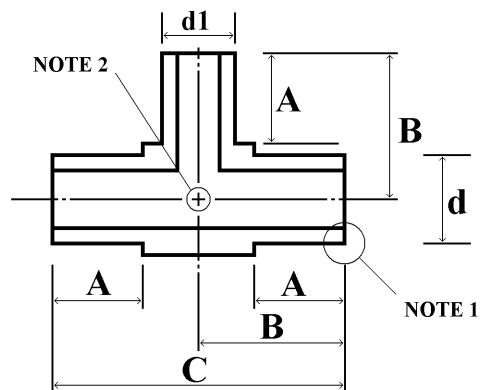


Figure 4A
Dimensions of Reducing Tee Weld Fittings

NOTE 1: Machined tube weld ends shall be square tolerance $\pm 0.5^\circ$.

NOTE 2: Intersection shall be square tolerance $\pm 0.5^\circ$.

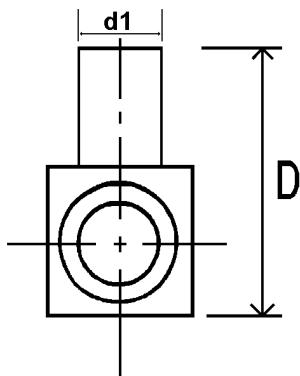


Figure 4B
Dimensions of Reducing Tee Weld Fittings

6 Marking the Reducing Weld Fittings

6.1 Marks include 1), 2), 3), 4), 5), 6) and 7). Marks 1) through 4) shall be made on the reducing weld fittings body. Marks 5) - 7) shall be made on the reducing weld fittings body or its package (both individual bagging and box).

- 1) Manufacturer's name
- 2) Material designator
- 3) Surface finish designator
- 4) Heat Number
- 5) Lot Number (optional)
- 6) Model (Part Number)
- 7) Wall thickness of tube end

6.2 To be agreed upon between supplier and user for marking items and marking locations. The example below explains marking applications. (see Figures 5A and 5B)

6.3 Manufacturer's name, Material designator, Surface finish designator and Heat Number should be marked on the body. The Heat Number shall be marked either on the body of the cube along with the other information, but if space is limited, then the Heat Number marked on the tube Outside Diameter close to the body is permissible.

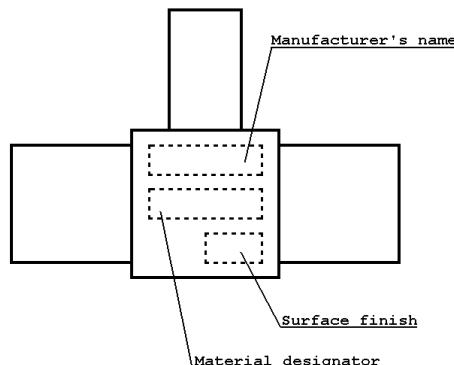


Figure 5A
Marking Application Example

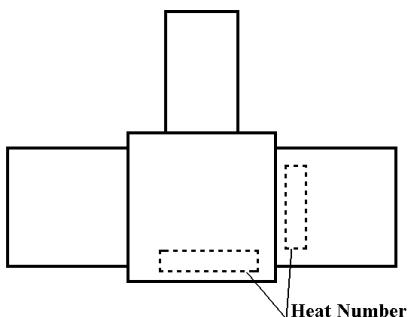


Figure 5B
Marking Application Example

7 Outside Diameter Tolerance

7.1 The Outside Diameter tolerance of 6.35 mm (1/4 in.), 9.53 mm (3/8 in.) and 12.7 mm (1/2 in.) is + 0.1 mm, - 0.0 mm (+ 0.004 in., - 0.000 in.).

8 Wall Thickness of Tube End

8.1 Wall thickness of tube end should be either 1 mm (0.039 inch) or 0.89 mm (0.035 inch), 1.24 mm (0.049 inch) and the thickness should be marked on the reducing weld fitting body or its package. Wall thickness tolerance is $\pm 8\%$.

Table 1 Dimensions and Tolerance

Nominal Diameter	<i>d</i>	<i>d1</i>	A	B	C	D
9.53 × 6.35 (3/8 × 1/4)	9.53 (0.375)	6.35 (0.25)	6.35 + 0.1 / - 0.05 (0.25 + 0.004 / - 0.002)	11.9 ± 0.1 (0.4685 ± 0.004)	23.8 ± 0.1 (0.937 ± 0.004)	17.45 ± 0.1 (0.687 ± 0.004)
12.7 × 6.35 (1/2 × 1/4)	12.7 (0.5)	6.35 (0.25)	6.35 + 0.1 / - 0.05 (0.25 + 0.004 / - 0.002)	13.5 ± 0.1 (0.5315 ± 0.004)	27.0 ± 0.1 (1.063 ± 0.004)	20.65 ± 0.1 (0.813 ± 0.004)
12.7 × 9.53 (1/2 × 3/8)	12.7 (0.5)	9.53 (0.375)	6.35 + 0.1 / - 0.05 (0.25 + 0.004 / - 0.002)	13.5 ± 0.1 (0.5315 ± 0.004)	27.0 ± 0.1 (1.063 ± 0.004)	20.65 ± 0.1 (0.813 ± 0.004)

Dimensions: mm (in.)

