

SEMI E140-0305

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

This guide was technically approved by the Global Metrics Committee and is the direct responsibility of the North American Metrics Committee. Current edition approved by the North American Regional Standards Committee on December 10, 2004. Initially available at www.semi.org February 2005; to be published March 2005.

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 industry.

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 piece of gas delivery equipment using this guide.

NOTE 1: A spreadsheet (Microsoft® Excel) has been provided as an illustrative example.

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.

NOTICE: This guide 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 Limitations

3.1 Effective building of a COO model requires identification of constraints and data values. Example data is provided in this document and may be updated periodically. Where possible, use direct values for inputs rather than deriving them from secondary models or using example values.

3.2 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.

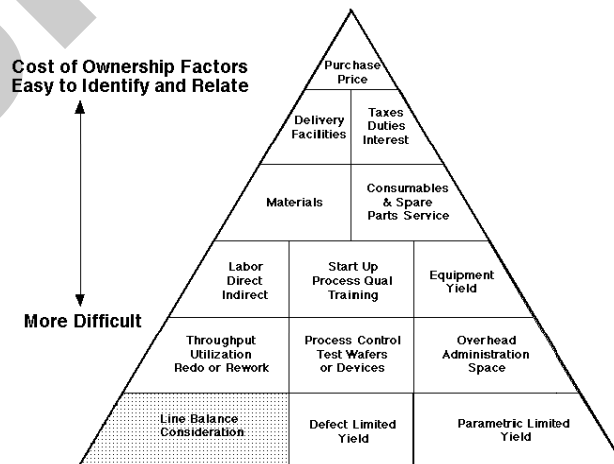


Figure 1
Relationship of Cost Factors to Difficulty of Collection and Validation

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.

4 Referenced Standards

4.1 SEMI Standards

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

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 COO — Cost of ownership

5.1.2 CYL — Cost of yield loss

5.1.3 DLY — Defect limited yield

5.1.4 ER — Equipment required (integer number)

5.1.5 EY — Equipment yield

5.1.6 PLY — Parametric limited yield

5.1.7 PRY — Product yield

5.1.8 PU — Production utilization (total)

5.1.9 TP — Throughput

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].

5.2.2 *comprehensive cost of ownership* — cost of ownership (COO) calculated with no constraints.

5.2.3 *constrained cost of ownership* — cost of ownership (COO) version with a set of defined restrictions to facilitate comparisons or to remove ambiguity.

5.2.4 *consumable* — part of the piece of equipment that is worn out by the process operation of the piece of equipment and requires replacement after less than one year of operation.

5.2.5 *cost footprint* — the area (A) of the smallest horizontal rectangle that contains all of the shadow footprint and half of the easement space around the piece of equipment. This is calculated as:

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

where:

De = Depth of the piece of equipment

Ds = Combined depth of the piece of equipment and easement space

We = Width of the piece of equipment

Ws = Combined width of the piece of equipment and easement space

5.2.6 *cost of ownership (COO)* — full cost of embedding, operating, and decommissioning in a factory environment equipment needed to accommodate the required volume of production units.

5.2.7 *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 accumulated cost of manufacturing before the unit is lost. Therefore, CYL should be tracked as a separate cost for factory optimization.

5.2.8 *default or default value* — a value to be used if actual data are not available. Also called example value. Where possible, actual data should be used in COO calculations.

5.2.9 *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.

5.2.10 *easement space* — the floor space that must remain clear to the rear and sides of the piece of 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.

5.2.11 *equipment required (ER)* — the integer number of pieces of equipment required to obtain the production throughput required for the step.

5.2.12 *equipment throughput* — see throughput.

5.2.13 *equipment yield (EY)* — the percentage of units received by the piece of 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.

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

5.2.15 *lifetime* — the time over which the fixed and recurring costs are spread on an annualized basis.

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

5.2.15.2 *tax lifetime* — the number of years as defined in compliance with local tax or accounting depreciation practices.

5.2.16 *material* — bulk gas, specialty gas, or general or specialty chemical used in the process. Includes monitor units consumed in the support of the piece of equipment.

5.2.17 *monitor unit* — test or filler unit (e.g., wafer or device) consumed in the support of the piece of equipment. Also called test unit.

5.2.18 *operational uptime (OU)* — the percentage of time the piece of equipment is in a condition to perform its intended function during the period of operations time. This calculation is intended to reflect overall operational performance for a piece of equipment (SEMI E10).

5.2.18.1 *Discussion* — As defined, OU has components attributable to both the unit manufacturer and to the equipment supplier.

5.2.19 *parametric limited yield (PLY)* — the fraction of units that are not lost from device parameters being outside the required range.

5.2.20 *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.

5.2.21 *recurring cost* — cost that is incurred on an ongoing basis based on time and/or usage.

5.2.22 *repair part* — component to service the piece of equipment purchased at the time of repair.

5.2.23 *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 piece of equipment.

5.2.24 *shadow footprint* — the area of the floor space directly under every part of the piece of equipment during its operation. This area includes any temporary projections from the piece of equipment during loading or processing

(e.g., carriers that stick out from the piece of equipment or equipment load ports that protrude only when the piece of equipment is being loaded).

5.2.25 *spare part* — prepurchased inventory of a part maintained to service the piece of equipment.

5.2.26 *supplier* — provider of equipment or services to the unit manufacturer. Also called equipment vendor or equipment manufacturer.

5.2.27 *test unit* — see monitor unit.

5.2.28 *throughput (TP)* — the number of units (e.g., wafers, devices) per hour the piece of 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.

5.2.29 *unit* — any wafer, die, packaged device, or piece part thereof (includes product and nonproduct units).

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

5.2.31 *yield* — see product yield.

6 Description of COO Model

6.1 *COO Model Calculation* — The formula for calculating COO is given in Equation 2.

$$\text{COO} = (\text{F\$} + \text{R\$} + \text{Y\$}) / (\text{L} \times \text{TP} \times \text{PRY} \times \text{OU}) \quad (2)$$

where

F\$ = annualized fixed costs, \$

R\$ = annualized recurring costs, \$

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

L = lifetime of piece of equipment, yrs

TP = throughput, units/yr

PRY = product yield, dimensionless

OU = operational uptime, dimensionless

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

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

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

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 wafers lost due to EY, DLY, and PLY.

6.1.6 The model calculates OU from inputs for scheduled and unscheduled maintenance (including assists), standby time, qualification time, engineering time, and the scheduled production hours.

6.1.6.1 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.