

Book Reviews

HAROLD F. DODGE and HARRY G. ROMIG, *Sampling Inspection Tables, Single and Double Sampling*, 2nd. ed. Revised and Expanded. New York: John Wiley and Sons, Inc., 1959. xi, 224 pp. quarto, \$8.

The ground-breaking work of Dodge and Romig in the development of sampling inspection came to its culmination with publication of their sampling tables in the *Bell System Technical Journal* in January, 1941. These were later put together with mathematical and other explanatory material and published by Wiley in book form in 1944. The *Tables* have for many years been used widely in industry and their contributions to the spread of sound quality control methods was in good measure responsible for the authors being individually awarded the Shewhart Medal, Dodge in 1949, Romig in 1953.

The sampling plans of the Dodge-Romig *Tables* are minimum total inspection plans, i.e., they are so designed as to yield, for a specified process average, a minimum long range average amount of inspection, including the inspection of rejected lots as well as inspection of the sample. They are indexed with reference to the Average Outgoing Quality Limit (AOQL) and the Lot Tolerance Per cent Defective (LTPD) (the latter for a Consumer's Risk of 10%) and are classified with respect to lot size and process average. They thus stand in contrast to the *Mil. Std.* tables, subsequently published by the Department of Defense, which are indexed with respect to Average Quality Level (AQL) only.

The numerical tables of the revised edition are the same as the numerical tables of the original edition except for minor changes in lay-out. Since the new volume has approximately double the dimensions of the old (the new pages are now 8-1/2" x 11"), the tables are set in larger size print. The term Process Average and the symbol $\bar{p}$ also now appear at the head of *each* column instead of only in the margin. Both these changes will increase the accuracy and ease of using the tables. A minor change that the reviewer did not like was the omission from the LTPD tables themselves of any statement of the Consumer's Risk.

The major changes in the volume as a whole are the addition of Operating Characteristic curves and the enlargement of the introductory chapter to include detailed directions of how to choose a sampling plan. The content of the original text in Chapters 1, 2, and 3 remains substantially unchanged.

One hundred and nine pages of the new edition are used to present the OC curves of the tabulated AOQL plans. Generally four charts are shown on each 8-1/2" x 11" page and the charts frequently contain 5 or 6 curves each. Like the numerical tables, the curves are indexed by AOQL's and grouped by lot sizes. OC curves for single sampling plans are based on exact binomial formulas, but those for double sampling plans are based on the Poisson approximation when sample sizes are large.

In the text, methods are given for deriving approximate OC curves for the tabulated LTPD plans from the curves given for the AOQL plans. Eight pages are also used to present a general set of OC curves for single sampling plans for $c = 0, 1, 2, 3$ and $n \leq 500$. These curves are indexed with respect to c and grouped according to values of n .

In their discussion of OC curves, Dodge and Romig distinguished Type A and Type B OC curves. Type A OC curves are defined as curves showing the probability of accepting a lot as a function of *lot* quality. Type B OC curves are defined as curves showing the probability of accepting a lot as a function of *process* quality. The authors point out that Type B curves are identical with Type A curves for $N = \infty$, since if lots can be viewed as random samples from a controlled process with fraction defective p , their lot qualities will be binomially distributed and samples from such lots may be treated as if they were actually samples taken directly from an infinite universe having a fraction defective p .

The OC curves given in the *Tables* are all Type B OC curves, i.e., they show what percentage of lots would be accepted if the *process* is running (in control) at the p level. The

authors point out that "while not so designated in the original published papers of Chapters 1 and 2, the Consumer's Risk, as used there, is more specifically, the Consumers' A Risk, and the Producers Risk, as used there, is the Producers' B Risk," (p. 56.)

This publication of the OC curves for the Dodge-Romig AOQL plans is a welcome addition to the original tables and will make the plans more generally useful. Reiteration of their emphasis upon AOQL type plans may also possibly induce the federal government to reconsider the AOQL aspects of *Mil. Std.* plans.

As noted above, Dodge and Romig base the "optimum" character of their plans squarely on the attainment of a minimum quantity of total inspection. It was therefore a little disappointing to the reviewer that they did not at some place in the revised edition discuss recent approaches to the problem of sampling inspection that seek to minimize overall cost, including the cost of passing a defective unit as well as the cost of inspection. The authors, however, do give the user of the tables the following advice. "In choosing a value of LTPD (or AOQL), consider and compare the cost of inspection with the economic loss that would ensue if quality as bad as the LTPD were accepted often (or if the *average level* of quality were greater than the AOQL). Even though the evaluation of economic loss may be difficult, relative values for different levels of per cent defective may often be determined." (p. 6.)

Acheson J. Duncan

RONALD A. HOWARD "Dynamic Programming and Markov Processes," (Technology Press and Wiley: 1960) pp. 136, \$5.75.