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SEMI F46-0999

GUIDE FOR ON-SITE CHEMICAL GENERATION (OSCG) SYSTEMS

This guide was technically approved by the Global Facilities Committee and is the direct responsibility of the North American Facilities Committee. Current edition approved by the North American Regional Standards Committee on April 15, 1999. Initially available on www.semi.org August 1999; to be published September 1999.

1 Purpose

1.1 This guide establishes the minimum System and Overall Implementation requirements for requirement of On-Site Chemical Generation (OSCG) used in semiconductor manufacturing. It is also intended to establish a common basis for developing detailed guides in subsequent documents concerning design, performance, and certification of OSCG systems.

2 Scope

2.1 This guide applies to the OSCG system design used for the generation of chemicals, particularly ultra high purity, used in the silicon wafer, integrated circuit, and/or substrate manufacturing processes. These will include, but are not limited to, various concentrations of NH₄OH, HCl, HF, and NH₄F aqueous solutions.

2.2 This standard does not purport to address all of the safety issues associated with its use. It is the responsibility of the users of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

3 Limitations

3.1 This guide is not intended to cover all chemicals used in these processes but only to those that can be generated, on-site, by means of reacting ultra-pure process gas with the appropriate liquid solution.

3.2 This guide is not intended to be applicable to "Point-of Use" generated process solutions.

3.3 This guide excludes construction protocols for OSCG such as clean manufacturing, integrity of fabrication, and prequalification of materials.

3.4 This guide does not intend to cover all the important safety considerations which relate to the OSCG systems, feed gas, equipment, or installations.

4 Referenced Standards

4.1 SEMI Standard

SEMI S2 — Safety Guidelines for Semiconductor Manufacturing Equipment

NOTE: As listed or revised, all documents cited shall be the latest publications of adopted standards.

5 Terminology

blending (or dilution) — the combination of two or more chemicals (one of which may be DI water) to create the desired solution mixture.

clean sampling — a specifically designed scheme to allow for the taking of chemical samples, avoiding any contamination from the operator or background environment of the area.

day tank — a chemical storage vessel, of appropriate material(s), used to store a volume of product chemical that could be consumed in one or more days.

DI water — high purity 18 megohm water

OSCG system — the stand-alone unit that produces (or uses) a high purity gas and reacts it with water (or the appropriate aqueous solution) to produce the desired ultra pure chemical solution. This unit is intended for use on the manufacturing site and in a centralized scheme to support all or a portion of the site's chemical requirement(s).

overall implementation — this term is used to refer to the entire scope for an OSCG installation, including the Gas Storage/Supply system, the OSCG system, chemical storage tanks, chemical plumbing, and interface with the chemical distribution system. Gas supplies are covered in related guides.

process plumbing — tubing or piping whose surface is directly in contact with the chemical. Typically constructed from high purity perfluorinated materials or other high purity polymers.

product chemical — the name given to the actual chemical produced on site by the OSCG system.

pump — a mechanical or pneumatically operated device used to create hydraulic force for chemical transfer.

QC tank — storage tank for the staging of chemical to be quality verified prior to release to the Product storage tank. This optional quality verification scheme allows for 100% chemical verification.

secondary containment — pipe or tubing that contains the process plumbing intended to provide a second level of containment in the event of failure of the primary

process plumbing. Clear PVC pipe is typically, but not exclusively, used for the secondary containment.

SPC scheme — an alternate quality verification scheme that would involve random sampling and analysis of product chemical. This scheme relies on Statistical Process Control to monitor and ensure product chemical quality.

6 General Requirements

6.1 Materials — Only specific materials are permitted to be in direct contact with the gas(es) and/or chemical(s) used or produced in the OSCG system. This is driven by both chemical compatibility to ensure long term system survivability and product chemical purity.

6.1.1 Cabinet Construction — Polypropylene or other suitable materials house chemical handling components (pumps, valves, filters, etc). All cabinets must be designed to be leak tight and provide a minimum of 110% liquid containment within the cabinet.

6.1.2 Process Plumbing and Components — Polymeric materials are recommended for all plumbing and components that will be in direct, routine contact with the chemical solutions.

6.1.3 Feed Gas Plumbing and Components — Feed Gas, prior to purification (when gas purification is part of the OSCG system), will be plumbed using compatible materials such as stainless steel.

