

SEMI F98-0618

GUIDE FOR WATER REUSE IN SEMICONDUCTOR INDUSTRY

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NOTICE: This Document was completely rewritten in 2018.

1 Purpose

1.1 This Guide provides definitions and recommendations for design of industrial water systems that reuse water in a semiconductor manufacturing facility. It is intended to establish a common basis for developing design specifications and decisions concerning planning and design of water reuse systems. This Guide also includes considerations for the water reuse systems operation.

1.2 This Document may be used by semiconductor factory engineers and suppliers for developing site-specific basis of design and performance criteria.

2 Scope

2.1 This Guide applies to water systems designed for water reuse within semiconductor manufacturing facilities, supplying water to a variety of applications. Such applications include directing secondary use water to the front end of an ultrapure water (UPW) system, cooling systems, scrubbers, point of use abatement, thermal processes, as well as to irrigation. Choice of the reuse scheme depends on the quality of the water, application requirements, and environmental regulations.

2.2 This Guide can be used to understand the design elements and functionality of water systems that support reuse of water. Although existing factories can be retrofitted to implement water reuse, there is a broader range of opportunities available in new facilities that can be designed with water saving applications in mind.

2.3 The scope of this Document is to provide recommendations regarding water reuse segregation strategy and possible treatment options.

2.4 This Guide reviews conditions and limitation for specific water reuse applications, economic and environmental considerations. It also provides reference for typical wastewater composition.

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 define the actual specifications generally negotiated between the user and the manufacturer of the water reclamation and reuse systems.

3.2 This Guide does not recommend specific water reuse scheme and treatment systems for a semiconductor factory. Economics and environmental requirements as well as other location specific conditions may drive different solutions. If water reuse is added to the existing facilities, installed equipment may add physical and other constraints.

3.3 This Guide does not address maintenance and operation of water reuse systems.

3.4 This Guide does not intend to cover any of the important safety considerations that relate to the proper installation, operation, or maintenance of water reclamation and reuse systems. Those are expected to be addressed using existing industry and company specific safety specifications and guidelines.

4 Referenced Standards and Documents

4.1 SEMI Standards and Safety Guidelines

SEMI F61 — Guide for Ultrapure Water System Used in Semiconductor Processing

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

4.2 Other Documents

Huber S., Balz A., Abert M., Pronk W. “Characterization of aquatic humic and non-humic matter with size-exclusion chromatography - organic carbon detection - organic nitrogen detection (LC-OCD-OND).” *Water Research*, Volume 45, Issue 2, January 2011, pp. 879–885.

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

5 Terminology

5.1 Abbreviations and Acronyms

5.1.1 *CMP* — chemical-mechanical planarization

5.1.2 *EDI* — electro deionization

5.1.3 *HF* — hydrofluoric acid

5.1.4 *HFW* — hydrofluoric acid waste

5.1.5 *LC-OCD-OND* — liquid chromatography with organic carbon detector and organic nitrogen detector

5.1.6 *POD* — point of discharge

5.1.7 *POTW* — publicly owned treatment works

5.1.8 *POU* — point of use

5.1.9 *RO* — reverse osmosis

5.1.10 *SCW* — slurry copper waste

5.1.11 *TOC* — total organic carbon

5.1.12 *UPW* — ultrapure water

5.2 Definitions

5.2.1 *reclaim water* — a product of water reclamation.

5.2.2 *UPW recycle* — the process of reclamation and reuse of water for UPW production.

5.2.3 *water reclamation* — a process of extracting/purifying water from wastewater for subsequent secondary use.

5.2.4 *water reuse* — the secondary use of water with or without reclamation for any purposes.

5.2.5 *water recycling* — the process that leads to water reuse at the system where it was originally used or produced from.

6 Water Reuse and Wastewater Segregation Strategy Considerations

6.1 There are two main platform reference strategies recommended for water reuse (see Appendix 1, Figure A1-1). Although site specific water reuse schemes may be different, it is recommended to decide on one of the two strategies below, then develop a site-specific water reuse plan based on that decision.

