SEMI E35-0701
COST OF OWNERSHIP FOR SEMICONDUCTOR MANUFACTURING EQUIPMENT METRICS

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1 Purpose

1.1 The purpose of this guide is to provide standard metrics for evaluating unit production cost effectiveness of factory equipment subsystems in the semiconductor industry. The guideline is appropriate for application to any type of equipment processing semiconductor units, which may be wafers, devices, or other material.

1.2 The guideline establishes a well-defined practice to facilitate an understanding of equipment-related costs by providing definitions, classifications, algorithms, methods, and default values necessary to build a full or constrained cost of ownership (COO) calculator. A number of constraint types are defined. Related Information 1 provides some discussion of COO to expand upon the guideline presentation. Default values which can be used in a COO calculation are presented in Related Information 2 to provide representative data. Such default data are not meant to be a substitute for having actual data appropriate to the process being analyzed.

2 Scope

2.1 The definitions provide a metric which can be applied to any factory equipment system, but are specialized to silicon integrated circuit wafer and device production. The guideline is formulated in terms of units which are wafers or wafer equivalents of the devices produced and is thus appropriate to both front-end and back-end considerations. Application specific guidelines based upon this general guideline will be developed in the future and will address particular aspects of various types of equipment, materials, gases, etc.

2.2 Effective use of the metric to build a COO model requires identification of the constraints, parameter values, and data values within the adopted category classification. Default data is provided in Related Information 2 to this document and may be updated periodically through support documents. Where possible, use direct values for inputs rather than deriving them from secondary models or using default values.

2.3 Full calculation of COO often requires data held proprietary and is coupled to the overall factory through yield and the related cost of yield loss. It is envisioned that this guide will be used for internal factory and equipment optimization as well as investment evaluation by IC manufacturers.

2.4 The companion guide, "Guide for Cost of Equipment Ownership Comparison," is intended for competitive evaluation of equipment and is an alternative to the full analysis defined in this guideline. Both guidelines identify elements that are attributable to the equipment and to the operating decisions made by manufacturers in using the equipment.

2.5 Section 7 lists limitations of the guideline.

2.6 This guideline does not purport to address safety issues, if any, associated with its use. It is the responsibility of the users of this guideline to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

3 Referenced Standards

3.1 *SEMI Documents*

SEMI E10 — Standard for Definition and Measurement of Equipment Reliability, Availability, and Maintainability (RAM)

SEMI E35.1 — Guide for Cost of Equipment Ownership Comparison Metric

SEMI Compilation of Terms

NOTE 1: As listed or revised, all documents cited shall be the latest publications of adopted standards.

4 Terminology

NOTE 2: Additional definitions are contained in Sections 10 and 11, Classification Element Details.

4.1 *Abbreviations and Acronyms*

4.1.1 *CEO* — Cost of equipment ownership

4.1.2 *COO* — Cost of ownership

4.1.3 *CYL* — Cost of yeld loss

4.1.4 *DLY* — Defect limited yield

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4.1.5 *EY* — Equipment yield

4.1.6 *GWE* — Good wafer equivalents

4.1.7 *P/T* — Precision tolerance ratio

4.1.8 *PLY* — Parametric limited yield

4.1.9 *PRY* — Product yield

4.1.10 *PU* — Production utilization

4.1.11 *SR* — Systems required - integer number

4.1.12 *TP* — Throughput

4.1.13 α — Type 1 test yield for false bad

4.1.14 β — Type 2 test yield for false good

4.2 *Definitions*

4.2.1 *baseline cost of ownership* — a constraint version of cost of ownership which only includes equipment yield, i.e., defect limited yield and parametric limited yield are not included.

4.2.2 *comprehensive cost of ownership* — cost of ownership calculated with no constraints.

4.2.3 *constraint version* — cost of ownership version with a set of defined restrictions to facilitate comparisons or to remove ambiguity. An example is baseline as defined in SEMI E35.1, which excludes defect limited yield and parametric limited yield.

4.2.4 *consumables* — cost of all parts of the equipment that are worn out by the process operation of equipment and require replacement after less than one (1) year of operation.

