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Inside

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Hi-Tech Equipment Reliability A Practical Guide for Engineers and the Engineering Manager

By Dr. Vallabh H. Dhudshia
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High-Tech Equipment Reliability Series

WWK recently received permission to reprint sections from Dr. Vallabh H. Dhudshia's book, *Hi-Tech Equipment Reliability: A Practical Guide for Engineers and Managers*. This book, first published in 1995, is now *back in print:*

http://www.iuniverse.com/bookstore/book_detail.asp?isbn=978-0-595-69727-4

Dr. Dhudshia has been an equipment reliability specialist with Texas Instruments and with Xerox Corporation. He served as a Texas Instruments assignee at SEMATECH for three years. Dr. Dhudshia received a Ph.D. in IE/OR from New York University. He is an ASQ fellow and a senior member of ASME. He has developed and taught courses in equipment reliability overview and design practices. He is an affiliate of WWK, specializing in reliability consulting.

In this issue of Applied Cost Modeling we are reprinting Chapter 7. We hope that you find the information in this series useful.

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Editorial Board

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Calendar of Events

January 2009

11-14 **Industry Strategy Symposium (ISS)**
The Ritz-Carlton
Half Moon Bay, CA

14-16 **Strategic Materials Conference (SMC)**
The Ritz-Carlton
Half Moon Bay, CA

20-22 **SOLARCON Korea**
COEX
Seoul, Korea

February 2009

1-3 **ISS Europe**
Hilton Hotel Dresden
Dresden, Germany

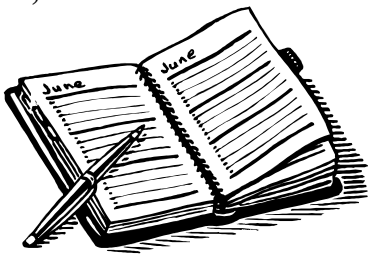
March 2009

17-19 **SOLARCON China**
Shanghai New Intl Expo Centre
Shanghai, China

29-30 **SEMI North America Standards Meeting**
Vancouver Marriott Pinnacle Downtown
Vancouver, Canada

April 2009

1-3 **SEMI North America Standards Meeting**
Vancouver Marriott Pinnacle Downtown
Vancouver, Canada



Equipment and Equipment Program Life Cycle Phases

Before we describe any life cycle phases, let us first understand the difference between equipment and equipment program. Equipment refers to an individual unit of equipment with a unique serial number that is used by a specific customer. It may be identical to other units, but it has a unique serial number.

On the other hand, an equipment program represents all the activities from concept of the equipment line to the discontinuation of the equipment line. This includes design, prototype testing, and production of an entire generation of one equipment line. In a specific equipment program, many individual units of equipment are manufactured and sold. Also, the basic equipment design during an equipment program remains almost unchanged, although it progressively improves from first release to last.

For example: A customer buys a plasma etcher model EZ2, serial number 112, from an equipment supplier. For the customer, the plasma etcher serial number 112 is equipment. For the supplier, it is a unit (sample) of the plasma etchers model EZ2 equipment program.

Now let us understand life cycle phases of the equipment and equipment program. A working knowledge of these phases enables proper planning and execution of the activities and functions necessary for design-in, build-in, and management of reliability growth in a cost effective manner.

7.1 Equipment Life Cycle Phases

The life of typical equipment has three phases:

Early life: This phase is also known as the infant mortality phase. Failure rate during this phase decreases with equipment age because the problems due to manufacturing errors, insufficient burning-in or screening, and improper debugging after the final assembly are removed over time and increased experience.

Useful life: This phase is also known as the constant failure rate phase. The failure rate remains at a constant level after decreasing from a high level during the early life phase. All the failures in this phase are categorized as random or chance failures.

Wear-out life: During this phase, the failure rate starts going up again because critical parts are wearing out. These three life cycle phases are shown in figure 2.7. (ACM Spring 2007)

7.2 Equipment Program Life Cycle Phases

An equipment program life cycle begins when the idea for the equipment design is conceived and ends when the equipment is no longer manufactured. The equipment program life cycle is divided into the following six phases.

