

SEMI F31-0313

GUIDE FOR BULK CHEMICAL DISTRIBUTION SYSTEMS

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NOTICE: This Document was completely rewritten in 2012.

1 Purpose

1.1 This Guide defines components of bulk chemical distribution systems (BCDS) and sets forth basic design elements and optional design features common to BCDS.

2 Scope

2.1 This Guide applies to BCDS used in semiconductor manufacturing facilities for supplying liquid chemicals to wafer manufacturing processes.

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 is not intended to be applicable to every possible use and type of chemical dispensing system but only to those systems that originate with sources of single lots of liquid materials of 200 liters or greater and which operate in a way that delivers to a single or multiple streams. Portions of this Guide may be applicable to liquid chemical systems sourced from vessels less than 200 liters (see Appendix 1) and typically excludes slurry systems and chemical waste stream reprocessing systems.

3.2 This Guide excludes construction protocols for BCDS, such as clean manufacturing practices, integrity of fabrication, and prequalification of materials. Such protocols are found elsewhere in § 4, Referenced Standards and Documents and § 10, Related Documents.

3.3 References to ‘containers’ in this Document are not limited to those described in the Code of Federal Regulations (CFR) 49 CFR 178, Sections 509, 706 and 707. They may also include smaller containers including various sizes of carboys and drums.

4 Referenced Standards and Documents

4.1 SEMI Standards and Safety Guidelines

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

4.2 Federal Regulations¹

49 CFR — Title 49 of the Code of Federal Regulations, Part 178 (as they pertain to the Department of Transportation)²

49 CFR 178.509 — Standards for Plastic Drums and Jerricans

49 CFR 178.706 — Standards for Rigid Plastic IBCs

49 CFR 178.707 — Standards for Composite IBCs (rigid structural IBCs with polymeric liners)

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

¹ United States Government Printing Office, 732 North Capitol Street, NW, Washington, DC, 20401-0001, USA; Telephone: 202.512.1800; <http://www.gpo.gov>

² Department of Transportation, 400 Seventh Street, SW, Washington, DC, 20590, USA.

5 Terminology

5.1 Abbreviations and Acronyms

5.1.1 *CDM* — chemical dispense module

5.1.2 *CDU* — chemical dispense unit

5.1.3 *DIW* — deionized water

5.1.4 *FMS or FMCS* — facility monitoring system or facility monitoring and control system

5.1.5 *IPC* — industrial process computer

5.1.6 *MDU* — modular dispensing unit

5.1.7 *PAC* — programmable automation controller

5.1.8 *PC* — programmable controller

5.1.9 *PLC* — programmable logic controller

5.1.10 *UPW* — ultrapure water

5.1.11 *VMC* — valve manifold box

5.2 Definitions

5.2.1 *blending* — combining two or more chemicals to create a mixture which contains specific chemical properties or desired ratio of constituents.

5.2.2 *chemical dispense system* — the module/system or physical process used for filtering and for dispensing chemical into the distribution piping network which may be referred to by a number of manufacturer's specific designations: CDM, CDU, and MDU.

5.2.3 *chemical reprocessing unit* — a subsystem which reclaims or recycles a chemical. Chemical reprocessing can also include neutralization, separation, waste reduction, or mitigation of hazardous waste.

5.2.4 *chemical transfer* — the technique used to move chemical between different points in the distribution system.

5.2.5 *day tank* — a vessel that stores that amount of chemical which may be consumed within one or more days.

5.2.6 *dead end distribution* — a distribution circuit design that terminates without circulating the process fluid back to the point of origin.

5.2.7 *decontamination* — cleaning up of a BCDS, or any subsystems thereof, by introducing DIW, UPW or chemical solutions into the piping systems.

5.2.8 *de-gassing* — the removal of collected gasses from liquid chemical or DIW streams.

5.2.9 *dilution* — combination of a concentrated chemical, DIW or UPW to create a lower concentration of the aqueous chemical.

5.2.10 *drum* — a container for storing chemicals, generally with a cylindrical shape and not more than 55 gallons or 200 liters in size.

5.2.11 *filter shock* — release of filtrate from filter media due to mechanical, pressure, or chemical influence.

5.2.12 *flush* — the use of DIW/UPW or some other liquid chemical to evacuate the line or vessel containing another chemical, waste or process media.

5.2.13 *hybrid system* — a combination of pressurization and pumping techniques used to transfer chemical.

5.2.14 *ISO container* — a container for storing chemicals, usually large in size, able to be transported directly, and designed in compliance with criteria from the International Standards Organization.

5.2.15 *loop distribution* — a distribution circuit design that circulates the process fluid back to the point of origin.

5.2.16 *metrology* — any device or process which measures a quality or property of any process fluid, solid or gas.

5.2.17 *on-site gas-to-chemical generation* — the contacting of a liquid and gas phase to create a liquid solution. The chemical is generated on-site in a form suitable for distribution through a dispense system.

5.2.18 *pickling* — conditioning of the system by filling it with the actual chemical or another chemical for which the system is designed. This chemical will stay in the system for a specified period of time. The purpose of this conditioning is to leach out impurities prior to actually using any chemical in the manufacturing process.

5.2.19 *polishing* — the process of flowing chemical through a filter one or more times to reduce the particulate concentration in the chemical.

5.2.20 *pressurization* — the use of high purity nitrogen or other appropriate gas to apply pressure to or displace liquid through the distribution system.