4.2.5 *cost footprint* — the area (A) of the smallest horizontal rectangle that contains all of the shadow footprint and half of the easement space around a tool. This is computed as:

$$A = \left[Wt + 1/2\left(Ws - Wt\right)\right] * \left[Dt + 1/2\left(Ds - Dt\right)\right]$$
$$= 1/4\left(Wt + Ws\right) * \left(Dt + Ds\right)$$

where:
Dt = Depth of tool
Ds = Combined depth of tool and easement space
Wt = Width of tool
Ws = Combined width of tool and easement space

4.2.6 *cost of equipment ownership (CEO)* — a factor in cost of ownership (see Sections 5.1.1 and 8.3).

4.2.7 *cost of ownership* — full cost of embedding, operating, and decommissioning in a factory environment a process system needed to accommodate the required volume of product material (see Section 5.1.1 for further description).

4.2.8 *cost of yield loss (CYL)* — a unit lost at the end of a given step represents the loss of the cost of manufacturing to that point. In addition, units leaving a step may be lost at some later step. Calculating cost of yield loss (CYL) therefore requires knowing the accumulated cost of manufacturing before the wafer is lost. Therefore, cost of yield loss should be tracked as a separate cost for factory optimization. CYL is given in Equation 4.

4.2.9 *default or default value* — value to be used if actual data are not available. In lieu of actual data, data should fall within the range specified by default values given in the Related Information section. Where possible, actual data should be used in COO calculations.

4.2.10 *defect limited yield (DYL)* — devices not lost from defects added by the equipment. For front-end process, defect yield is usually derived from a model.

4.2.11 *easement space* — the floor space that must remain clear to the rear and sides of the tool (but not in front of the load face plane). This includes safety aisles, ergonomic maintenance access space, component removal space, and room for doors to swing out.

4.2.12 *equipment availability* — equipment dependent uptime or the percent of time the equipment is in a condition to perform its intended function during the period of operations time minus the sum of all maintenance delay, out-of-spec input downtime, and facilities-related downtime. This calculation is intended to reflect equipment reliability and maintainability based solely on equipment merit see SEMI E10. (NOTE: Equipment availability is the responsibility of the equipment supplier and should reflect the need for unscheduled maintenance and any scheduled maintenance that cannot be accomplished within the semiconductor manufacturer's standard allotment.)

4.2.13 *equipment production lifetime* — the number of years a piece of equipment is used for manufacturing.

4.2.14 *equipment yield (EY)* — the percentage of units received by the equipment which can be passed to the next step based on any criteria such as damaged material, or material determined to be defective by inspection or test. Inclusion of equipment yield results in a decreasing population of units flowing through the factory. At later steps, equipment will process fewer units than the full factory wafer starts. For test equipment, validly rejected material is scrap, but not a component of equipment yield.

4.2.15 *factory utilization (FU)* — a measure of the allocation for operating hours, scheduled maintenance shifts, and other nonproduction hours as defined by SEMI E10. Expressed as hours and % of 365 × 24 =

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8,760 hours per year. As defined, FU is determined by the semiconductor manufacturer.

4.2.16 *fixed costs* — costs incurred once and usually associated with the acquisition and incorporation of equipment into the factory.

4.2.17 *good wafer equivalents (GWE)* — derived from the number of good product die at wafer probe or devices at test and expressed as completely good product wafers.

4.2.18 *lifetime* — the time over which the fixed and recurring costs are spread for an annualized basis. Examples are: 1) tax lifetime - lifetime used for tax depreciation and 2) equipment production lifetime.

4.2.19 *materials* — bulk gases, specialty gases, general or specialty chemicals used in the process. Test and filler wafers consumed in the support of the equipment.

4.2.20 *monitor units* — test or filler units (wafers or devices) consumed in the support of the equipment. Also called test units.

4.2.21 *parametric limited yield (PLY)* — an estimate of devices that are not lost from device parameters being outside the required range.

4.2.22 *precision-tolerance ratio (P/T)* — characterization of test equipment being used to evaluate product quality for yield determination.

4.2.23 *production utilization (PU)* — a measure of factory utilization and equipment availability expressed as hours and % of 8,760 hrs per year.

PU = factory utilization * equipment availability

As defined, PU has a component attributable to the manufacturer and a component attributable to the equipment supplier.

4.2.24 *product yield (PRY)* — the percentage of units expressed as good unit equivalents which pass through the factory and result in good product. Product yield for wafers is the composite yield from Equation 2. The components are defined in this section. Since defect limited yield (DLY) is generally a wafer level phenomena, Equation 2 may be simplified for other types of units by setting DLY=1. Particle additions are a predictor of defect yield loss at a future step, but not a complete predictor of all the possible loss since there may be other defects or parametric problems.

