Guidelines for Manufacturing Equipment Reference Manuals

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Abstract: This document provides suggested standard contents for equipment reference manuals for semiconductor process equipment. It includes a generic and detailed outline for equipment manuals, with major sections on installing, operating, controlling, and integrating process equipment. The contents of this document were published previously as Section I of *Guidelines for Semiconductor Manufacturing Equipment Reference Manuals, Technician Training Programs, and Training Evaluation*, Technology Transfer #93031567A-XFR. However, those contents are being republished here for user convenience.

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1. EXECUTIVE SUMMARY

This document contains semiconductor equipment reference manual guidelines as agreed upon by the Council of SEMATECH and SEMI/SEMATECH Training Professionals and its subgroup, the Documentation and Training Guidelines Update Task Force. The contents of this document were published previously as Section I of *Guidelines for Semiconductor Manufacturing Equipment Reference Manuals, Technician Training Programs, and Training Evaluation*, Technology Transfer #93031567A-XFR, published by SEMATECH on May 6, 1993. In the interest of user convenience, however, that section is being published separately in this form.

Rapidly changing and complex technologies in semiconductor manufacturing require accurate and well organized equipment documentation to enable technicians to repair and maintain process tools within tight tolerances. Indeed, equipment documentation is a critical part of the product and serves as a job aid for the technician working on the tool. Accurate and easy-to-use documentation also is very important in training technicians to maintain and service manufacturing equipment.

Equipment suppliers are primarily responsible for publishing timely and accurate reference manuals, and customers expect such documentation to be available when purchasing decisions are made. Suppliers could better meet this demand if the semiconductor industry agreed to standard formatting and content for equipment reference manuals. Accordingly, the Council of SEMATECH and SEMI/SEMATECH Technician Training Professionals has agreed on the following set of reference manual guidelines and offers them to manufacturers and suppliers alike.

2. GENERIC MANUAL CONTENTS

Each manual should contain the following general contents.

2.1. Guidelines for Each Stage of Product Development

1. Alpha
2. Beta
3. Gamma
4. Fielded product

2.2. Fielded Product Manual Contents

I Manual Revision Status
- a. Machines covered
- b. People who worked on manual
- c. Revision history
- d. Other versions available, e.g., earlier revision number or CDROM, etc.
- e. “To be used with” links to other manuals

II Table of Contents

III List of Illustrations

IV List of Tables

V List of Schematics

VI How to Use Reference manual with Other Reference Manuals

VII List of Related Documents

VIII Required Service Tooling

IX What’s New in This Manual

3. REFERENCE MANUAL SECTION DESCRIPTIONS

Following is a suggested structure for reference documents. Subsequent headings in this section pertain to the generic manual being described.

SECTION 1.0: INTRODUCTION

1.1 Equipment description
- a. Purpose/function
- b. Basic system structure/features

1.2 System specifications

1.3 Configuration
- a. Hardware features supplied/options available
- b. Software features supplied/options available

1.4 Safety considerations (highlight critical safety items in manual)

1.5 Warranty information (include only standard warranty information here. Other specified warranty agreements negotiated at purchase time should be referenced in contract.)

1.6 Model of equipment and revisions

1.7 Accessories

SECTION 2.0: EQUIPMENT/PROCESS OVERVIEW

2.1 Equipment overview
- a. Brief history: what's changed in the machine/component design and why the change was implemented
- b. Conceptual overview of design
- c. Functional block diagrams
- d. Basic theory of operation
- e. System flow charts

2.2 Process applications
- a. Background principles
- b. Process history/system performance
- c. Process description/concepts/sequence
- d. System interaction during processing
- e. Key parameters (process and equipment variables)
- f. Process trend charts
- g. Process equipment capabilities/limitations

SECTION 3.0: SAFETY HAZARDS/PRECAUTIONS

3.1 Overview of equipment-specific safety hazards

3.2 Identification of functional hazards/precautions
- a. Electrical
- b. Mechanical
- c. Chemical
- d. Thermal
- e. Other
- f. Matrix of emergency/corrective response actions
- g. Lockout/tagout procedures and information

