

SEMATECH Guide for Documenting Tool Installation Time and Cost

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Abstract: This document provides the industry with a standardized approach to collecting data associated with tool installation including total calendar days, total labor hours, and total cost. It includes a sample spreadsheet for capturing direct cost and time data for the tool installation phases of design, prefabrication, and hookup. Data collected in this format can be used to establish internal and external benchmarks and evaluate industry goals. Additionally, standardized data collection could help identify best practices and leading suppliers in a continuing effort to reduce costs and improve factory rampup time. This document includes an Excel 5.0 spreadsheet for calculating tool installation times and costs.

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1 EXECUTIVE SUMMARY

This document is designed to provide the semiconductor industry with a standardized approach to collecting data associated with tool installation, including total calendar days, total labor hours, and total cost. It includes the following elements:

- A description of steps associated with the comprehensive methodology of tool accommodation
- A list of SEMI standards pertaining to this approach
- Definitions of terms used in this document
- A sample spreadsheet for capturing direct cost and time data for the tool installation phases of design, prefacilitation, and hookup
- A line-by-line description of the items to be included in the spreadsheet

Data collected in this format can be used to establish internal and external benchmarks and evaluate industry goals. Additionally, standardized data collection could help identify best practices and leading suppliers in a continuing effort to reduce cost and improve factory rampup time.

2 INTRODUCTION

2.1 Purpose

The member companies of the International 300 mm Initiative (I300I) have charged the equipment supplier community to support an aggressive goal for reducing equipment installation time and cost for 300 mm tools. In that charge, a goal was set to reduce installation and qualification cost by 6% of tool cost and to reduce the installation time by 30% of existing 200 mm technology.

2.2 Scope

The following steps illustrate the various domains associated with the comprehensive methodology of tool accommodation, defined as an inclusive process from procurement through acceptance of semiconductor processing equipment.

1. *Procurement*—the process of specifying, bidding, purchasing, receiving, and accepting semiconductor processing equipment. Conditions jointly agreed upon by the equipment supplier and the customer.
2. *Base build*— installation of a base factory building, services, and fitup of equipment to establish functional environmental controls and utilities to support production equipment installation.
3. *Installation*—the act of physically installing semiconductor processing equipment into a wafer fabrication facility including detailed installation design, prefacilitation and hookup. Prefacilitation precedes the delivery of equipment while hookup occurs after equipment is on site.

4. *Qualification*—the manufacturing method for rigorously characterizing and burning in semiconductor processing equipment before the equipment is accepted and released for production.

The spreadsheet provided in Table 1 at the end of Section 5 captures direct cost and time data associated with the third step, tool installation (including the installation phases of design, prefacilitation, and hookup). This document does not address more comprehensive tool accommodation costs that might be incurred during procurement, base build, or qualification.

3 REFERENCED DOCUMENTS

Semiconductor Equipment and Materials International (SEMI) Standards:

SEMI E6—*Facilities Interface Specifications Guideline and Format*

SEMI E49—*Guide for Standard Performance, Practices, and Sub-Assembly for High Purity Piping Systems and Final Assembly for Semiconductor Manufacturing Equipment*

SEMI E49.1—*Guide for Tool Final Assembly, Packaging and Delivery*

SEMI E49.2—*Guide for High Purity Deionized Water and Chemical Distribution Systems in Semiconductor Manufacturing Equipment*

SEMI E49.3—*Guide for Ultrahigh Purity Deionized Water and Chemical Distribution Systems in Semiconductor Manufacturing Equipment*

SEMI E49.4—*Guide for High Purity Solvent Distribution Systems in Semiconductor Manufacturing Equipment*

SEMI E49.5—*Guide for Ultrahigh Purity Solvent Distribution Systems in Semiconductor Manufacturing Equipment*

SEMI E49.6—*Guide for Subsystem Assembly and Testing Procedures—Stainless Steel Systems*

SEMI E49.7—*Guide for Subsystem Assembly and Testing Procedures—Polymer Systems*

SEMI E49.8—*Guide for High Purity Gas Distribution Systems in Semiconductor Manufacturing Equipment*

SEMI E49.9—*Guide for Ultrahigh Purity Gas Distribution Systems in Semiconductor Manufacturing Equipment*

SEMI E51—*Guide for Typical Facilities Services and Termination Matrix*

SEMI E70—*Guide for Tool Accommodation Process*

Note: The cited documents shall be the latest publications of adopted standards available from SEMI, 805 East Middlefield Road, Mountain View, CA 94943.