6.1.4 Storage Tanks — Liner materials used in chemical storage tanks that will be in direct contact with the chemical solution will be chosen to maintain chemical purity.

6.2 Overall System Installation

6.2.1 All OSCG systems, support equipment, process plumbing, and tanks will be installed and facilitated according to vendor guide which ensures mechanical integrity, leak integrity, minimal contamination, and overall proper operation.

6.2.2 All OSCG implementations will require the following basic components: Feed Gas Storage and Delivery Subsystem, the OSCG system(s), some type of Quality Control Scheme with “Clean Sampling” provisions, Product Chemical Storage with a suitable volume of Product storage, and, optionally, a Back-up Chemical scheme.

6.2.3 Prior to any introduction of chemical to any system or subsystem, a complete water test is performed to verify leak integrity. This process will also be used to provide the initial clean-up of all systems, tanks, and process plumbing.

6.2.4 The protocol for the installation and start-up of

all systems and subsystems follows a predefined procedure and timeline which incorporates all of the physical activities, testing parameters, and check points for approval at each stage.

6.2.5 Cleanroom environment is not necessary.

6.3 Initial System Qualification — The following general procedure will be required for the initial mechanical and chemical qualification of the OSCG installation.

6.3.1 Electro-mechanical check-out

6.3.2 Initial chemical charge

6.3.3 Initial processing to fill and purge all systems, plumbing, and tanks with chemical.

6.3.4 Initial sampling to verify purity and assay.

6.3.5 Continuous processing to prove purity and capacity through a specific number of samples.

6.3.6 Continuous processing to establish overall system reliability.

7 Basic Design Specifications

7.1 General — Each OSCG installation contains certain basic components and a variety of design options to meet a specific customer’s needs. This section describes the basic installation requirements.

7.2 Feed Gas Storage — All OSCG implementation will require an appropriately sized Feed Gas storage vessel.

7.2.1 The Feed Gas Storage vessel should be of sufficient volume per customer, vendor, and logistical considerations.

7.2.2 The gas delivery system must be designed to deliver sufficient gas flowrates at the correct pressure to the OSCG system.

7.2.3 The appropriate containment and controls are required to ensure safe and reliable operation.

7.3 Gas Supply Plumbing — Gas supply plumbing will be required to bring Feed gas from the storage vessel to the OSCG system.

7.3.1 Materials used for the gas supply plumbing will be chosen based on compatibility with the specific feed gas.

7.3.2 Supply plumbing size will be chosen based on the flow requirements and delivery distance to ensure adequate supply volume and pressure at the OSCG system.

7.3.3 Secondary containment may be required based on the Feed gas, delivery plumbing routing, and local

and/or company codes.

7.3.4 An appropriate component design must be used for the gas/liquid interface(s).

7.4 *The OSCG System* — The appropriate OSCG system will be defined based on overall capacity requirements.

7.4.1 The OSCG system can provide feed gas purification and chemical generation within a stand alone packaged unit or use externally purified feed gases. Optional Feed gas purification may also be provided in this package.

7.4.2 The OSCG system will have a dedicated control system to control all process parameters and monitor all system safety interlocks including external safety systems.

7.4.3 The OSCG will provide pressurized chemical to the Product Quality verification subsystem.

7.5 *Product Quality Verification* — All OSCG installation will include some type of Product sampling and quality verification scheme.

7.5.1 The standard quality verification scheme will provide for an in-line, "Clean Sample" station to allow for random samples to be taken for analysis.

7.5.2 A SPC quality assurance scheme can be utilized to track and record product chemical purity and assay guides. Readings are plotted using X-bar/R format and reacted to based on standard SPC rules.

7.5.3 In this scheme product chemical is transferred to the Product storage tank directly from the OSCG system, through the sampling subsystem or directly to chemical delivery systems.

7.6 *Product Storage* — All OSCG implementation will include a Product chemical storage scheme to ensure chemical availability to the customer.

7.6.1 Product storage is achieved, typically, by including an appropriately sized storage tank. This tank becomes the source to the chemical distribution system.

7.6.2 Product storage volume is defined to provide suitable inventory of product chemical storage. This will provide chemical available to the distribution system during periods of both scheduled and unscheduled maintenance.

7.6.3 Additionally, a back-up supply of prequalified chemical may be available to transfer into the Product tank, if required.

7.7 *Central Monitoring System* — A central CPU based monitoring system is required for multiple purposes in the overall implementation.

7.7.1 The central CPU will communicate with all subsystems and tanks to share information, as required, to ensure total system operations.

7.7.2 The central CPU also provides data logging and database features to track and log product quality and system failure data as required.

7.7.3 The central CPU can also provide a remote monitoring feature and interface with the customer's facility tracking system (if desired).

