

SEMI E140-0312

GUIDE TO CALCULATE COST OF OWNERSHIP (COO) METRICS FOR GAS DELIVERY SYSTEMS

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1 Purpose

1.1 The purpose of this Guide is to provide standard cost of ownership (COO) metrics for evaluating unit production cost effectiveness of gas delivery systems in the semiconductor and related industries.

1.1.1 Gas delivery systems include gases delivered from a solid, liquid, or gaseous source.

1.2 This Guide also illustrates how to apply the COO metrics to gas delivery systems. Users should be able to calculate the COO for any gas delivery equipment using this Guide.

NOTE 1: A spreadsheet has been provided as an illustrative example in the Supplemental Materials: Other Files and Materials section of the SEMI Standards Web site. It uses the example values found in Related Information 1.

1.3 The Guide establishes a well-defined procedure to facilitate an understanding of equipment-related costs by providing definitions, classifications, algorithms, methods, and default values necessary to build a full or constrained COO calculator.

2 Scope

2.1 This Guide defines a COO metric that can be applied to any gas delivery system. Some terms are specialized to integrated circuit wafer and device production, but may be adapted for other applications in related industries.

2.2 Effective use of the metric to build a COO model requires identification of constraints and data values. Where possible, use direct values for inputs rather than deriving them from secondary models or using example values.

NOTE 2: Related Information 1 provides some example data.

2.3 Full calculation of COO often requires data held proprietary and is coupled to the overall factory yield and the related cost of yield loss. It is envisioned that this Guide will be used for internal factory and equipment optimization, investment evaluation, and equipment design and process improvements.

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 Certain factors are more difficult than others to accurately determine. Figure 1 depicts the relationship of some of the COO factors to ability to collect and validate information. The accuracy of a COO calculation may be prone to a variety of errors or omissions.

3.2 Bottleneck, cycle time, and line balance interrelationships are not included in the COO calculation. They are not included because it is difficult, in an individual COO model, to show the impact of equipment being modeled on the complete manufacturing factory. A factory-level cost and/or simulation model should be used for these purposes.

3.3 A COO calculation may have more detail than presented explicitly in this Guide. The structure of the Guide, however, allows for these situations.

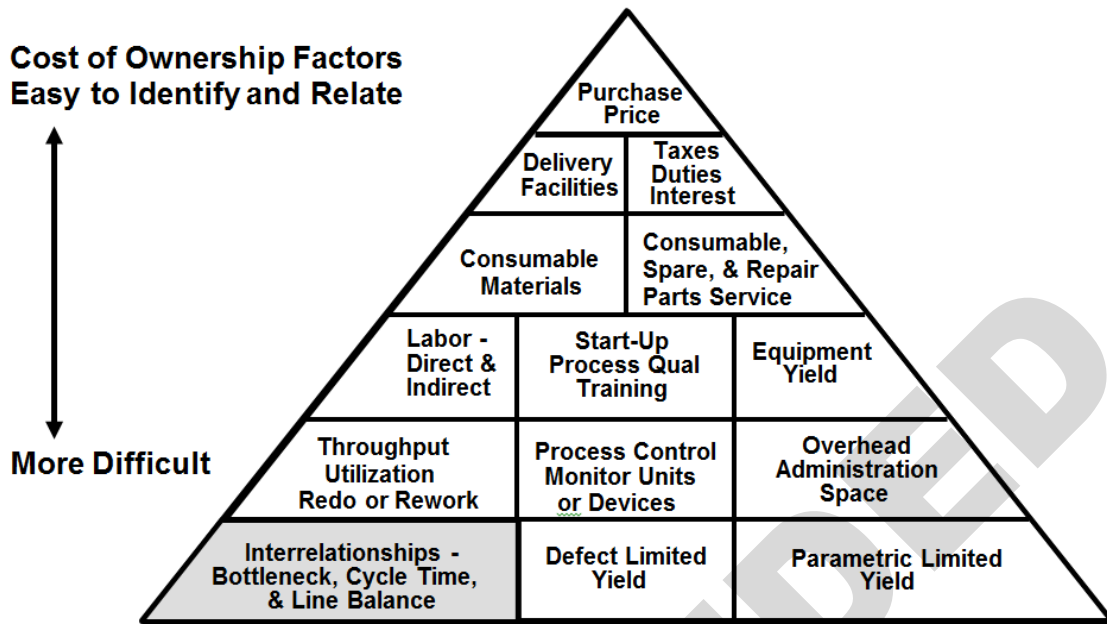


Figure 1
Relationship of Cost Factors to Difficulty of Collection and Validation

4 Referenced Standards and Documents

4.1 SEMI Standards and Safety Guidelines

SEMI E35 — Guide to Calculate Cost of Ownership (COO) Metrics for Semiconductor Manufacturing Equipment