4 TERMINOLOGY

Acceleration cost—Additional costs incurred to complete the project sooner than the original scheduled baseline plan. [SEMI E70]

As-built drawings—Documentation describing the actual configuration and dimensions at the end of construction. [SEMI E70]

Base build—Installation of base building, services, and equipment to establish functional environmental controls and utilities to support production equipment installation. [SEMI E70]

Change order—A document defining a formal change in drawings, specifications, and/or scope of work. [SEMI E70]

Component—An individual piece or a complete assembly of individual pieces, including industrial products that are manufactured as independent units, capable of being joined with other pieces or components. The typical components are valves, fittings, regulators, gauges, instrument sensors, a single length of tubing, several pieces of tubing welded together, tubing welded to fittings, and the like. [SEMI F1]

Construction—The set of activities that transform plans and specifications into functional systems capable of performing to specification. [SEMI E70]

Contingency—A reserve of funds, time, and/or material that is allocated to maintain schedule and budget. A reserve for scope changes, unforeseen site conditions, change in material prices, or unanticipated events. [SEMI E70]

Contractor—A licensed company hired to accomplish a contractually specified scope of work. [SEMI E70]

Design start—A milestone event that designates the initial conversion of equipment specifications and design concepts into engineering plans and specifications. [SEMI E70]

Detailing—Generation of dimensioned shop fabrication plans based on process and instrumentation drawings (P&ID), field surveys, and configuration verifications. [SEMI E70]

Direct/indirect cost—Direct costs are the cost of anything physically associated with the installation, removal, or modification of equipment. Indirect costs cannot be associated with a specific piece of equipment. Profit, overhead, and administrative costs are typically considered indirect. [SEMI E70]

Distribution system—The collection of subsystems and components used in a semiconductor manufacturing facility to control and deliver process chemicals from source to point of use for wafer manufacturing processes. [SEMI E70]

Dock date—The date when the fab equipment, including all ancillary components, is on-site at the loading dock. [SEMI E70]

Facilities interface specification—Documentation provided by a tool supplier that contains the tool requirements for utilities and installation as defined in SEMI E6. So called equipment data sheets are one section of this document that also includes requirements for safety, facilities services, shipping and receiving, install, startup, acceptance, and training. [SEMI E70]

Fast track—A scheduling method that eliminates float and maximizes parallel activities thereby reducing overall project duration. Selective use of overtime is typically used to reduce the duration of critical path activities. [SEMI E70]

Field fabrication—Assembly and/or modification of components on the job site to accommodate site-specific conditions. [SEMI E70]

Free on board (FOB)—Goods placed on a truck or other means of transportation at a point specified by the seller without charge to the buyer, but with all further transportation at the buyer's expense. [SEMI E70]

Gas interface box (GIB)—An enclosure located between the tool mainframe and facility services containing components for pressure regulation and filtration. Functions to consolidate all gas requirements to single points of connection. Provides location and ability to pre-facilitate tool hookups in advance of tool delivery. [SEMI E70]

Hookup—The set of activities and organization required to accept incoming process equipment, move it into place, connect the equipment to all facilities, and test the connections. The connection of all necessary facilities and interconnects required to make the equipment package fully operational. The hookup activity is complete when all of the following are met:

- The equipment positioning and bolting down is complete.
- The final equipment utility connections and interconnects are complete, tested, and certified.
- The process piping certification is complete. The wall system, including bulkheads as required, is complete.
- Government inspections have been conducted as required. [SEMI E70]

Inertia base—A structural unit using mass damping to attenuate vibration for production equipment. [SEMI E70]

Installation time—Gross time in days to install process equipment, typically starting from dock date to date released for qualification. Net time in actual hours devoted to construction activities related to tool hookup from dock date through completion.