Statisticians, industrial engineers, operations research analysts and other technical personnel are frequently called upon either to provide counsel or to execute the solution of problems involving models or operational systems. This short, easy to read, and highly stimulating book will be helpful to such people in framing and solving certain types of mathematical models.

The author's purpose is to develop a computational technique—similar to dynamic programming—for solving particular problems arising from Markov processes. These problems pose the following question: how to maximize the attainment of some "reward", which is linked to a Markov process, through the manipulation of a parameter (the available policies). The iterative method suggested by Howard offers the advantage of being adequately descriptive, computationally feasible and usually providing the solution in a small number of iterations.

Chapter 1 deals with discrete-time Markov processes. The author presents a simple example of a Markov process in the behavior of a frog in a lily pond. Each lily pad is a state of the system. At a given point in time the frog occupies the i 'th pad (the i 'th state where $i = 1, 2, \dots, N$) and he leaps from pad to pad at random. If he moves at the end of equal discrete-time intervals and if his transition time is instantaneous, we have a discrete-time Markov process. The probability of moving from state i to state j for every state may be known. It is thus possible to define a transition matrix which consists of all transition probabilities.

At an early stage of the analysis the author introduces a generating function called a z -transform. The z -transform provides both limiting state probabilities (i.e. the probability distribution of state occupancy after a large number of leaps, or time intervals) and an expression for evaluating the transient behavior of the system. This is followed by a discussion of the application of the z -transform to systems portraying multichain and periodic behavior.

Chapter 2 introduces a reward variable, which is assumed to be a function of the transition made by the system. This implies that the reward depends upon the transition matrix. In the case involving our frog, the reward structure could emerge from a set of friendly wagers between another party and oneself and hence, from my point of view, some rewards could be positive, others negative. In the author's models, the dimension of the reward is arbitrary, so one can deal with dollars or physical units.

After introducing a definition of "expected reward", which is dependent upon the initial state, the z -transform is applied to the definition to facilitate deriving total "expected rewards" as a function of time. In this case the process is assumed to have but one recurrent chain.

Suppose now that we are able to influence the movements of the frog (by perhaps prodding him with an electric shock). If, while he is sitting on the i 'th pad, the charge is applied to his head, his response may be described by a new vector of transition probabilities. There may be k alternative body locations to which the charge may be applied. For each pad which he may occupy we arbitrarily assign a particular surface of the frog's anatomy for prodding, i.e. to each state one, and only one, surface is assigned. This N -component vector of assignments is called a "policy". There exist, of course, a number of policies, depending upon N and the number of alternative body surfaces available for each state.

Given the expected reward function for the system the author illustrates how the total expected reward can be maximized by choosing an appropriate policy. In chapter 3 this is accomplished by iteration. But this is only feasible if n , the number of time intervals, is small. Suppose n is large. Then we turn to Chapter 4 where Howard's main contribution, the policy-iteration method, is clearly explained.

There is one other difference introduced at this point: for a large number of time intervals it is more useful to maximize *average* gain per transition rather than *total* gain. With this change in maximizing criterion, and assuming both a large n and that the limiting state probabilities for each policy are independent of the initial state, the policy-iteration method is derived. The optimal policy is a vector, with components specifying the decision to be made in each state, and it will usually be found in a small number of iterations.

Simple but clearly explained applications of the method to problems of taxicab operation, baseball strategy, and automobile replacement constitute the subject matter of Chapter 5. The last application is particularly revealing and useful since so many replacement problems in industry possess similar logical structures. The reader will find in this chapter a ready computational technique for solving such problems.

Chapter 6 deals with an extension of the policy-iteration method to Markov processes with more than one recurrent chain. In such cases the limiting state probabilities depend upon the starting state and the policy-iteration method of Chapter 4 is revised to accommodate this fact.

In Chapter 7 we find a revision of the method to reflect a different criterion: maximizing the present value of the expected reward. In other words, the rewards are discounted to give effect to the fact that immediate rewards are valued more highly than future rewards. Some insights are provided indicating numerical values of the discount factor that are important and under what conditions the no-discount solution of previous chapters will be equivalent to the discount solution.

Finally, the methods are extended to embrace continuous-time processes—i.e., the time between transitions is random. For the study of such Markov processes the Laplace transform is introduced to supplant the z -transform. A policy-iteration method, analogous to the one derived for discrete-time processes, is developed for solving long-duration continuous time decision problems involving rewards. Fortunately, the two procedures are computationally equivalent, so that a computer program developed for one procedure may be employed to solve problems posed by the other. The continuous-time-policy iteration method, like the discrete-time method, can be modified to handle discounting of expected rewards.

An excellent feature of this book is the liberal use of carefully chosen illustrative examples, literally one to support each new idea.

The book is designed for advanced courses in operations analysis or systems design courses at the graduate level in schools of engineering. But it will also serve as an excellent reference for technical personnel who are called upon to study Markov processes, mathematical models based upon Markov processes, or similarly structured problems.

William Beranek