(See Equation 2, Section 5.5.2).

4.2.25 *recurring costs* — costs that are incurred on an accrued basis.

4.2.26 *rework* — any units being reprocessed by the equipment because of a fault or defect.

4.2.27 *service contract* — an agreement for the supplier to provide equipment maintenance under specified terms and conditions.

4.2.28 *shadow footprint* — the area of the floor space directly under every part of the tool during its operation. This includes any temporary projections from the tool during loading or processing (such as carriers that stick out from the tool or tool load ports that protrude only when the tool is being loaded).

4.2.29 *spare parts* — pre-purchased inventory of components maintained to service the equipment. Repair parts are paid for at the time of repair.

4.2.30 *supplier* — provider of equipment or services to the semiconductor manufacturer, same as a vendor or equipment manufacturer.

4.2.31 *system throughput* — see throughput.

4.2.32 *systems required (SR)* — the integer number of systems required to obtain the throughput for the step.

4.2.33 *test wafers* — see monitor units.

4.2.34 *test yield* — incorrect test determination of a die being good or bad:

α or type 1 is percentage of false bad.

β or type 2 is percentage of false good.

4.2.35 *throughput (TP)* — the number of units (wafers or devices) per hour the process system delivers to the factory, including all input, output, and internal overhead operation. Throughput includes all test or monitor wafers processed, since the cost of these non-product wafers is accounted for directly.

4.2.36 *tool* — often used synonomously with equipment in the silicon wafer processing industry.

4.2.37 *unit* — any wafer, die, packaged device, or piece part thereof (includes product and non-product units) see SEMI E10. For the purposes of this guideline, units are converted to wafer equivalents so that cost of ownership is expressed on a per wafer basis.

4.2.38 *volume requirement* — the number of units required to be processed by the equipment in a specific time period, normally units per week.

4.2.39 *warranty contract or service contract* — an alternate method for handling maintenance beyond that which is supplied with the equipment.

4.2.40 *yield* — see product yield.