Interconnect—Connections between tool mainframe and peripheral tool subsystem equipment. [SEMI E6]

Labor rate—The contractually stipulated cost of labor. [SEMI E70]

Laterals / sublaterals—Intermediate facility service distribution lines that run between mains and equipment-specific isolation valves. [SEMI E70]

layout fixed—The milestone date when the physical layout of equipment and components is fixed and all stockholders complete approval signoff. [SEMI E70]

Local abatement—Treatment of emissions at the point of generation at the tool. [SEMI E70]

Long lead materials—Material requiring early ordering due to availability or long manufacturing time. [SEMI E70]

Mains / submains—Central distribution lines from a facility services source to which laterals are connected. Individual equipment is not connected directly to mains. [SEMI E70]

Minienvironment—A localized environment created by an enclosure to isolate the product from contamination and people. [SEMI E44, SEMI E45]

Mobilization—Initial assignment of resources to a project resulting in measurable work being accomplished. [SEMI E70]

Move-in date—Milestone date indicating completion of step when processing equipment is moved into designated location in fab. [SEMI E70]

Move-in—The movement of the process equipment from the loading dock into the fab area and into the final taped position. The piece of equipment is defined as the main body of the equipment and all its subsystems, assemblies, and components, excluding the hookup. If major subsystems such as pumps or chillers are missing, move-in will not be considered complete until they arrive. [SEMI E70]

Overtime—Time spent in excess of normal working hours. [SEMI E70]

Pedestal—Structural support element upon which equipment or raised floor rests. [SEMI E70]

Permits—Legal governmental documents granting permission for specific construction activities. [SEMI E70]

Prefacilitation—A stage in the equipment installation process that follows base build and precedes tool hookup. Prefacilitation brings the various facilities services close to the new equipment location, including new facilities services and structural modifications required to prepare the facility to accept the equipment. Also known as rough-in, this step is performed as a time-saving operation. The activity requires the following conditions to be met:

- The raised floor is in (if required).
- The ceiling is in.
- The seismic or isolation frame is in.
- Minienvironment structural frame is in.
- All utilities are within 1.8 meters (6 feet) of the equipment or terminated in a utility box.
- The floor is taped with the equipment location. [SEMI E70]

Prepurchase—Purchase of materials and equipment in advance of total scope definition to accommodate long lead times. [SEMI E70]

Process and instrumentation drawing (P&ID)—A diagram using graphic engineering symbols to represent the components, flows, and functions that make up a process delivery system. [SEMI E70]

Quality assurance / quality control (QA/QC)—Activities performed to ensure compliance with contractually stipulated conditions. [SEMI E70]

Seismic bracing—Structural reinforcement to minimize damage due to earthquakes. [SEMI E70]

Source inspection—Inspection at the equipment manufacturer's factory to confirm configuration details, review modifications, and confirm installation designs prior to shipment of equipment. [SEMI E70]

Specialty gas—Non-bulk process gases typically stored in cylinders and used to supply one or more process tools through specialized manifolds. [SEMI E70]

Subfab—The area within the cleanroom boundaries directly below the production level. [SEMI E70]

Support equipment—Ancillary equipment not part of the main chassis. [SEMI E70]

Tool—Any piece of semiconductor fabrication or inspection equipment designed to process wafers. Often used synonymously with *equipment* in the silicon wafer processing industry. [SEMI E70]

Tool accommodation—A methodology by which semiconductor processing equipment is installed in a cost-effective and timely manner. [SEMI E70]

Tool point of connection (TPOC)—A fitting typically at a valve on a processing tool (either external or internal), the tool end/termination of the hookup. [SEMI E70]

Utility point of connection (UPOC)—A fitting typically located at a valve on a lateral to provide service for a tool, the facilities end/termination of the hookup. [SEMI E70]

Valve manifold box (VMB) / valve manifold panel (VMP)—A metal enclosure and/or panel including distribution valves and components required to distribute gases or liquids to multiple points of use from a single source. [SEMI E70]

5 INSTRUCTIONS AND SAMPLE

The following is a line-by-line description of the items to be included in the tool installation cost spreadsheet, a sample of which appears as Table 1. The blank form shown in Table 1 represents a simple one-page spreadsheet. This document can be copied and filled out or set up in any spreadsheet software. An electronic version in Excel 5.0 is provided with this document for the reader's convenience.

