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Zero Acceptance Number Sampling Plans

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Nicholas L. Squeglia

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This book is dedicated to my wife Joan; my children Vanessa, Nicholas, and Jacqueline; and my grandson Shane.

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PREFACE

For many years, the acceptable quality level (AQL)[1] concept was used largely because of the influence of MIL-STD-105 and its revisions. However, in the current business climate of immense worldwide competition and greater demands by customers, more companies are realizing that quality control does not cost—it pays. As a result, the prevailing wisdom has moved toward zero defects, and AQLs are no longer the rule, but the exception; they are simply not compatible with today's environment. Many companies are striving for zero defects through statistical process control, improved processes, closed loop inspection systems, and other means.

The use of sampling plans with zero acceptance numbers is the norm today. The sampling plans in this book (c=0) actually represent a revision in 1963 of similar plans I developed in 1961. Because of the widespread use of MIL-STD-105C in 1961, the only way to depart from this standard was to develop a set of plans that could be compared favorably with the military standard. The c=0 plans were developed and originally implemented in a medium-sized plant that did both military and commercial work. Although the plans were not formally approved, there was no opposition to them.

In 1963, MIL-STD-105D was introduced, and the c=0 plans were updated and revised. This time, the plans were proposed to a large aerospace manufacturer with a staff of resident government quality control representatives. It was necessary to deliver a formal presentation and explain the c=0 plans in great detail. The aerospace manufacturer and the government representatives agreed to accept the plans on a trial basis. While the plans were targeted essentially to the limiting quality (LQ) percentages in the military standard tables, there were departures from these targets in several instances. These special adjustments were necessary to maintain the logic of the c=0 plans. These adjustments were highlighted during the presentation to the aerospace manufacturer.

The results of the trial period at this company were excellent. Not only were the savings significant, but there was a significant reduction in assembly problems as well. A check with the company in 1983 (20 years later) revealed the c=0 plans were still being used.

The c=0 sampling plans were presented in a national publication in 1965 (N. L. Squeglia, "Sampling Plans for Zero Defects," *Quality Assurance* 4 [August 1965]: 28). The inquiries and interest generated by the article prompted me to write the first edition of this book. Published in 1969, it described the plans in more detail and contained operating characteristic (OC) curves. The continual interest in the c=0 plans and encouragement from Professor N. L. Enrick of Kent State University resulted in the publication of the second edition in 1981.

In 1983, I conducted an informal survey to get some idea of the extent of the savings realized by users of the c=0 plans who had switched from MIL-STD-105D. A few said it was too early to tell, but the majority reported a range of savings from 8 percent to 30 percent, with an average of 18 percent. Of course, the extent of savings is based on the lot sizes and index value (associated AQL) used. The larger the lot and index value, the greater the savings. It is not necessary to implement the plans to determine the savings. The savings potential can be evaluated from past data as described later, in the section titled "Estimating Potential Savings."

While the hypergeometric distribution was used originally to maximize mathematical accuracy, it is my humble opinion that the most important feature of the plans is the philosophy of zero defects.

The c=0 sampling plans are now in wide use throughout the United States and in other countries. In 1983, the c=0 plans became a part of the Department of Defense's DLAM 8200.2 for use by government Defense Contract Administration Services quality assurance representatives. In 1989, MIL-STD-105E superseded 105D. This revision placed emphasis on the use of 105E as a guide in developing inspection strategies, and it recognized the limitation of the AQL concept. The sampling plans were not changed. As a result of this

1. ANSI Z1.4 changed "acceptable quality level" to "acceptance quality limit" and provided an explanation. The c=0 plans are not AQL plans. For comparison purposes, they are associated with particular ANSI plans. See Table 1a; the numbers are index values.

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revision, the fourth edition of this book was published in 1994. That edition included important updates and a small-lot sampling table.

In the earliest editions it was necessary to compare the c=0 plans to the MIL-STD plans in order to show the advantages of the c=0 plans. The comparisons provide important information as to their derivation that provided for a smooth transition from the MIL-STD plans to the c=0 plans, as discussed in the section titled "Relationship of c=0 Plans to ANSI Z1.4 Plans." After years of extensive application by government contractors, commercial manufacturing, and service industries, the c=0 sampling plans presented in this book are now considered stand-alone sampling plans, although the c=0 plans provide equal or greater protection than the MIL-STD plans.