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5 Cost of Ownership

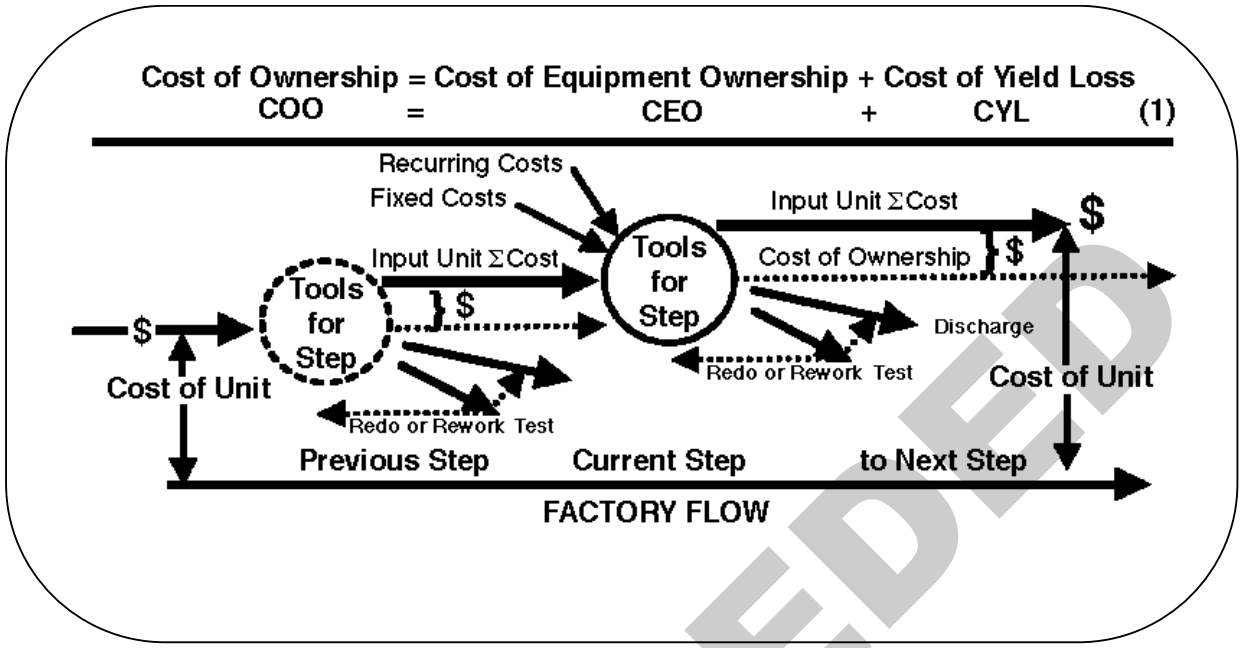

Figure 1
Factory Flow

5.1 *Description*

5.1.1 A cost of ownership metric is the incremental cost added to a unit of good product material flowing through a volume-sized process system embedded in a factory environment for a specified lifetime plus the cost of yield loss. COO is calculated on an annualized basis. The metric is expressed as cost per good wafer equivalents (GWE) for one pass through the system. GWE is determined from the good die yield at wafer probe or at a later stage if appropriate. Figure 1 depicts this accumulation of cost which can be factored into two components, cost of equipment ownership (CEO) and cost of yield loss (CYL).

5.1.2 COO is the full cost of embedding, operating, and decommissioning in a factory environment a process system needed to accommodate the required volume of product material.

5.2 *Constraint Version*

5.2.1 A constraint version of cost of ownership imposes a set of defined restrictions to facilitate comparisons or to remove ambiguity. An example is: baseline cost of ownership which only includes equipment yield, i.e., defect limited yield and parametric limited yield are not included. Cost of ownership calculated with no constraint is referred to as comprehensive.

5.2.2 The constraint type definition will also provide a unique description of the elements included in the classification system defined in Section 9 as well as other details. SEMI E35.1, "Guide for Cost of Equipment Ownership Comparison Metric," is a specific constraint version equivalent to a baseline cost of ownership.

5.3 *Lifetimes*

5.3.1 The time over which the fixed and recurring costs are spread for the annualized basis is the equipment production lifetime. Tax life-depreciation is customarily used in COO, based upon standard accounting practice.

5.3.2 The equipment usually remains in production much longer than the tax life, so it is often useful to consider the equipment production lifetime in evaluating the value of equipment.

COO Lifetimes

1. Tax life - depreciation

2. Equipment production lifetime

5.4 *CEO: Fixed and Recurring Costs*

5.4.1 Determining CEO requires enumerating all of the fixed and recurring costs that are incurred in the life cycle of the equipment. Fixed costs are those incurred once and are usually associated with the acquisition and

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incorporation of equipment into the factory. Recurring costs are those which arise on an annual basis from the operation and maintenance of the equipment. The calculation is shown in Section 8.

5.5 *Yield*

5.5.1 Yield is a metric of the percentage of the unit volume that results in good product. Yield affects the cost of ownership in a number of ways.

1. Volume of units that must be processed for the required product requirements.

2. Cost of units that do not produce good product.

5.5.2 Product yield (PRY) is the percentage of units expressed as good unit equivalents which pass through the factory and result in good product. Product yield for wafers is the composite yield from Equation 2. The components are defined in Section 4. Since defect limited yield (DLY) is generally a wafer-level phenomena, Equation 2 may be simplified for other types of units by setting DLY = 1. Particle additions are a predictor of defect yield loss at a future step, but not a complete predictor of all the possible loss since there may be other defects or parametric problems.

$$\mathrm{PRY} = \mathrm{EY} \times (1 - \alpha) \times (1 - \beta) \times \mathrm{DLY} \times \mathrm{PLY} \times (1 - \mathrm{Rework}) \quad (2)$$

5.6 *Cost of Yields*

5.6.1 A unit lost at the end of a given step represents the loss of the cost of manufacturing to that point. In addition, units leaving a step may be lost at some later step. Calculating cost of yield loss (CYL) therefore requires knowing the accumlated cost of manufacturing before the wafter is lost. Therefore, cost of yield loss should be tracked as a separate cost for factory optimization. CYL is given in Equation 4 in Section 8.1.

5.7 *Volume Requirement*

5.7.1 The volume requirement is the unit flow to be processed and can be derived from specification of the product units needed corrected for yield and the number of other units required to be processed by equipment in a specific time period such as those being redone. One complication in accurately dealing with the volume requirement is that the volume of units actually reaching the equipment will depend on the volume loss from equipment yield for all the prior steps. One common approach is to deal with volume parametrically.

