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Book Review

"PRODUCT RELIABILITY, MAINTAINABILITY, AND SUPPORTABILITY HANDBOOK," edited by Michael Pecht, CRC Press, New York, NY, 1995, 413 pages, $89.95.

REVIEWED BY ANTHONY J. RAFANELLI[1]

This reviewer had the privilege of using the book as a secondary reference while instructing a professional development course in Product Reliability. Therefore, it is from a teaching point of view that the review is given. Generally speaking, the book is well written and provides a very comprehensive overview on all aspects of reliability and maintainability. The book could have been enhanced by providing more illustrative examples in each chapter. However, it serves its "handbook" function very well as a desk manual for the practicing reliability engineer. One interesting quality is how the concept of life cycle is continuously mentioned throughout most of the chapters. This quality is very critical since engineers need to consider the reliability of a design from conception right through to logistic support (and aftermarket). Simply accounting for reliability during design and verification becomes an injustice to the consumer in that the latter's critical life cycle concerns, i.e. warranty, repair, aftermarket, etc., greatly influence purchase of the specific item and purchases of future items under the company name.

Chapter 1 deals with Product Effectiveness and Worth. The emphasis is on life cycle of a product: specifically on the design team and customer appreciating all aspects of life cycle such as concept formulation, R & D, production, operation, and disposal. Perhaps the idea of life cycle would have been improved with the inclusion of "maintainability" or "maintenance", as a specific aspect also, i.e., warranty and non-warranty repair also would have included "after market" as an aspect (if applicable.) The author(s) do a nice job of characterizing attributes of product effectiveness, such as operational readiness and availability, dependability, capability, reliability, and maintainability. Also, there is an interesting presentation of the effects of time components (administration, logistics, active repair and operating) on product effectiveness.

Chapter 2 addresses Probability Concepts and begins with basic set theory. The chapter provides a very adequate presentation of all basic probability rules, theorems, and concepts (which adds "handbook" value to the book and enhances its value to those in industry.) One comment is that the inclusion of typical criteria or guidelines for the use of each probability distribution would have been useful. In addition to the basics, the chapter also includes some relatively advanced concepts that will greatly aid researchers.

Chapter 3 is entitled Statistical Inference Concepts and covers statistical estimation hypothesis testing and regression model fitting. Included are sections that describe accelerated life models while, appearing very general, are relatively advanced. Some additional information on specific, traditionally used models such as Van Hoff, Arrhennius, for example would be beneficial to the "industrial" reliability engineer.

Chapter 4 discusses Practical Reliability Concepts. It does a good job of presenting the basic life distributions such as geometric, binomial, exponential, etc.

In Chapter 5, the author(s) discuss Hardware Reliability. This chapter is one of the strongest in the entire book. The beginning of the chapter provides a good treatise on the significance of understanding all aspects of failure, i.e. mode, mechanism, etc. While advocating reliability assessment through modeling, the author(s) wisely emphasize the degree of uncertainty with this approach and reiterate the value of "comprehensive validation through field data." The chapter is well organized in discussing such topics as generic failure mechanisms, analytical techniques for evaluating failure stresses, reliability qualification and validation techniques, and quality assessment techniques with respect to the impact of manufacturing processes. In particular, this reviewer found the term "deadhesion" to be novel and enlightening as, apparently it is a term to generally describe an interface failure whether it be a delamination in a composite material or adhesive failure in a bonded joint. Section 1, of the chapter, addresses failure mechanisms and models. Subsection 1.7 provides a very concise presentation of adhesive strength with respect to interfacial or surface tension. Coffin-Manson fatigue concepts are nicely summarized in Subsection 1.8 as is creep in 1.9. The mechanism of wearout, not usually highlighted in failure analysis tools, methodologies, references, etc. is included in Subsection 1.10. Additional subsections address the other mechanisms such as interdiffusion effects on aging, particle radiation effects on aging, corrosion, and metal migration. In short, Section 1, is an excellent resource for the failure analyst in identifying and correlating observed failure mechanisms. Other sections worth highlighting are Section 4, addressing reliability prediction techniques which provide an illustrative case study using the physics of failure approach for a wirebond assembly problem. Section 6 provides good qualitative information with regard to performing qualification and accelerated life tests. Similarly, Section 8 provides a good overview on manufacturing issues including process qualification, manufacturability, process variability, defects, yields, and process verification.