6.2 *Strategy 1* — Centralized: end-of-pipe reclamation, where the main fab effluent stream is collected and treated by a centralized reclamation plant and subsequently reused.

6.3 *Strategy 2* — Decentralized: segregation based approach, where tool level segregation of the wastewater is provided at the manufacturing tool level. Then each stream is treated separately with subsequent reuse.

6.4 Independent of the strategy chosen, some of the wastewater streams are not intended for reuse. They are collected and treated separately. Separate collection and treatment is usually due to regulatory requirements or cost considerations. Examples of such streams are wastewater containing heavy metals, concentrated solvents, high content of suspended solids, and concentrated acids.

6.5 The choice of the segregation and reuse strategy for a new fab depends on a number of factors, including environmental regulations, corporate environmental sustainability goals, cost, composition of the streams, application specifications, and feasibility to segregate streams at the tool level. Application of single wafer processing tools can make the tool level segregation more complex, thus driving the centralized treatment strategy.

6.6 In the case of existing fabs where segregation was not part of the original base-build, there are still possibilities to collect and treat combined fab wastewater after diversion of the concentrated streams. In that case, implementation of the decentralized strategy may be difficult due to cost, and the complexity of making changes in the drain system of an operating fab.

6.7 Another important consideration when choosing the strategy is related to the factory technology roadmap. If the tool set is expected to change significantly in the future, associated drain systems/wastewater composition may change. For stable tool set and consistent wastewater characteristics, use of a decentralized water reuse strategy may be possible and cost effective. Otherwise, centralized strategy may be preferred.

6.8 Each water or wastewater treatment system effluent may be considered for reuse opportunities. For example, UPW RO reject can be treated and recycled back to UPW production. Cooling towers blowdown can be reclaimed and recycled, or reused in other non-critical applications.

6.8.1 One of the key decisions to be made when determining the water reuse scheme is related to the environmental compliance for salt content. Many sites are regulated to the level of salinity in the site outfall. Often this issue becomes determining for the extent of the water reuse and the water management scheme. When salinity limit is exceeded, capital intense and energy intense solutions may be required to address this issue. This may include the following options:

6.8.1.1 Brine concentrators and crystallizers;

6.8.1.2 Evaporation ponds or other enhanced evaporating processes;

6.8.1.3 Off-site disposal via pipelines or hauled away.

6.8.2 New, more creative energy efficient, and low capital solutions may need to be explored. Specific examples exist, but are not listed in this Guide due to their proprietary nature.

7 Design Considerations

7.1 *Collection of Wastewater Streams* — The most common collection system includes fab-wide gravity collection piping using PVC, CPVC, PP, PE or PVDF materials, as well as associated pipe racks and tunnels to the collection tanks. Choice of the piping material is a function of physical and chemical compatibility and cost. Proper venting is critical to sustain operation. The collection system typically includes a lift station, pumps, tanks, and controls. Separate holding tanks are used for each grade of water so routing of the effluent streams to specific types of treatment and reuse can be matched to specific needs (see Figure 1).

7.1.1 General interest in efficient water reuse by semiconductor fabs encourages tool manufacturers to include multiple drain lines within the tool so waste streams can be easily segregated. Divert valves can be used to segregate chemicals. In some applications, such as CMP, tool manufacturers can also incorporate plumbing and treatment modules for recycling spent water discharge from a tool as feed water for that tool (POD recycling). Purchasing tools with recycle hardware already built-in eliminates the need for users to design and install customized water reuse systems unique to their site.

7.2 *Treatment of Wastewater Streams* — In addition to choosing the most effective and technically sound design solutions, other considerations for treatment options include easy access to major components for operation and maintenance, availability of consumables and spare parts, as well as the level of automation and reliability.

7.2.1 The level of automation and sophistication in the design may be influenced by availability of the trained operating personnel.

7.3 Depending on the choice of segregation strategy different treatment technologies may be used.

7.3.1 For the centralized strategy, the end-of-pipe reclamation commonly employs biological treatment followed by polishing with RO.