5.8 *Good Wafer Equivalents (GWE)*

5.8.1 Good wafer equivalents (GWE) is derived from the number of good product units or good product die at wafer probe or at a later stage, if appropriate, and is expressed as completely good wafers.

5.9 *Systems Required*

5.9.1 Once the volume is specified, the number of systems required (SR) is obtained from the throughput (TP), and the production utilization (PU).

$$\mathrm{SR} = \mathrm{VOLUME\ REQUIRED}/(\mathrm{TP} \times \mathrm{PU}) \quad (3)$$

6 Reporting Results

6.1 Reports on cost of ownership should always show the following items. Other data items should be reported as required by clarity.

6.1.1 *Input Items*

1. Identification of standard conformance

2. Declarations

   1. Classification system: functional, cost center, or other
   2. Summed categories: all or enumerate
   3. Volume requirement
   4. Factory utilization
   5. Equipment availability
   6. Production utilization
   7. Equipment throughput
   8. Number of systems and chambers

6.1.2 *Output Items:*

1. Cost per unit

2. Classification summary cost distribution

3. Related statistics

7 Limitations

7.1 Certain factors are more difficult than others to accurately determine. Figure 2 depicts the relation-ship of some of the cost of ownership factors. Thus, the accuracy of a cost of ownership calculation may be prone to a variety of errors or omissions.

7.2 In addition, line balance considerations are not included in cost of ownership calculation. Line balance considerations are not included because an individual COO model does not have the capability to know what impact the process being modeled has on the rest of the fab.

7.3 A cost of ownership calculation may have more detail than presented explicitly in this guideline. The structure of the guideline, however, allows for the proper handling of these situations.

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8 Procedures

8.1 *COO Calculation*

8.1.1 The COO algorithm requires the specification or calculation of the volume level, the determination of the number of systems required to process the volume, the enumeration of all fixed and recurring costs associated with processing the volume by the systems, and the yield related costs. The COO metric is a function defined by equation 1 to be:

$$COO = CEO + CYL$$

The cost of yield loss (CYL), is given by Equation 4, and is broken into two components. The CEO component is described in Equation 5 and is expressed in Equation 6 as the sum of a number of categories which constitute a classification system. The classification system is described in Section 9. Constrained versions of COO restrict certain elements included in calculation.

8.1.2 The algorithm for CEO is depicted in diagrams presented in Related Information 1. The CEO is expressed as a sum over the elements in the Category Table 1 as expressed in Equation 5. Each item in the classification system is defined, and a method for evaluating its expression given as described in Section 9. Default values or handling are specified in Related Information 2. All costs must be assigned through the defined classification system and calculated per system for the number of production hours.