1. Concept and feasibility phase
2. Design phase
3. Prototype phase
4. Pilot production phase
5. Production phase
6. Phase-out phase

There are two ways of executing the above phases: (i) sequential format, and (ii) concurrent format in which the work is carried out on a number of equipment life cycle phases simultaneously in parallel, instead of working sequentially through the phases. The recent trend is to use the

concurrent format, as described in chapter 15. Let us examine these phases in detail.

Concept and Feasibility Phase

The life cycle begins here. The need for new equipment is identified, and alternative approaches to fulfilling that need are explored. The need could be driven by existing equipment that can no longer perform its intended functions or by customer requirements that no existing equipment can provide.

During this phase, marketing and sales personnel, customer service representatives, design and reliability engineers, and manufacturing engineers work with the customer to:

- Determine the need for new equipment
- Establish reliability goals
- Evaluate the feasibility of meeting these goals
- Examine alternative design concepts
- Perform preliminary cost tradeoffs

Design Phase

The alternative design concepts, selected during the concept and feasibility phase, are explored in more detail by the design engineers during this phase of the life cycle. Reliability and manufacturing engineers, as well as quality assurance and field service personnel, are generally called on by the design engineers for input regarding parts selection, serviceability, and manufacturing processes. Also, reliability goals set for the equipment during the concept and feasibility phase are translated into requirements for subsystems and components very early in the design phase.

Most of the designing-in reliability activities are performed during this phase. These activities include:

- Simplification of equipment design
- Derating
- Use of proven components and methods
- Redundancy
- Design reviews

Chapter 8 elaborates the above activities.

Several iterations of design review and redesign are required before a design is ready for prototype construction. Design reviews are important for measuring the progress of design requirements and for gaining management approval to proceed with the prototype phase of the life cycle. These reviews are conducted in parallel with the design process.

Prototype Phase

Specific designs that are selected during the design phase are built and tested to determine if all design requirements are met. The prototype phase provides the first opportunity to validate the entire design and is commonly called alpha-site evaluation. Selected customers are included in alpha-site evaluations and are asked to provide feedback on all aspects of the equipment. Multiple design alternatives are required for prototyping and testing whenever a serious question exists concerning the best overall choice.

Design reviews are continued to give the customer an opportunity to review the latest design being considered.

Concurrent with redesigns and design reviews, reliability engineers, quality assurance personnel, and manufacturing engineers develop quality and reliability improvement plans, design inspection and testing programs, set up production facilities, and develop production plans in preparation for the pilot production phase.

Pilot Production Phase
This phase of the life cycle serves as a bridge between the prototype phase and the production phase. The purpose of the pilot production phase is to identify and correct manufacturing problems with the equipment before full-scale production begins. This is the first opportunity for the production equipment to be evaluated in an extended customer environment, and it is commonly called a beta-site evaluation. In fact, it is the first time that the equipment is exposed to a customer's manufacturing processes.

Design and reliability engineers evaluate the actually observed level of equipment reliability. From this they can determine what needs to be done to meet requirements in a cost effective manner. Prior to the production and operation phase of the life cycle, reliability and design engineers continue design reviews to evaluate equipment reliability level and make the appropriate recommendations. This is the last opportunity to make design changes and other improvements before full production.

Production Phase
This phase of the life cycle represents the time when units are produced and sold. All major reliability problems are identified and corrected prior to the production phase. A formal program is in place (similar to that described in section 8.5) for collecting and analyzing field service data, identifying root causes of problems, and implementing corrective actions.

After proper review, decisions are made for resource allocation and for continuous improvement in the reliability level. The supplier and customer function as partners in these efforts.

Phase Out Phase
The equipment product line approaches the end of its useful life during this final phase of the life cycle. The end of production phase for an equipment manufacturer can occur due to obsolescence or lack of demand. To remain competitive, the manufacturer has to make plans for the next generation of equipment before phasing out the current-generation production.

