

SEMI F39-0621

GUIDE FOR CHEMICAL BLENDING SYSTEMS

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1 Purpose

1.1 This Guide establishes terminology, blend technique classification(s), system specification(s), performance characterization, and qualification methods for liquid chemical blending equipment.

2 Scope

2.1 This Guide applies to chemical blending equipment interfaced with bulk chemical distribution systems (BCDS).

NOTICE: SEMI Standards and Safety Guidelines do not purport to address all safety issues associated with their use. It is the responsibility of the users of the Documents to establish appropriate safety and health practices, and determine the applicability of regulatory or other limitations prior to use.

3 Limitations

3.1 This Guide 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 Standards and Documents

4.1 SEMI Standards and Safety Guidelines

SEMI C1 — Guide for the Analysis of Liquid Chemicals

SEMI E49 — Guide for High Purity and Ultrahigh Purity Piping Performance, Subassemblies, and Final Assemblies

SEMI E49.2 — Guide for the Qualification of Polymer Assemblies Used for Liquid Chemical Systems in Semiconductor Equipment

SEMI F57 — Specification for Polymer Materials and Components Used in Ultrapure Water and Liquid Chemical Distribution Systems

SEMI S2 — Environmental, Health, and Safety Guideline for Semiconductor Manufacturing Equipment

NOTICE: Unless otherwise indicated, all documents cited shall be the latest published versions.

5 Terminology

5.1 Refer to the SEMI International Standards: Compilation of Terms for the current list of Abbreviations, Acronyms, Definitions, and Symbols.

5.2 Definitions

5.2.1 *assay* — a chemical analysis of a substance; it is a chemical testing carried out to determine the composition of a substance or the concentration of its components. It can also be a sample of a material for analysis.

5.2.2 *baseline contamination level* — the level of impurity measured in the source of constituents.

5.2.3 *batch* — an accumulation of material produced during and at the end of the process of blending.

5.2.4 *blending* — the process in which two or more materials are combined to create a mixture which contains a desired proportion and quantity. 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.

5.2.5 *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 ten or greater.

5.2.6 *constituents* — solids, liquids and/or gases.

5.2.7 *continuous blending* — a method of blending that involves mixing all components simultaneously and allows immediate use of the result.

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

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

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

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

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

5.2.13 *statistical analysis* — basic statistical analysis and presentation of data for testing and verification of performance parameters. Refer to the ASTM MNL7, Manual on Presentation of Data and Control Chart Analysis.

6 Blending Techniques

6.1 *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.

6.2 *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).

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

6.2.2 *Continuous (In-Line) Blending* — The process of chemical blending, where the chemical constituents are combined in-line and are immediately available for use.

6.2.3 *Semi-Batch Blending* — The process of chemical blending where the chemical constituents are combined in line, and then held in a tank/vessel for dispense at a later time. This method allows for blended batch composition qualification prior to the release for consumption or use.

6.3 Blending Accuracy

6.3.1 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.

6.4 Production Rate

6.4.1 All production rates described should reference the duty cycle. The duty cycle must take into account the duration of consumption, the amount being consumed at a specific period of time, and frequency of consumption events.

6.4.2 Batch Production Rate (Volume of blended material available per unit time):

$$\text{Available Material} - \text{Accumulation} = \text{Material Required By Customer} \quad (1)$$

This is comprised of:

- a) Available blended material produced by the blend tool per unit time.
- b) Amount of blended material required by the customer per unit time.

c) Accumulation of blended material that accounts for the differences between average and acute/peak demand by the customer.

6.4.3 In-line Production Rate:

$$\text{Flow Rate (volume/day) of Blended Chemical} \times \text{Duty Cycle} \quad (2)$$

6.5 Purity

6.5.1 *Particles* — Definition of particle performance is documented in SEMI E49.2.

6.5.2 *Trace Metals* — Trace metals for components are defined in SEMI F57. Trace Metals for assemblies are defined in SEMI E49.2.

6.5.3 *Ionic Contamination/TOC* — For components this is defined in SEMI F57 and assemblies in SEMI E49.2.

6.6 *Uptime* — The amount of time, expressed as a % that the system operates between unscheduled shutdowns.

6.7 *Production Rate* — The volume of chemical able to be blended and provided to the BCDS per day.

6.8 The benefits and limitations inherent in each blend technique should be carefully considered for its intended application. It is not possible to make a general recommendation of one blend technique over another without having full understanding of the intended application. The following table is provided as a guideline for evaluation and selection of blend technique.

Table 1 Guideline for Evaluation and Selection of Blend Technique

<i>Feature</i>	<i>Batch</i>	<i>Semi-Batch</i>	<i>Continuous</i>
Feed-forward Control	Con	Pro/Con	Pro
Feedback Control	Con	Pro/Con	Pro
Production Rate	Con	Pro/Con	Pro
Accuracy	Pro	Pro/Con	Con
Linearity ^{#1}	Pro/Con	Pro/Con	Con
Precision	Pro	Con	Con
Repeatability	Pro	Con	Con
Real-time Analysis	Con	Pro/Con	Pro
Parsed Analysis	Pro	Pro	Con
Homogeneity	Pro	Con	Pro/Con
Duty Cycle	Con	Con	Pro
Material Phase Limitations	Pro	Con	Con
Throughput/Size Scalability ^{#2}	Con	Con	Pro
Constituent Ratio ^{#3}	Pro	Pro	Pro
Process Stability ^{#4}	Pro	Pro/Con	Con

#1 Linearity is intended as the variance in the y or measured variable as multiple independent variables are shifted away from the target recipe.

#2 Throughput/Size Scalability is intended as the range (±) in supply flow as a function of physical system size.

#3 Constituent Ratio is intended as the ratio of each constituent to the total. It is further described as being small when the quantity of any given constituent is very small relative to the total.

#4 Process Stability is intended as a measure of the blend system robustness to changes in the physical (not chemical) input properties.

7 System Specification

7.1 Typical system specifications may include but are not limited to the following:

- Required output flow rates, velocities, duty cycle, min/max rates