8.1.3 Figure 2 depicts some of the elements in terms of the difficulty in establishing various costs.

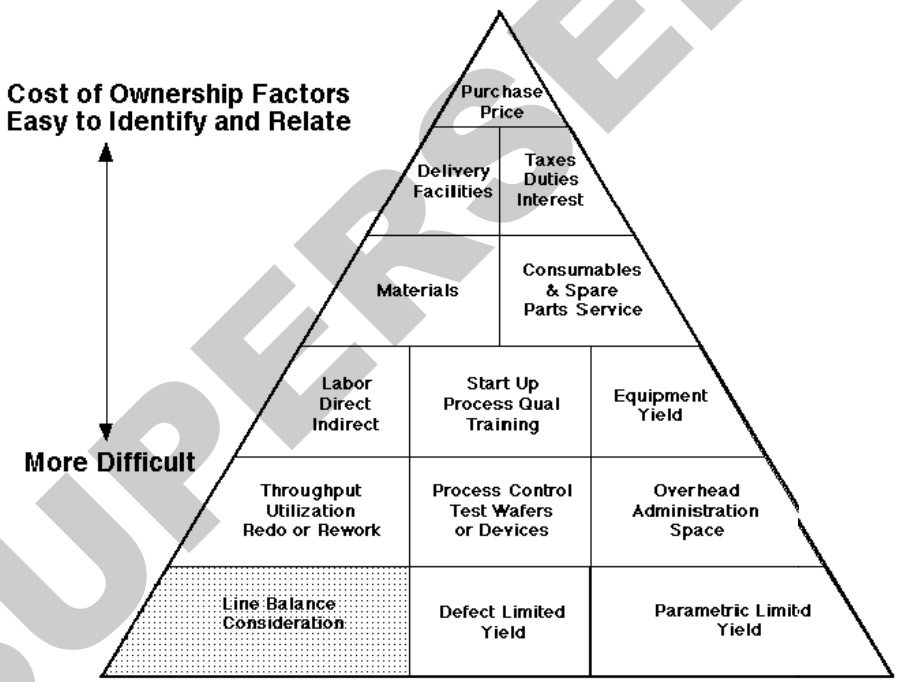

Figure 2

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8.2 *Cost of Yield Loss*

$$\text{CYL} = \begin{pmatrix} \text{annualized} \\ \text{cost of} \\ \text{wafers lost to} \\ \text{equipment yield} \end{pmatrix} + \begin{pmatrix} \text{annualized} \\ \text{attributed cost of} \\ \text{wafers lost to} \\ \text{die \& parametric yield} \end{pmatrix} * \frac{1}{\begin{matrix}\text{good units} \\ \text{per year}\end{matrix}} \tag{4}$$

8.3 *Cost of Equipment Ownership*

$$\text{CEO} = \begin{pmatrix} \text{annualized} & \text{annualized} \\ \text{fixed cost} & + \text{recurring cost} \\ \text{per system} & \text{per system} \end{pmatrix} * \frac{\begin{matrix}\text{volume required} \\ \text{\# systems}\end{matrix}}{\begin{matrix}\text{good units} \\ \text{per year}\end{matrix}} \tag{5}$$

$$= \left(\sum_j F_{j0} + \sum_k R_{k0} \right) * \left(\frac{\begin{matrix}\text{volume required} \\ \text{\# systems}\end{matrix}}{\begin{matrix}\text{good units} \\ \text{per year}\end{matrix}} \right) \tag{6}$$

$$= \left(\sum_{ij} F_{ij} + \sum_{kl} R_{kl} \right) * \left(\frac{\begin{matrix}\text{volume required} \\ \text{\# systems}\end{matrix}}{\begin{matrix}\text{good units} \\ \text{per year}\end{matrix}} \right) \tag{7}$$

Where j and k are the number of primary categories in Table 1, and ij and kl are the number of detailed elements in Sections 10 and 11.

8.3.1 Fj0 and Rk0 are the primary categories in Table 1 and in the expansions shown in Sections 10 and 11. Fij and Rkl are the detailed elements, each of which is defined.

9 Cost Classifications and Categories

9.1 Cost classifications may be defined as a tree starting with the superclass/class category structure shown in Table 1. The superclass structure starts from the fixed and recurring cost categories. Detailed element expansion is shown in Sections 10 and 11. Equation 5 shows the way the tables are used to represent the CEO calculation. The purpose of this format is to remove ambiguity that often results in trying to follow calculations done with spreadsheets.

Note that any class expansion should give the same results since they are just different views of the same fixed and recurring costs.

9.2 Subclass elements may be expanded into further items and then summed up to the next level if more detail is required. The cost center example in Table 1 is one view of the categories. Another view is given in section 11 for a functional view of the costs. Note that since both views are summing the same fixed and recurring costs, they give equivalent results. Category tables can be developed as required to expose particular details of the cost structure with the requirement that the table be reported in the documentation.

9.3 Constrained versions of the COO calculation are created by defining a modification of the calculation such as the way yield is included or in restricting the items in the classification tables that are used.

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Table 1 Example Classification Structure for Expanding COO

VIEW	*SuperClass*		*Class*	*SubClass*
Cost Center	Fixed	1	Equipment	
		2		
		3		
	Recurring	1	Consumables	
		2	Material	
		3	Maintenance	
		4	Labor	
		5	Support personnel	
		6	Scrap	
		7	Support Services	
		8		
		9		

This set is similar to the original Sematech COO model. Another example is given in Section 11, which is called a Functional Classification. Definitions used by both classification examples are included in the guideline.