Software Reliability is addressed in Chapter 6. The chapter appears to cover all of the basics of software quality control and reliability assurance including a presentation on software development (e.g. waterfall life-cycle) and techniques to improve and assess software reliability.

Maintainability Concepts and Analyses are dealt with in Chapter 7. Included is a very good presentation of maintainability concepts: measures, requirements, program, design, verification, and preventative maintenance. The elements of a maintainability program are nicely summarized. Also, mentioned is

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designing for serviceability. It was refreshing to see this concept highlighted and emphasized. How many of us have had difficulty changing oil filters or installing new stereo systems in our vehicles? With respect to the customer's view of life cycle cost, design for serviceability is a very influencing factor in a customer's decision to purchase a product. Today's economy forces a consumer to perform as much servicing as possible! Therefore, a serviceable product, from a customer's point of view, would enhance the value of the product to the customer and improve the product's life cycle. Also worth mentioning is Section 8 which discusses preventative maintenance (PM) scheduling and portrays the importance of tradeoffs in PM planning with regard to cost of in-service failures versus cost of scheduled replacement.

Chapter 8 is entitled Design for Product Effectiveness. The organization and content of this chapter is such that it would greatly compliment Concurrent Engineering and Quality Functional Deployment. Several key factors are highlighted as considerations during the design phase including user requirements, life cycle environment, general guidelines/techniques, operability, environment, maintainability, and design reviews/controls.

Chapter 9 discusses Reliability Analysis of Redundant and Fault-Tolerant Products. Section 1, in covering static redundancy, discusses combinatorial modeling. In addition to series, parallel, and series-parallel connections, a very good explanation of non series-parallel connections, such as pathsets and conditional systems, is provided. This particular discussion is well done since it has been the experience of this reviewer that explanations of conditionals of system components has been lacking in some reliability books. Redundancy is comprehensively discussed as is time dependence (MTTF, hazard rate), dynamic redundancy (MARKOV MODELING), dependent failures, coverage modeling, and bounded approximate models.

Chapter 10, entitled Reliability Models and Data Analysis for Repairable Products, provides a thorough discussion on fault repair (*F-R*) processes, data analysis, estimation, goodness-of-fit, and confidence intervals.

The subject of Chapter 11 is Continuous Reliability Improvement. Basically, the chapter addresses the reliability growth process and the test, analyze, and fix (TAAF) methodology of reliability improvement. A good portrayal of a reliability improvement program is provided. A flow diagram, for failure analysis, is presented and appears to be "flexible" in that in could be adapted for specific products, approaches, and directions. A stress margin testing section includes discussion on highly accelerated life testing (HALT). There is also a section on continuous growth models including Duane, AMSAA, and discrete models.

Logistics Support is the topic of Chapter 12. In general, the chapter serves to emphasize the effects of logistics and after market concerns on the life cycle of a product. Logistics is comprised of many elements, all of which contribute to life cycle from cost and schedule perspectives. The influence of logistics resources on reliability is included.

Chapter 13 addresses Product Effectiveness and Cost Analysis. The first section presents a framework for quantifying effectiveness using Markov processes. Section 2 discusses factors requiring thought in analyzing product effectiveness. The third section illustrates a cost effectiveness analysis.

Dr. Pecht and his contributing authors should be congratulated on producing a fine work. **Product Reliability, Maintainability, and Supportability Handbook** is a very "usable" book and should be a part of the serious reliability engineer's library. The book represents a comprehensive collection of all the necessary aspects of performing reliability analyses and also provides in-depth information on maintainability and supportability which enhances, what this reviewer feels is the key theme throughout the book, comprehension of every aspect of life cycle in reliability analysis.