Basically, each new generation of equipment will go through the same life cycle. The knowledge gained during the six phases of the life cycle is retained so it can be used to improve future generations of similar or new equipment.

7.3 Applying Applications of the Reliability Metrics during Equipment Life Cycle Phases

Figure 7.1 shows the six equipment life cycle phases in relation to the three application categories of reliability metrics (described in chapter 3 - ACM Summer/Fall 2007). The figure shows whether they should be derived or if they should be used for a comparison purpose in each phase. This figure provides a guideline for proper use of the reliability metrics throughout the equipment life cycle phases. For example:

- Desired values are derived during the feasibility phase. They are used to compare with either theoretical or observed values during the rest of the life cycle phases.
- The theoretical values are derived during the design phase. They are used to compare either with goals or with observed values during the rest of the life cycle phases.
- The goals (desired values) are not derived during the production phase.

Application of Reliability Metrics	Equipment Life Cycle Phase					
	Feasibility	Design	Prototype	Pilot Production	Production	Phase Out
Desired Values						
Analytical Values						
Observed Values						

Derived Used for Comparison

Figure 7.1 Proper Uses of Applications of Reliability Metrics throughout Equipment Life Cycle Phases

Spire Corp. Teams with Wright Williams & Kelly, Inc.

Partnership Looks to Further Increase Spire's Advantages in PV Market

Wright Williams & Kelly, Inc. (WWK), the global leader in operational cost modeling for high-tech industries, is proud to announce the continuation of its decade long support of productivity improvements in photovoltaic manufacturing, an industry vital to U.S. national interests for energy independence. WWK has joined with Spire Corporation (Nasdaq: SPIR), a global solar company providing turnkey solar factories and capital equipment to manufacture and test photovoltaic (PV) modules and cells, in a strategic partnership to provide Spire's clients with an unprecedented view of their production costs and return on investment.

"We offer our customers cost effective solar technology at both the cell and module level," stated Spire's Chairman and CEO, Roger Little. "By adding Factory Commander® we now have a world-class tool for performing sophisticated business analyses with our customers. Factory Commander® allows Spire to address real world business complexities more accurately and quickly than ever before. In turn, this provides our customers a distinct advantage in getting the most profit from their investments."

David Jimenez, WWK's President commented, "We are pleased to be working with such a forward-looking firm as Spire. Rapid changes in the solar business, coupled with increased investments, have made the environment too complex for companies to adequately analyze their business opportunities and risks using homegrown spreadsheets. Spire's move to integrate Factory Commander® into their business practices will provide their customers with the most realistic view of projected operating costs and profitability, providing Spire and their clients a distinct competitive advantage."

Spire Corporation is a global solar company providing turnkey production lines and capital equipment to manufacture photovoltaic cells and modules worldwide. Spire Semiconductor develops and manufactures custom gallium arsenide solar cells and other related products. For corporate or product information, contact Spire Corporation, "The Turnkey Solar Factory Company," at 781-275-6000, or visit www.spirecorp.com.

With more than 3,000 users worldwide, Wright Williams & Kelly, Inc. is the largest privately held operational cost management software and consulting company serving technology-dependent and technology-driven organizations. WWK maintains long-term relationships with prominent industry resources including SEMATECH, SELETE, Semiconductor Equipment and Materials International (SEMI), and national labs and universities. Its client base includes nearly all of the top 20 semiconductor manufacturers and equipment and materials suppliers as well as leaders in nanotechnology, micro-electro-mechanical systems (MEMS), thin film record heads, magnetic media, flat panel displays (FPD), and photovoltaics (PV).

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Wright Williams & Kelly, Inc. Adds to Solar Base

Partners with Innovative Photovoltaic Business to Drive Down Manufacturing Costs

Wright Williams & Kelly, Inc. (WWK), the global leader in cost and productivity management software and consulting services, announced today the addition of a revolutionary photovoltaic manufacturer to its client list. In recent weeks, WWK has added additional turnkey PV suppliers, individual PV equipment suppliers, and PV cell manufacturers to its client base.