10 Classification Element Details: Cost Center

Fixed Cost Classification

CF	*1*	*2*	*3*	*4*
.0	*Equipment*			
.1	Depreciation			
.2	Qualification			
.3	Installation			
.4	Training			
.5	Moves & Rearrange			
.6	Floor Space			
.7				

Recurring Cost Classification

CR	*1*	*2*	*3*	*4*	*5*	*6*	*7*
.0	*Material*	*Consumables*	*Maintenance*	*Labor*	*Support Personnel*	*Scrap*	*Support Services*
.1	Test/Filler Wafers		Labor	Operation	Supervision	Equipment Yield	
.2	Utilities		Spare Parts		Engineering	Defect Yield	
.3	Supplies		Repair Parts			Parametric Yield	
.4	Waste Disposal		Service Contract				
.5			Training				
.6							
.7							

On the following pages are given the definitions of the items included in the classification and the methods for calculating the items if the values are not available. Default values are given in Related Information 2.

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CF1.0 Equipment

Definition	Fixed cost categories associated with the purchase of equipment.
Method	Sum of all subcategories.

CF1.1 Equipment: Depreciation

Definition	Equipment purchase price divided by the appropriate depreciation schedule.
Method	Any accepted depreciation schedule (straight-line, double declining balance, etc.).

CF1.2 Equipment: System Qualification

Definition	The cost of qualifying for production.
Method	Expressed in person-hours of expended effort and material costs.

CF1.3 Equipment: Installation

Definition	The cost of installing a system for production.
Method	Expressed in terms of actual cost.

CF1.4 Equipment: Training

Definition	The initial training requirements for new equipment for operators, supervision, engineers, and maintenance personnel.
Method	The training person-hours for each personnel classification will be multiplied by their respective burdened wage or salary. Training course costs will be added if applicable.

CF1.5 Equipment: Moves & Rearrangements

Definition	The cost of displacing existing equipment in order to install the new equipment.
Method	Provided by semiconductor manufacturer.

CF1.6 Equipment: Floor Space

Definition	The cleanroom overhead allocated to the equipment.
Method	The cost footprint of the equipment is multiplied by the cost of cleanroom space for each class of cleanroom space utilized.

CR1.0 Material

Definition	Material cost categories associated with the operation of equipment.
Method	Sum of all subcategories.

CR1.1 Material: Test/Filler Wafers

Definition	Test and/or filler wafers consumed in the support of the equipment.
Method	Number of wafers consumed multiplied by the cost of the wafer.

CR1.2 Material: Utilities

Definition	Cost of electricity, city water, deionized water, and chilled water used by the equipment.
Method	Cost of electricity, city water, deionized water, and chilled water per system per year.

CR1.3 Material: Supplies

Definition	Cost of all supplies used by, or in support of, the equipment to produce water. This would include bulk gases, specialty gases, and specialty chemicals.
Method	Cost of supplies per system per year.

CR1.4 Material: Waste Disposal

Definition	Removing spent chemical or effluent. Gas exhaust charges.
Method	Cost per system per year.

CR2.0 Consumables

Definition	Cost of all parts of the equipment that are worn out by the process operation of equipment and require replacement after less than 1 year of operation.
Method	Consumable costs per system per year.

CR3.0 Maintenance

Definition	Maintenance cost categories associated with the operation of a manufacturing equipment.
Method	Sum of all subcategories.

CR3.1 Maintenance: Labor

Definition	IC manufacturer's internal repair and maintenance labor costs.
Method	Scheduled and unscheduled downtime are calculated by the COO model from E10 inputs and multiplied by the maintenance labor rate. Actual cost may be affected by warranty and service contract coverage.

CR3.2 Maintenance: Spare Parts

Definition	Spares Inventory Cost of IC manufacturer.
Method	Spare parts costs per system per year.

CR3.3 Maintenance: Repair Parts

Definition	Repair parts charged to the IC manufacturer.
Method	Repair parts costs per system per year.

CR3.4 Maintenance: Service Contracts

Definition	Service contracts charged to the IC manufacturer.
Method	Service contract costs per system per year.

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CR3.5 Maintenance: Training

Definition	The ongoing training requirements for operators, supervision, engineers, and maintenance personnel.
Method	The training costs per system per year.

CR4.0 Labor

Definition	Labor cost categories associated with the operation of a manufacturing equipment.
Method	Sum of all subcategories.

CR4.1 Labor: Operation

Definition	The operator labor required to support the equipment set needed to meet the wafer start requirements of the IC manufacturer.
Method	Calculated by the COO model from equipment and tab specifications.

CR5.0 Support Personnel

Definition	Support personnel cost categories associated with the operation of a manufacturing equipment.
Method	Sum of all subcategories.