Line 1—Mobilization/Start Date

Record date establishing the initial assignment of resources that result in measurable work being accomplished on the project.

Line 2—Tool Configuration Research

Include cost associated with collection of documentation containing the tool requirements for utilities and installation such as equipment data sheets and process and instrumentation drawings (P&ID). Site-specific exceptions to SEMI E51 and SEMI E49 are identified and reviewed with equipment suppliers. Complete facilities interface specification documentation to be provided by a tool supplier are defined in SEMI E6. Equipment data sheets are one section of this document that also includes requirements for safety, facilities services, shipping and receiving, install, startup, acceptance, and training. See related standards SEMI E6, E49, E51, and E70.

Line 3—Tool Layout Generation

Process tool location is identified by the customer. Physical location is determined by collaboration between production, industrial, and facilities engineering. A layout document of record is generated and approved by all affected parties.

Line 4—Installation Design Detailing

Include time and costs for installation design detailing. Include utilizing interface documentation provided by equipment supplier to generate drawings, get approval, and distribute to contractors.

Line 5—Prepurchased Materials

Cost of long lead-time hookup materials identified and prepurchased should be noted by category in the following lines 6-10. Long lead materials require early ordering due to availability or long manufacturing time. Do not include entries for time on these lines

Line 6—Components

Include material costs for any discrete components required for support services, such as valves, fittings, regulators, gauges, sensors, tubing, fittings, meters, filters, etc.

Line 7—Local Abatement Equipment

Include material costs for any local abatement required for treatment of emissions at the point of generation at the tool.

Line 8—Gas Cabinets

Include material costs for any specialty gas cabinets required for production equipment.

Line 9—Vibration Isolation System

Include material costs for any vibration isolation system or inertia bases purchased to dampen or attenuate vibration for production equipment.

Line 10—Other

Include material costs for any other prepurchased long lead-time materials like electrical breakers, controls, and contamination control equipment.

Line 11—Field Work Start Date

Record date when field fabrication begins on the job site to modify site-specific conditions for equipment.

Line 12—Prefacilitation by Trade

Prefacilitation is performed before tool delivery to provide accurate and quick hookup of the tool on arrival. Time and material costs should be noted by trade/contractor in the following lines 13-18.

Line 13—Plumbing and Pipe Fitting

Include time and material costs for plumbing and pipe fitting of air, process gas, process chemical, water and drain lines. This includes modifications to distribution systems like extension of mains and laterals and installation of valve manifold boxes (VMB) and gas interface boxes (GIB).

Line 14—Architectural

Include time and material costs for architectural construction and modification of walls, floors, ceilings, and isolation. This may also include structural support elements such as pedestals or seismic bracing.

Line 15—Electrical

Include time and material costs for electrical work on power, safety, and data communication lines This may also include tool specific power conditioning equipment such as uninterruptable power supplies (UPS).

Line 16—Sheetmetal

Include time and material costs for sheetmetal work on exhaust, minienvironments, and HVAC.

Line 17—QA/QC and Permitting

Include time and material costs for quality assurance/quality control (QA/QC) activities performed to ensure compliance with contractually stipulated conditions. This may also include legal governmental permitting for specific construction activities.

Line 18—Source Inspection

Include cost related to source inspection of equipment at the supplier's factory. Source inspection should confirm configuration details, review modifications, and confirm installation designs prior to shipment of equipment.