8 Optional Configurations and Support Systems

8.1 *Feed Gas Supply* — Some customers may already have an existing source of an appropriate Feed gas for the OSCG system. Implementation schemes can be configured to utilize this existing gas storage and supply system. The existing system will need to meet the vendors guides for gas purity and line pressures.

8.2 *Product Storage and Staging Tanks* — Some customers may already have tanks that can be used for Product Storage and/or staging applications. Implementation schemes can be configured to utilize these existing storage tanks. The existing tanks must meet vendors guides for materials, inlets/outlets, and volume. Level sensor data will be provided to the central CPU system.

8.3 *Multiple OSCG Systems* — Depending on capacity requirements, OSCG installations can be configured to have multiple Generator systems in parallel. All product outputs should have the capability to be sampled individually before combining into a common product stream for storage.

8.4 *Support Systems* — Various support systems and options can be provided to support the overall implementation scheme.

8.4.1 Stand-alone, water-cooled Chiller(s) may be required, if the house chilled water is not available.

8.4.2 Redundant pump options should be available in any pumping system to allow for either manual switch over or automatic back-up.

8.4.3 Transfer pumping systems or transfer options should be available for the transfer of chemical from or to remote storage tanks.

8.5 *Chemical Distribution* — Chemical distribution systems may or may not be in existence at specific customer sites. The distribution of chemical from the product storage to use points will be important to maintain chemical purity. These distribution systems should be available as a directly supplied option or offered through a sub-contracted supplier.



8.6 Filtration Options — Recirculation filtration of either QC tanks or the Product storage tank is important to control particle levels in the final chemical. Recirculation filtration options should be provided, depending on the specific chemical storage configuration.

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SEMI F47-0200

SPECIFICATION FOR SEMICONDUCTOR PROCESSING EQUIPMENT VOLTAGE SAG IMMUNITY

This specification was technically approved by the Global Facilities Committee and is the direct responsibility of the North American Facilities Committee. Current edition approved by the North American Regional Standards Committee on December 15, 1999. Initially available on www.semi.org January 2000; to be published February 2000. Originally published September 1999.

1 Purpose

1.1 Semiconductor factories require high levels of power quality due to the sensitivity of equipment and process controls. Semiconductor processing equipment is especially vulnerable to voltage sags. This document defines the voltage sag ride-through capability required for semiconductor processing, metrology, and automated test equipment.

1.2 The requirements in this international standard were developed to satisfy semiconductor industry needs. While more stringent than existing generic standards, this industry-specific specification is not in conflict with known generic equipment regulations from other regions or generic equipment standards from other organizations (see Related Information section).

1.3 It is the intent of this standard to provide specifications for semiconductor processing equipment that will lead to improved selection criteria for sub-components and improvements in equipment systems design. While it is recognized that in certain extreme cases or for specific functions battery storage devices may be appropriate, it is not the intent of this standard to increase the size or use of battery storage devices provided with equipment. Focus on improvements in equipment component and system design should lead to a reduction or elimination in the use of battery storage devices to achieve equipment reliability during voltage sag events.

2 Scope

2.1 This document specifies the minimum voltage sag ride-through capability design requirements for equipment used in the semiconductor industry. The expected equipment performance capability is shown graphically on a chart representing voltage sag duration and percent deviation of equipment nominal voltage. Standard evaluation test method references are also included.

2.2 The primary focus for this specification is semiconductor processing equipment including but not limited to the following tool types:

- Etch equipment (Dry & Wet),
- Film deposition equipment (CVD & PVD),

- Thermal equipment,
- Surface prep and clean,
- Photolithography equipment (Stepper & Tracks),
- Chemical Mechanical Polishing equipment,
- Ion Implant equipment,
- Metrology equipment, and
- Automated test equipment.

2.3 This specification applies to semiconductor processing equipment to include the equipment mainframe and all subsystems whose electrical power is directly affected by the operation of the equipment's EMO system.

2.4 This standard does not purport to address safety issues, if any, associated with its use. It is the responsibility of the users of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

3 Limitations

3.1 Not included in this standard are over voltage conditions, voltage sag duration of less than 0.05 seconds (50 milliseconds), and voltage sag duration of greater than 1.0 seconds. If necessary, the Information Technology Industry Council (ITIC) "CBEMA-curve" contained in IEEE 446, IEEE 1100, and SEMI E51 can be used to specify additional requirements outside the range of this document (see Related Information, Section R1-1).

3.2 This specification does not address wafer quality with regard to processing variation caused by voltage sags. It is recommended that each equipment supplier consider the effects of voltage sags on their equipment processes. If voltage sags above the defined line can result in known wafer quality problems, then an appropriate notification-only scheme should be considered in the equipment design. To be in conformance with this standard that notification scheme should not be classified as an equipment interrupt per SEMI E10.

3.3 This standard addresses specifications for semiconductor processing equipment voltage sag immunity. Factory systems voltage sag immunity and electric utility voltage sag performance are covered in