5.2.21 *primary containment* — tubing, piping, or components whose wetted surface is directly in contact with the chemical. These components are generally made from high purity polymeric materials.

5.2.22 *pumping* — a mechanical or pneumatically operated technique used to create hydraulic force in the system.

5.2.23 *purge* — the use of N₂, CDA or some other inert or nonreactive gas to evacuate the line or vessel containing another chemical, waste or process media. Selection of the gas should consider that it is neither reactive nor contaminating to the process line or vessel.

5.2.24 *secondary containment* — tubing or piping which contains the primary piping or tubing. The purpose of this configuration is to control leaks and to protect against spills. Secondary containment of liquid chemical systems often consist of compatible materials.

5.2.25 *surge suppression* — use of a device or in-line chamber that minimizes the flow pulsations caused by a pump. This device may also be referred to as pulsation dampener.

5.2.26 *tichelman loop* — a distribution circuit characterized by separate pressure control and separate *return from each point* of use. In many instances the point of use return lines, connect to the bulk return line downstream of the pressure control device.

5.2.27 *tote* — a container for storing chemicals, generally 417 liters (110 gallons), 833 liters (220 gallons), 1000 liters (264 gallons) or 1249 liters (330 gallons) in size and requiring an outer shell to provide structural support to the vessel.

5.2.28 *valve manifold box (VMB)* — a chemical-resistant enclosure which houses manual and/or automatically actuated valves, tees, and fittings. The box can also act as a distribution point allowing multiple take offs for a delivered chemical.

5.2.29 *vessel* — a receptacle fabricated from or equipped with an inner lining of chemically inert and resistant materials which is specifically designed to contain and/or maintain the purity level of the chemical for a long period of time. All containers are fabricated from or at least contain an inner lining of chemically inert and resistant materials and are specifically designed to maintain the purity level of the chemical for long periods of time. The larger containers are generally designed in conformance to Department of Transportation Regulations (DOT) and may be transported by ground. These containers have fittings which are compatible to this purpose so that they may be hooked up to the BCD Systems directly. Such containers include but are not limited to drums, totes and ISO containers.

5.2.30 *wetted surface* — any surface which comes into contact with the process or waste media.

6 General Requirements

6.1 *Materials* — Components of the BCDS must be appropriate to the application and conform to electrical, mechanical, and chemical requirements as defined by the physical installation environment, local and national code interpretations, process requirements, and delivery specifications.

6.2 *System Installation* — The BCDS is installed according to a protocol which ensures mechanical integrity, leak proof operation, and minimal contamination to any liquids being distributed throughout the system.

6.2.1 System installation procedures include a rinse down protocol which may include any of the following: (1) a flushing procedure with DIW; (2) a sanitization step using hydrogen peroxide; (3) a drying step using nitrogen gas; and (4) a 'pickling' process using various concentrations of the actual chemical or another cleaning chemical. For

solvent systems, the rinse-down chemicals introduced are generally the same as the solvent that is designated to be used in the system, whereas for acid systems, the rinse down solutions may include DIW, ozonated water, or a dilute form of hydrogen peroxide.

6.2.2 The protocol for system installation and start-up follows a predefined sequence of events which incorporates all of the physical activities incumbent to the tool design and testing parameters; and establishes check points for approvals at each stage.

6.3 *Acceptance Tests* — Acceptance tests are conducted on each subsystem or system produced. They are the basis for acceptance or rejection by the purchaser. These tests may include but are not limited to factory, customer and process acceptance tests (FAT, CAT, PAT) as well as ESH.

6.3.1 Acceptance testing may include performance demonstrations, demonstration of reliability criteria, and achievement of purity standards. Safety considerations are addressed elsewhere.

6.4 *Qualification Testing* — Qualification testing is performed on the liquid chemicals being transported through each chemical piping subsystem.

6.4.1 Qualification testing may include tests for:

6.4.1.1 physical tool hookup/connections

6.4.1.2 fluid system leak integrity

6.4.1.3 control system function integrity to include cables and cable harnesses

6.4.1.4 utility consumption

6.4.1.5 hydraulic distribution performance

6.4.1.6 trace metals

6.4.1.7 anions

6.4.1.8 particles

6.4.1.9 total organic carbon

6.4.1.10 or other physical/chemical properties that are process required

NOTE 1: The end-user may choose third party or in-house testing as the means for qualification.

6.5 *Chemical Specifications* — BCDS may be specified with different levels of impurities at the point of use as compared to the quality of the incoming chemical. These impurities include:

6.5.1 Particulate impurities expressed as the number of particles of a specific size greater than some threshold per mL;

6.5.2 Metallic impurities expressed as ppt, ppb or ppm

6.5.3 Anions expressed as ppt, ppb or ppm

6.5.4 organic impurities express as ppt, ppb or ppm

6.5.5 moisture content, expressed as % or mass per unit volume

7 Basic Design Elements

7.1 *General* — Each BCDS contains certain basic components and a variety of design options to meet particular customer and facility needs. A simple example system is shown in Appendix 1.

7.2 *Source* — The source of all fluids for incoming BCDS is a container suitable for holding chemicals in a 200 liter or greater size, which may include drums, IBC totes or other containers.

7.3 *Fluid Transfer* — Fluids in the BCDS are transported through pipes or tubes using either an active or passive transfer method such as pumping system, a pressure differential system, gravity or some combination (hybrid) of these types of basic systems. Often fluids are transported in secondary containment piping systems for safety reasons.