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

5 Terminology

5.1 Abbreviations and Acronyms

- 5.1.1 *CF* — cost footprint (of the equipment)
- 5.1.2 *COO* — cost of ownership
- 5.1.3 *CYL* — cost of yield loss
- 5.1.4 *DLY* — defect limited yield
- 5.1.5 *ER* — equipment required (integer number)
- 5.1.6 *EY* — equipment yield
- 5.1.7 *OEM* — original equipment manufacturer
- 5.1.8 *PLY* — parametric limited yield
- 5.1.9 *PRY* — product yield
- 5.1.10 *TP* — throughput
- 5.1.11 *TU* — total utilization

5.2 Definitions

- 5.2.1 *baseline cost of ownership* — a constrained version of cost of ownership (COO) that only includes equipment yield (i.e., defect limited yield and parametric limited yield are not included). [SEMI E35].

- 5.2.2 *component part* — a constituent part, which can be separated from or attached to an assembly, not normally considered capable of independent operation. Also sometimes just called ‘part’. [SEMI E149]
- 5.2.3 *comprehensive cost of ownership* — cost of ownership (COO) calculated with no constraints. [SEMI E35]
- 5.2.4 *constrained cost of ownership* — cost of ownership (COO) version with a set of defined restrictions to facilitate comparisons or to remove ambiguity. [SEMI E35]
- 5.2.5 *consumable material* — the material used by or in support of the equipment system at any time. Examples include gases (e.g., Ar, air), liquids (e.g., acids, solvents, ultrapure water, cooling water, mold compounds), solids (e.g., reticles, targets, implant sources, bonding wire, lead frames). Examples do not include equipment component parts (e.g., consumable parts), support tools (e.g., carriers, probe cards), production substrates (e.g., wafers, die, assembly components), monitor/filler units (e.g., test wafers), and facility utilities (e.g., electricity, exhaust). [SEMI E10]
- 5.2.6 *consumable part* — component part of the equipment that is consumed by the process operation of the equipment with a predictable life expectancy of less than one year. It requires periodic replacement with another component part to allow equipment to perform its intended function. [SEMI E35]
- 5.2.7 *cost footprint (CF)* — the area of the smallest horizontal rectangle that contains all of the shadow footprint and half of the easement space around the equipment. [SEMI E35]
- 5.2.8 *cost of ownership (COO)* — full cost of embedding, operating, and decommissioning in a factory environment equipment needed to accommodate the required volume of units actually processed through the equipment. [SEMI E35]
- 5.2.9 *cost of yield loss (CYL)* — a unit lost at the end of a given step represents the loss of the cost of the starting unit and the manufacturing to that point. In addition, units leaving a step may be lost at some later step. Calculating CYL therefore requires knowing the starting unit cost and the accumulated cost of manufacturing before the unit is lost. Therefore, CYL should be tracked as a separate cost for factory optimization. [SEMI E35]
- 5.2.10 *default or default value* — a value to be used if actual data are not available. Also called example value. [SEMI E35]
- 5.2.11 *defect limited yield (DLY)* — the fraction of units that are not lost from defects added by the equipment. For wafer processing, defect yield is usually derived from a model. [SEMI E35]
- 5.2.12 *easement space* — the floor space that must remain clear to the rear and sides of the equipment (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. [SEMI E35]
- 5.2.13 *equipment* — the combination of hardware and software required to perform an operation or activity (e.g., processing, transporting, storing), including all direct auxiliary support or peripheral equipment (e.g., vacuum pumps, heat exchangers, effluent/exhaust treatment equipment). [SEMI E149]
- 5.2.14 *equipment required (ER)* — the integer number of equipment required to obtain the throughput required for the step. [SEMI E35]
- 5.2.15 *equipment throughput* — see throughput. [SEMI E35]
- 5.2.16 *equipment yield (EY)* — the fraction of units received by the equipment that can be passed to the next step based on any criteria such as damaged units, or units 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 unit starts. For test equipment, validly rejected units are scrap, but not a component of equipment yield. [SEMI E35]
- 5.2.17 *gas delivery system* — a system installed in semiconductor manufacturing equipment to deliver process and carrier gases to reactors, which typically consists of tubing, fittings, valves, filters, mass flow controllers and regulators; can be surface mount or conventional system. [SEMI F71]
- 5.2.18 *fixed costs* — costs incurred once and usually associated with the acquisition and incorporation of equipment into the factory. [SEMI E35]
- 5.2.19 *lifetime* — the time over which the fixed and recurring costs are spread on an annualized basis. [SEMI E35]