Line 19—Shipping

Include buyers portion of equipment shipping typically sent free on board (FOB). Record shipping costs in materials column. (See related standards SEMI E6 and E49.1)

*Line 20—Subtotal for prefacilitation activity time and costs**Line 21—Delivery/Dock Date*

Record date when the processing equipment, including all ancillary components, is on-site at the loading dock. *Note: This date is typically a break point between prefacilitation activity and hook up activity. In the case where prefacilitation activity extends past delivery/dock date, you have two options: 1) break out costs as pre- and post-delivery activity or 2) break out costs as prefacilitation and hookup activity regardless of delivery/dock date. Option 2 is preferred. In either case, delivery date should be accurate as well as subtotals on lines 20 and 38. Be sure to note which option is used on line 45.*

Line 22—On Site Inspection

Include costs associated with verification that equipment matches supplier provided specifications and is compliant with purchase order. This would include verification of physical dimensions, points of connections, and interface cabling and tubing upon arrival of equipment at the job site.

Line 23—Tool Move-In

Include time and material costs for movement of process equipment from the loading dock into the fab area to the final position. The piece of equipment is defined as the main body of the equipment and all its subsystems, assemblies, and components, excluding the hookup. If major subsystems such as pumps or chillers are missing, move-in will not be considered complete until they arrive.

Line 24—Hook-up by Trade

Hookup is performed to mate process equipment points of connection to utility service connections. The hookup activity begins when equipment is on site and ends when the equipment package is fully operational and ready for qualification. Connections between tool mainframe and peripheral tool support equipment are completed in this phase. Time, labor, and material costs should be noted by trade/contractor in the following lines 25-29.

Line 25—Plumbing and Pipe Fitting

Include time and material costs for plumbing and pipe fitting of air, process gas, process chemical, water, and drain lines.

Line 26—Architectural

Include time and material costs for architectural construction and modification of walls, floors, ceilings, vibration isolation, and pedestals.

Line 27—Electrical

Include time and material costs for electrical work on power, safety, and data communication lines.

Line 28—Sheetmetal

Include time and material costs for sheetmetal work on exhaust and HVAC.

Line 29—QA/QC and Permitting

Include time and material costs for quality assurance/quality control (QA/QC) activities performed to ensure compliance with contractually stipulated conditions. This may also include legal governmental permitting for specific construction activities.

Line 30—Change Orders

Change order documents define a formal change in drawings, specifications, and/or scope of work. Time and material costs noted on change orders should be included by category in the following lines 31-34.

Line 31—Owner Driven

Include costs for changes originated by the device manufacture/customer (i.e., layout change or process chemistry change).

Line 32—Equipment Driven

Include costs for changes originated due to equipment supplier modifications to the tool (i.e., undocumented connections or undocumented maintenance access requirements).

Line 33—Design Driven

Include costs for changes originated due to modifications in installation design detailing (i.e., utility piping/duct interference or distribution system capacity constraints).

Line 34—Other

Include costs for changes due to other reasons (i.e., schedule compression or manpower availability).

Line 35—Final Approval/Sign-off

Include costs for activities performed to receive approval and sign-off from all effected parties.

Line 36—As-built Drawing Update

Include costs to update permanent record drawings showing newly installed tool, actual configuration, and dimensions at the end of construction.

Line 37—Acceleration Costs

Include any additional costs incurred to complete the project sooner than the originally scheduled baseline plan. May include fast track, overtime, and contingency costs.

*Line 38—Subtotal for Post Delivery Activity Time and Costs**Line 39—Hook-up Completion Date*

Record date when the equipment is ready for vendor startup and commissioning. This includes the connection of all necessary facilities and interconnects required to make the equipment package fully operational.

Line 41—Calendar Days from Delivery to Hook-up Completion

Total number of days from tool delivery/dock date to date hookup was completed.

Line 40—Net Installation Man Hours

Total hours devoted to construction activities related to tool hookup from start date through hookup completion.

Line 42—Total Installation Costs

Line 43—Total Tool Capital Cost

Line 44—Installation Cost as % of Tool Cost

Line 45—Notes

Notes on any unusual or extraordinary items relating to installation time and material costs.