SECTION 4.0: INSTALLATION

4.1 Facilities requirements
- a. Floor space requirements
- b. Air conditioning/ventilation/environmental requirements
- c. Facilities
  1. Floor loading (weights of individual subassemblies, assemblies are helpful, identify very heavy items)
  2. Electrical
  3. Vacuum/pneumatic
  4. Process/special gases
  5. Air conditioning requirements
  6. Ventilation requirements
  7. Exhaust
  8. Drains
  9. Other

4.2 Unpacking and inspection procedures, including checklist for unpacking equipment

4.3 System setup procedures
- a. Equipment assembly
- b. Installation, including recommended clearances needed for effective maintenance, and installation checklist

4.4 System checkout procedures (refer to sections in main manuals)
- a. Safety/interlock checks
- b. Mechanical checks
- c. Utility checks
- d. Pre-operation checks
- e. Power-up sequence
- f. Specifications (limits/tolerances of operation)

SECTION 5.0: MACHINE ASSEMBLIES (HARDWARE) AND DETAIL THEORY OF OPERATION

5.1 Overview of machine assemblies
- a. Functional block diagrams
- b. Basic theory of operation

5.2 Electrical systems
- a. DC systems
  1. Identify and explain the name, location, and function of all motors, solenoids, etc.
  2. Identify interactive effects and why specific components are used
- b. AC systems
  1. Identify and explain the name, location, and function of all motors, solenoids, etc.
  2. Identify interactive effects and why specific components are used
- c. Power supplies
  1. Identify and explain the name, location and function of all AC and DC power supplies
  2. Identify interactive effects and why specific components are used
- d. Printed circuit (PC) boards
  1. Identify and explain the name, location, and function of all printed circuit boards within the system
  2. Block diagrams of each PC board with identification of major components (microprocessor, electrically programmable read-only memories [EPROMs], etc.)
  3. Discussion of PC board schematics (test/check points, signal wave forms, etc.)

5.3 Mechanical Systems
- a. Identify and explain the name, location, and function of all major assemblies and subassemblies
  1. Describe all major parts
  2. Identify interactive effects and explain why used
- b. Discuss applicable disciplines for each assembly
  1. Mechanics
  2. Electronics
  3. Pneumatics
  4. Other disciplines
- c. Disassembly, repair, and reassembly procedures
  1. Discuss of each assembly
  2. Explain spare parts replacement approach to individual assembly
- d. Maintenance checks
  1. Discussion of maintenance parts of each assembly
  2. Explain effect upon machine performance

e. Calibration/adjustments
   1. Discussion of all calibration/adjustments performed on each assembly
   2. Explain interactive effects and relative importance of calibration/adjustments on machine performance

f. Discussion of interrelationship between hardware and system operation.
   1. Explain the interrelationship of all major components and assemblies and how they function together to provide overall system operation

5.4 Pneumatic Systems

a. Identify and explain the name, location, and function of all major assemblies and subassemblies
   1. Describe all major parts
   2. Identify interactive effects and explain why specific components are used

b. Discuss applicable disciplines for each assembly
   1. Mechanics
   2. Electronics
   3. Pneumatics
   4. Other disciplines

c. Disassembly, repair, and reassembly
   1. Discussion of each assembly
   2. Explain spare parts replacement approach for individual assemblies

d. Maintenance checks
   1. Discuss maintenance of each assembly
   2. Explain effect upon machine performance

e. Calibration/adjustments
   1. Discussion of all calibrations/adjustments performed on each assembly
   2. Explain interactive effects and the relative importance of calibration/adjustment on machine performance

f. Discussion of interrelationship between hardware and system operation
   1. Explain the interrelationship of all major components and assemblies and how they function together to provide overall system operation

5.5 Vacuum Systems

a. Identify and explain the name, location and function of all major assemblies and subassemblies
   1. Describe all major parts
   2. Identify interactive effects and explain why specific components are used

b. Discuss applicable disciplines for each assembly
    1. Mechanics
    2. Electronics
    3. Pneumatics
    4. Other disciplines
c. Disassembly, repair, and reassembly
    1. Discussion of each assembly
    2. Explain spare parts replacement approach for individual assemblies
d. Maintenance checks
    1. Discussion maintenance of each assembly
    2. Explain effect upon machine performance
e. Calibration/adjustments
    1. Discussion of all calibrations/adjustments performed on each assembly
    2. Explain interactive effects and the relative importance of calibration/adjustment on machine performance
f. Discussion of interrelationship between hardware and system operation
    1. Explain the interrelationship of all major components and assemblies and how they function together to provide overall system operation