CR5.1 Support Personnel: Supervision

Definition	The supervisor labor required to support the equipment set needed to meet the wafer start requirements of the IC manufacturer.
Method	Supervision person-hours/week multiplied by the burdened salary rate.

CR5.2 Support Personnel: Engineering

Definition	The engineering labor required to support the equipment set needed to meet the wafer start requirements of the IC manufacturer.
Method	Engineering person-hours/week multiplied by the burdened salary rate.

CR6.0 Scrap

Definition	Scrap cost categories associated with the operation of a manufacturing equipment.
Method	Sum of all subcategories.

CR6.1 Scrap: Equipment Yield

Definition	The percent of units that are not broken or irreversibly misprocessed by the equipment.
Method	(1- Equipment Yield) multiplied by the value of the unit at that step in the process.

CR6.2 Scrap: Defect Yield

Definition	The percent of equivalent wafers that are not lost due to electrical malfunctions caused by particulate defects.
Method	(1- Defect Yield) multiplied by the value of the wafer at the end of the process. Defect yield is calulated by the COO model using a modified Seed's formula. $$Y = \frac{1}{1 + (A_a \times D \times P)}$$ Where A_a is the active area of the device, D is the defect density, and P is the probability that a defect will be fatal.

CR6.3 Scrap: Parametric Yield

Definition	The percentage of equivalent wafers that are not lost due to electrical malfunction caused by device parameters being outside the required range.
Method	(1- Parametric Yield) multiplied by the value of the wafer at the end of the process.

CR7.0 Support Services

Definition	Support services cost categories associated with the support of a manufacturing equipment.
Method	Support service cost per system per year.

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11 Classification Element Details: Functional

View	*SuperClass*		*Class*	*SubClass*
Functional	Fixed	1	Acquisition	
		2	Facilities	
		3	Decommission	
	Recurring	1	Factory Interface	
		2	Equipment Management	
		3	Maintenance	
		4	Control	
		5	Inputs	
		6	Operation Labor	
		7	Quality/Performance	
		8	Non-Product Waste	
		9	Product Waste	

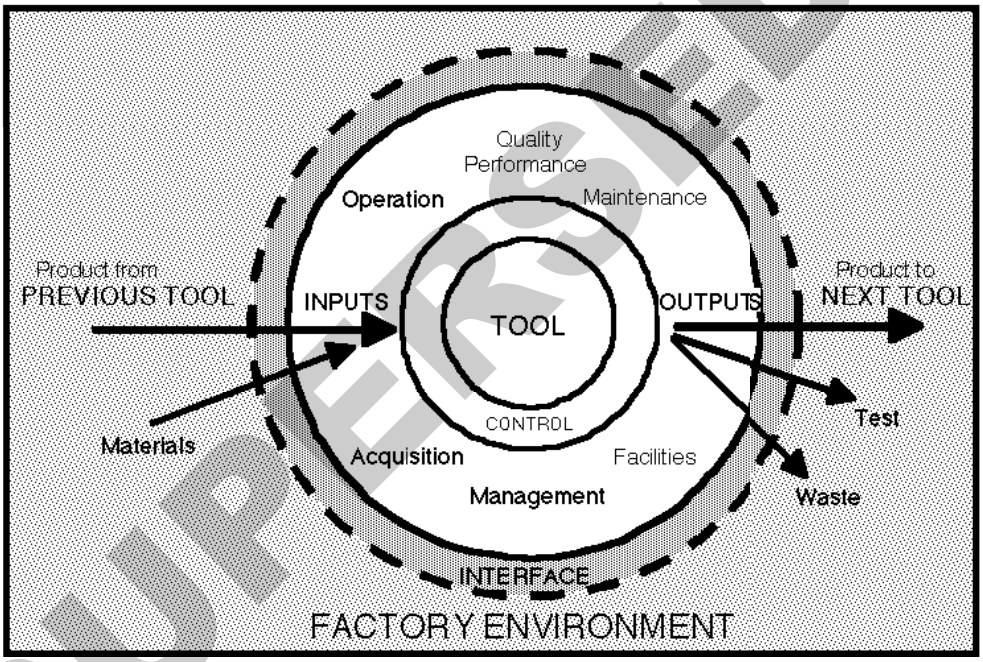

Figure 3
Functional Categories, Cost of Ownership

SUPERSEDED

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