This new solar manufacturing client has added both TWO COOL® for cost of ownership and Factory Commander® for business analysis. Their use of these software modeling tools will help them optimize their vendor relationships, including the proliferation of cost of ownership requirements to their supply base, and internal operations. These tools allow a detailed understanding of individual process step costs and holistic business level value. The ability to look at costs as intelligently as possible is essential in their efforts to achieve grid parity.

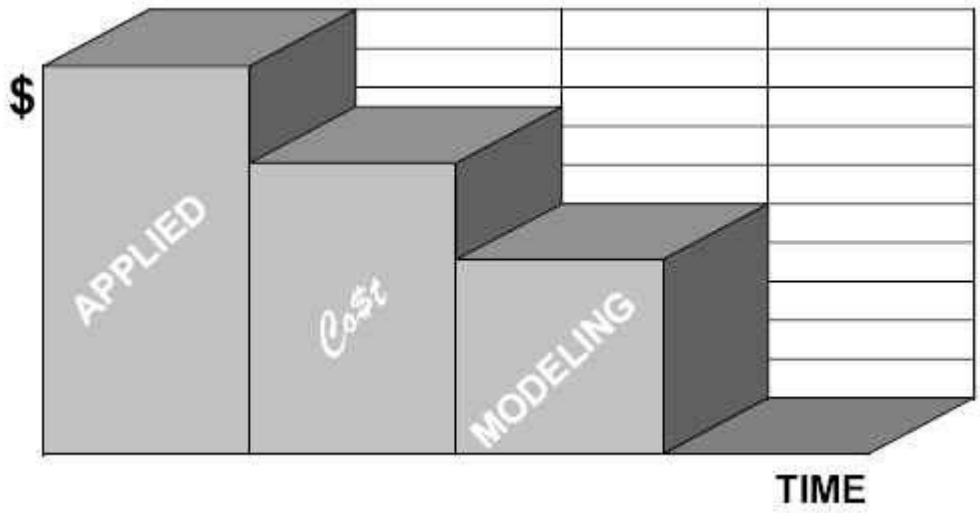
With more than 3,000 users worldwide, Wright Williams & Kelly, Inc. is the largest privately held operational cost management software and consulting company serving technology-dependent and technology-driven organizations. WWK maintains long-term relationships with prominent industry resources including SEMATECH, SELETE, Semiconductor Equipment and Materials International (SEMI), and national labs and universities. Its client base includes nearly all of the top 20 semiconductor manufacturers and equipment and materials suppliers as well as leaders in nanotechnology, micro-electro-mechanical systems (MEMS), thin film record heads, magnetic media, flat panel displays (FPD), and photovoltaics (PV).

WWK's product line includes TWO COOL® for detailed process step level cost of ownership (COO) and overall equipment efficiency (OEE), PRO COOL® for process flow and test cell costing, Factory Commander® for full factory capacity analysis and activity based costing, and Factory Explorer® for cycle time reduction and WIP planning. Additionally, WWK offers a highly flexible product management software package that helps sales forces eliminate errors in product configuration and quotation processes.

Semiconductor FABTECH Highlights Special Feature from Wright Williams & Kelly, Inc.

FABTECH's 38th Edition is now available as a free download at www.fabtech.org. This edition includes a feature paper on page 14 from WWK. The paper provides a review of WWK's annual survey of semiconductor industry insiders and is entitled "2008 Semiconductor Manufacturing Survey Results and the Fabs of 2013." The topics examined include current and next generation lithography as well as the always hot topic of 450mm wafer manufacturing.

WWK will once again be conducting its survey in early 2009. If you would like to receive your summary results as soon as they are available, don't forget to participate. Participation is the only guarantee of having access to the results. Please contact WWK at info@wwk.com to make sure you are on our mailing list.



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