5.6 Hydraulic Systems
a. Identify and explain the name, location, and function of all major assemblies and subassemblies
    1. Describe all major parts
    2. Identify interactive effects and explain why specific components are used
b. Discuss applicable disciplines for each assembly
    1. Mechanics
    2. Electronics
    3. Pneumatics
    4. Other disciplines
c. Disassembly, repair, and reassembly
    1. Discussion of each assembly
    2. Explain spare parts replacement approach for individual assemblies
d. Maintenance checks
    1. Discuss maintenance of each assembly
    2. Explain effect upon machine performance
e. Calibration/adjustments
    1. Discussion of all calibrations/adjustments performed on each assembly
    2. Explain interactive effects and the relative importance of calibration/adjustment on machine performance

f. Discussion of interrelationship between hardware and system operation
    1. Explain the interrelationship of all major components and assemblies and how they function together to provide overall system operation

5.7 Optics Systems
- a. Identify and explain the name, location, and function of all major assemblies and subassemblies
    1. Describe all major parts
    2. Identify interactive effects and explain why specific components are used
- b. Discuss applicable disciplines for each assembly
    1. Mechanics
    2. Electronics
    3. Pneumatics
    4. Other disciplines
- c. Disassembly, repair, and reassembly
    1. Discussion of each assembly
    2. Explain spare parts replacement approach for individual assemblies
- d. Maintenance checks
    1. Discuss maintenance of each assembly
    2. Explain effect upon machine performance
- e. Calibration/adjustments
    1. Discussion of all calibrations/adjustments performed on each assembly
    2. Explain interactive effects and the relative importance of calibration/adjustment on machine performance
- f. Discussion of interrelationship between hardware and system operation
    1. Explain the interrelationship of all major components and assemblies and how they function together to provide overall system operation

SECTION 6.0: SYSTEM INTEGRATION/CONTROL SYSTEMS

6.1 Overview of integrated system

6.2 Functional breakdown of control systems

6.3 Control systems
- a. Basic components/functional block diagram
- b. Signal paths/wave forms

SECTION 7.0: CONTROL/INDICATORS

7.1 Overview of controls/indicators
- a. Functional grouping of controls
- b. Use of each control group
- c. General relationship of each control group to assembly operation (identify interactive effects of controls)

7.2 Control/indicator identification
- a. Name of individual control/indicator
- b. Location of individual control/indicator
- c. Function/user of individual control/indicator (manipulation of machine's internal components)
- d. How each control affects the machine's internal components.

SECTION 8.0: SOFTWARE

8.1 Overview of software structure
- a. Operating system
- b. Disk systems
  1. Winchester
  2. Floppy
- c. Basic prompts/edit control
- d. Copyright protection and software changes allowed

8.2 File and command definitions
- a. Functional breakdown of files
  1. Define each file
  2. Logical function of file
- b. Functional breakdown of procedures/commands/command options
  1. Define each procedure, command, and command option
  2. Discuss software flow chart

8.3 Software tutorial

8.4 Programming
- a. Overview of programming
- b. Functional breakdown of programming instructions
- c. Discuss programming flow chart

8.5 Diagnostic program
- a. Discuss of diagnostic features
- b. Capabilities and limitations

8.6 Software troubleshooting and debugging

8.7 References to software tutorials and documentation

SECTION 9.0: SYSTEM OPERATION

9.1 System operation overview and vocabulary

9.2 Discussion/flow chart of all systems, and product safety precautions

9.3 Discussion/flow chart of step-by-step system operation flowchart

9.4 Discussion/flow chart of step-by-step procedures for various operation modes
- a. Manual vs. automatic
- b. Edit
- c. Diagnostic
- d. Etc.