- 5.2.19.1 *production lifetime* — the number of years the equipment is used for manufacturing. [SEMI E35]
- 5.2.19.2 *tax lifetime* — the number of years as defined in compliance with local tax or accounting depreciation practices. [SEMI E35]
- 5.2.20 *monitor unit* — test or filler unit (e.g., wafer, device) consumed in the support of the equipment. Also called test unit. [SEMI E35]
- 5.2.21 *parametric limited yield (PLY)* — the fraction of units that are not lost from device parameters being outside the required range. [SEMI E35]
- 5.2.22 *product yield (PRY)* — the fraction of units that pass through the factory and result in good product. Product yield for units is the composite of all sources of yield loss. [SEMI E35]
- 5.2.23 *recurring cost* — cost that is incurred on an ongoing basis, based on time and/or usage. [SEMI E35]
- 5.2.24 *repair part* — component part to service the equipment purchased at the time of repair. [SEMI E35]
- 5.2.25 *service contract* — an agreement for the supplier to provide equipment service or maintenance under specified terms and conditions beyond that which is supplied with the equipment. [SEMI E35]
- 5.2.26 *shadow footprint* — the area of the floor space directly under every part of the equipment during its operation. This area includes any temporary projections from the equipment during loading or processing (e.g., carriers that stick out from the equipment or equipment load ports that protrude only when the equipment is being loaded). [SEMI E35]
- 5.2.27 *spare part* — prepurchased inventory of a component part maintained to service the equipment. [SEMI E35]
- 5.2.28 *supplier* — provider of equipment and related services to the user (e.g., unit manufacturer). Also called equipment vendor or original equipment manufacturer (OEM). [SEMI E10]
- 5.2.29 *test unit* — see monitor unit. [SEMI E35]
- 5.2.30 *throughput (TP)* — the number of units (e.g., wafers, devices) per hour the equipment delivers to the factory, including all input, output, and internal overhead operation. TP includes all test or monitor units processed, since the cost of these nonproduct units is accounted for directly. [SEMI E35]
- 5.2.31 *total utilization (TU)* — the percent of productive time during total time. This calculation is intended to reflect bottom-line equipment utilization.
- 5.2.32 *unit* — any wafer, die, packaged device, or piece part thereof (includes product and nonproduct units). [SEMI E35]
- 5.2.33 *volume requirement* — the number of units required to be processed by the equipment in a specific time period, normally units per week. [SEMI E35]
- 5.2.34 *yield* — see product yield. [SEMI E35]

5.3 Symbols

- 5.3.1 *De* — depth of the equipment.
- 5.3.2 *Ds* — combined depth of the equipment and easement space.
- 5.3.3 *We* — width of the equipment.
- 5.3.4 *Ws* — combined width of the equipment and easement space.

6 Description of COO Model

- 6.1 *COO Model Calculation* — The formula for calculating COO is given in Equation 1.

$$COO = (F\$ + R\$ + Y\$) / (L \times TP \times PRY \times TU) \quad (1)$$

where:

F\$ = annualized fixed costs, \$

R\$ = annualized recurring costs, \$

$Y\$$ = annualized yield costs (CYL), \$

L = production lifetime of equipment, hrs

TP = throughput, units/hr

PRY = product yield, dimensionless

TU = total utilization, dimensionless

6.1.1 $F\$$ is calculated by summing the fixed cost categories and elements F_{ij} in Table 1 in SEMI E35.

6.1.2 $R\$$ is calculated by summing the recurring cost categories and elements R_{ij} in Table 2 in SEMI E35.

6.1.3 $Y\$$ is calculated by summing the recurring scrap cost categories and elements in Table 3 in SEMI E35.

NOTE 3: Note that the EHS-related cost categories and elements in Tables 4, 5, and 6 in SEMI E35 are not specifically included or excluded in this Guide, but may be included in the COO calculation if they are included in user inputs for the appropriate category inputs.

6.1.4 The parameters L and TP are input directly into the model.

6.1.5 The model calculates PRY from user inputs on numbers of units lost due to EY , DLY , and PLY .

6.1.6 The model calculates TU from inputs for scheduled and unscheduled downtime maintenance time, standby time, qualification time, engineering time, and nonscheduled time.

6.1.7 While the cost terms used specific currency units of dollars as an example, any currency may be used as long as it is applied consistently throughout the model.

6.2 Cost Footprint

6.2.1 The cost footprint (CF) is the area of the smallest horizontal rectangle that contains all of the shadow footprint and half of the easement space around the equipment. This is calculated in Equation 2 as:

$$\begin{aligned} CF &= [W_e + (1/2) \times (W_s - W_e)] \times [D_e + (1/2) \times (D_s - D_e)] \\ &= (1/4) \times (W_e + W_s) \times (D_e + D_s) \end{aligned} \quad (2)$$

where:

D_e = Depth of the equipment,

D_s = Combined depth of the equipment and easement space,

W_e = Width of the equipment, and

W_s = Combined width of the equipment and easement space.