In 2000 the Department of Defense declared MIL-STD-105E obsolete and recommended that the c=0 plans from this book be used in its place. Upon cancellation of MIL-STD-105E, the c=0 plans were authorized for use by the Defense Contract Management Agency/Department of Defense. This correspondence in part reads:

> *Zero Acceptance Sampling Plans By Nicholas L. Squeglia* This book gives a number of zero based sampling plans and their corresponding Operating Characteristic (OC) Curves and values. It is the state of the art in zero based sampling plans. (DCMA Guidebook)

The companies who were using the 105E plans at the time of their obsolescence switched to ANSI Z1.4 (2003), which, ironically, is a virtual copy of the AQL-oriented 105E plans.

In the early 2000s, a large aerospace manufacturer was given permission by ASQ to reproduce the c=0 sampling table. They modified the table by changing several sample sizes, and for convenience it was therefore originally decided to carry those modifications into this fifth edition. Although the changes were relatively minor, this resulted in some confusion among purchasers. Therefore, starting with the third printing, this fifth edition was revised to include the original c=0 sampling table and the related AOQLs. The operating characteristic curves apply to the original c=0 sampling table and where the sample sizes in the modified table are the same as in the original table. *Again, the table and related AOQLs are now exactly the same as they were in the fourth edition.*

In May 2005, I was awarded ASQ's Shainin Medal at the World Quality Congress in Milwaukee for my c=0 sampling plans. The citation read:

> Nicholas L. Squeglia is credited as one of the most significant contributors to the effort for driving Zero Defects by developing a set of zero acceptance number sampling plans (c=0) forcing preventive actions, thus saving millions of dollars in military and commercial applications. There was widespread acceptance of the plans because they proved to be practical, simple to use, and economical.

The c=0 plans have been continually gaining in popularity for more than 45 years.

Nicholas L. Squeglia

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INTRODUCTION

The zero acceptance number plans developed by the author were originally designed and used to provide overall equal or greater consumer protection with less inspection than the corresponding MIL-STD-105 sampling plans. In addition to the economic advantages they offer, these plans are simple to use and administer. Because of these advantages and because greater emphasis is now being placed on zero defects and product liability prevention, these plans have found their place in many commercial industries, although they were originally developed for military products. Comparisons can now be made to ANSI Z1.4 (2003) because it is a virtual copy of the cancelled MIL-STD-105E.

The derivation of these plans is covered in detail. It is important, however, to emphasize that although the derivation involves considerable comparison with MIL-STD-105E/ANSI Z1.4, the c=0 plans are not limited to applications involving industries that are using those plans.

There is no specific sampling plan or procedure that can be considered best suited for all applications. It is impractical to cite all of the applications in which these c=0 plans are used. Some examples are machined, formed, cast, powered metal, plastic, and stamped parts; and electrical, electronic, and mechanical components. They have found application in receiving inspection, in-process inspection, and final inspection in many industries. *Regardless of the product, wherever the potential for lot-by-lot sampling exists, the c=0 plans may be applicable.*

Quite often, the basic objective of sampling is overlooked. The primary objective is derived from the question, "Why sample?" Most of us are aware that sampling is employed simply to provide a degree of quality protection against accepting nonconforming material. Further, we know that what we are continually striving for is 100 percent good product. Assuming our inspection capability is 100 percent efficient in detecting nonconformances, the only way to assure 100 percent good product is to inspect everything 100 percent. This, then, is the reason for sampling: *We sample because it is impractical in most cases to perform 100 percent inspection.* What we are seeking, therefore, are sampling plans that economically provide us with a reasonable amount of protection to ensure 100 percent good quality. There are times when something less than 100 percent good product is considered acceptable; in other words, there are times when we knowingly accept defective product. Such cases, however, should be treated on an exception basis.

This book provides a set of attribute plans for lot-by-lot inspection. The acceptance number in all cases is zero. This means that for some level of protection you select a certain size sample and withhold the lot if the sample contains one or more nonconforming pieces.

The phrase "withhold the lot" is significant in that it does not necessarily mean rejection. Under these plans, the inspector does not automatically reject the lot if one or more nonconformances are found. The inspector only accepts the lot if zero nonconformances are found in the sample. Withholding the lot forces a review and disposition by engineering or management personnel in regard to the extent and seriousness of the nonconformance.

From this point on, we will use the terms "defective" and "defect" to describe nonconformances, regardless of whether the defective is fit for use. The term "defective" is commonly used in quality control to describe a part, component, item, or any other unit of product that contains one or more defects. The word "defect" is commonly used to describe a particular nonconforming characteristic on a unit of product. For example, a particular item contains a slot of a certain width and length, and it also contains a hole. Everything about the item conforms to specifications except the diameter of the hole. This nonconforming diameter is a defect, and the item is therefore defective.