9.5 Discussion/flow chart of system operation sequence
- a. System initialization
- b. System shutdown
  1. Normal (description of operational steps and functional description)
  2. Emergency (description …)
  3. Consequences and recovery from emergency shutdown
- c. System setup
- d. System process sequence

9.6 Discussion/flow chart of operator assists and error messages

9.7 Discussion/flow chart of troubleshooting decision tree

SECTION 10.0: CALIBRATION/ADJUSTMENTS

10.1 Overview of calibration/adjustments

10.2 Discuss of limits and tolerances

10.3 Interaction of adjustments

10.4 Identify required tools/test equipment

10.5 Calibration/adjustment strategy/procedures

SECTION 11.0: PREVENTIVE AND CORRECTIVE MAINTENANCE

11.1 Overview of preventive and corrective maintenance
- a. Purpose (indicate why interval is based on time or wafer rate)
- b. Specified knowledge/skill level needed to perform each preventive maintenance (PM) procedure and task
- c. Estimated time required to perform and complete each PM and/or task
- d. List of tools, equipment, fluids, gasses, and materials required
- e. List and quantity of replacement parts, fluids, gases, and materials
- f. Testing required to ensure equipment is production-ready after a PM or corrective maintenance
- g. Discussion/flowchart of step-by-step preventive and corrective maintenance procedures
- h. Chart of recommended PM intervals/frequencies
- i. PM parts/kits

SECTION 12.0: DIAGNOSTICS AND TROUBLESHOOTING

12.1 Overview of diagnostic features/usage

12.1 Discussion/flow chart of failure analysis
- a. List problem/symptom
- b. List probable cause
- c. List corrective action
- d. List error codes and most probable causes

12.3 Troubleshooting fault/decision trees
- a. Sectional flow charts and troubleshooting guides
- b. Procedures/theory of using “half-step” process to isolate and locate problems

12.4 Process troubleshooting

SECTION 13.0: SCHEMATICS

13.1 Point-to-point diagrams

13.2 Cabling diagrams

13.3 PCB schematics

13.4 Interlock diagrams

13.5 Pin-in, pin-out diagrams

SECTION 14.0: APPENDIX

14.1 Recommended spare parts list

14.2 Recommended consumables list

14.3 Recommended calibration adjustments

14.4 List of machine specifications and other commonly used data

14.5 Vendor and non-vendor data sheets

14.6 Glossary

14.7 Index

14.8 Parts list with exploded diagrams

14.9 Change information
- a. Change notices for life of equipment
- b. Newsletter service for process, safety, equipment, parts, troubleshooting, etc.

14.10 Miscellaneous information
- a. Ordering information
- b. Vendor contracts
- c. Service contract information

14.11 Commonly used information for technicians
- a. Torque settings
- b. Materials
- c. Specification lists
- d. Conversion charts

14.12 Lists of critical spare parts
- a. Consumables to have on-hand/quantity
- b. Shelf life
- c. Lead times for ordering

4. IMPLEMENTATION STRATEGIES

4.1. Communication

- Involve high level decision makers within each member company. List the benefits in the executive summary of this workshop. Be sure to emphasize the "bottom line" benefits.

- Utilize SEMETECH to promote guidelines in a "road show."

- Use existing industry organizations to promote the use of these guidelines (e.g., U.S. Equipment Trade Association).

- Develop contact list of individual(s) who can field questions on content in the guidelines.

- SEMATECH and SEMI/SEMATECH compile a list of semiconductor and subcomponent manufacturers. Communicate the existence of this guideline with cover letter.

4.2. Purchase Agreements/Acceptance Criteria

- Use guideline as template for discussion with equipment suppliers during negotiation of purchase agreements.

- Include guideline as part of equipment acceptance criteria.

- Use the "contracting model" to establish partnerships between customers and suppliers for documentation projects.

4.3. Testing

Beta-test manual guidelines with an existing/recognized equipment supplier. Communicate successes throughout member companies.

4.4. Expectations

- Equipment suppliers should use these guidelines in the development of new equipment documentation and the update of existing manuals.
  - New products (after a specific date) must have manuals in recommended format.

- Incorporate these guidelines with the requirements of ISO 9000.

- Develop a SEMI guideline that meshes with this SEMATECH and SEMI/SEMATECH guideline.

- Develop a media standard for use with these guidelines.

- Work with suppliers of subsystems to use these guidelines in developing their documentation.

- A process should be established to provide an avenue for updating guidelines that reflect industry needs. This process should include roles, responsibilities, and communication guidelines.

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