Table 1 Tool Installation Time and Cost Spreadsheet

		Equipment Supplier :		Model :				
		Tool Type :		Process :				
		Tool ID # :		Work Order # :				
		Number of Same Tool Previously Installed :						
Item	Activity Description	Duration Days	Duration Labor Hrs.	Percent	Labor \$	Material \$	Total \$	Percent
1	MOBILIZATION/START DATE							
	PRE-DELIVERY ACTIVITY (Design Engineering)							
2	Tool Configuration Research (SEMI E51, E49, E6)							
3	Tool Layout Generation							
4	Installation Design Detailing							
5	Pre Purchased Material (site specific/long lead time)							
6	Components (valves & fittings)							
7	Local Abatement Equipment							
8	Gas Cabinets							
9	Vibration Isolation System							
10	Other:							
11	FIELD WORK START DATE							
	PRE-DELIVERY ACTIVITY (Prefacilitation Field Work)							
12	Prefacilitization by Trade (Pre-delivery)							
13	Plumbing & Pipe Fitting (gases, liquids, drains)							
14	Architectural (walls, floors, ceilings, isolation)							
15	Electrical (power, detection)							
16	Sheetmetal (exhaust, HVAC)							
17	QA/QC							
18	Source Inspection/Factory Visit Confirm Tool Config.							
19	Shipping (SEMI E49.1)							
20	Subtotal Pre-delivery Activity Time and Costs							
21	DELIVERY/DOCK DATE							
	POST DELIVERY ACTIVITY (Hookup)							
22	Tool Configuration Confirmation (SEMI E6)							
23	Tool Move-in							
24	Hookup by Trade (Post-delivery)							
25	Plumbing & Pipe Fitting (gases, liquids, drains)							
26	Architectural (walls, floors, ceilings)							
27	Electrical (power, detection)							
28	Sheetmetal (exhaust, HVAC)							
29	QA/QC							
30	Change Orders							
31	Owner Driven							
32	Equipment Driven							
33	Design Driven							
34	Other:							
35	Final Approval/Sign-off							
36	As-Built Drawing Update							
37	Acceleration Costs (premium time)							
38	Subtotal Post Delivery Activity Time and Costs							
39	HOOKUP COMPLETION DATE							
	TOTALS							
41	Calendar Days from Delivery to Hookup Completion							
40	Net Installation Man Hours							
42	Total Installation Costs							
43	Total Tool Capital Cost							
44	Installation Cost as % of Tool Cost							
45	NOTES							

APPENDIX A

Facility Comparison Information

Location-to-location differences can contribute to substantial variations in tool installation time and cost. To achieve valid benchmarking information, the characteristics of each facility must be taken into account. To do so, the following facility information should be included for each location where installation data is collected. As with any such activity, confidentiality must be maintained to ensure accuracy and completeness of data.

Company:

Facility Name:

Location:

Installation Manager:

Wafer Fab Characteristics:

Cleanroom Configuration	<input type="checkbox"/> Bay & Chase	<input type="checkbox"/> Ballroom	<input type="checkbox"/> Other _____
Support Area Configuration	Number of Sub-levels	0 1 2 3	
Support Area Protocol	Cleanroom Class in support area:		
Use of Minienvironments			
Use of AMHS	<input type="checkbox"/> Interbay	<input type="checkbox"/> Intrabay	
Seismic Zone	Zone	1 2 3 4	
Distribution System	<input type="checkbox"/> Dedicated (single source/single tool)	<input type="checkbox"/> Distributed (single source/multi tool)	

Tool Set Characteristics:

Wafer Size:

Technology (line width):

Manufacturing or R&D:

Tool Accommodation Approach

Managed by	<input type="checkbox"/> In House	<input type="checkbox"/> Construction Manager
	<input type="checkbox"/> Installation Contractor	<input type="checkbox"/> Other _____
Contract Type	<input type="checkbox"/> Time & Materials	<input type="checkbox"/> Not To Exceed
	<input type="checkbox"/> Turnkey	<input type="checkbox"/> Lump Sum
	<input type="checkbox"/> Other _____	

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