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AICPA
American Institute of Certified Public Accountants

AUDIT AND ACCOUNTING GUIDE

AUDIT SAMPLING

PREPARED BY THE STATISTICAL SAMPLING SUBCOMMITTEE

NOTICE TO READERS

This audit and accounting guide presents recommendations of the AICPA Statistical Sampling Subcommittee regarding the application of generally accepted auditing standards to audits involving audit sampling methods. It represents the considered opinion of the subcommittee on the best auditing practice involving audit sampling and has been reviewed by members of the AICPA Auditing Standards Board for consistency with existing auditing standards. AICPA members may have to justify departures from the recommendations contained in this guide if their work is challenged.

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AUDIT SAMPLING

PREPARED BY THE
STATISTICAL SAMPLING
SUBCOMMITTEE

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Preface

Statement on Auditing Standards No. 39, *Audit Sampling*, applies to all audit sampling, both statistical and nonstatistical. This document provides guidance to assist auditors using either approach in applying SAS No. 39. Guidance relating to nonstatistical sampling is found in chapters 1 and 2 and in chapter 3, sections 1 and 2. Essentially all the guidance relating solely to statistical sampling begins in chapter 3, section 3.

This guide is organized as follows:

- The introduction describes the scope and provides guidance on the type of audit procedures covered by SAS No. 39 and this guide.
- Chapter 1 provides an overview of the relationship between audit sampling and the audit process.
- Chapter 2 provides guidance on the use of audit sampling for tests of compliance with prescribed internal accounting control procedures. This guidance applies to both nonstatistical and statistical sampling, except where noted.
- Chapter 3 provides guidance on the use of audit sampling for substantive tests of details. Chapter 3 is divided into four sections. Section 1 provides general guidance that applies to both nonstatistical and statistical sampling. Section 2 provides guidance for nonstatistical sampling applications for substantive tests. Two types of statistical sampling approaches for substantive tests are described in sections 3 and 4. Sections 2, 3, and 4 each include a case study illustrating the application of the guidance in the respective section.
- This guide includes several appendixes. Appendixes A through E are primarily useful in applying certain statistical sampling approaches. Appendix F provides further guidance on the use of the

risk model included in the appendix of SAS No. 39. Appendixes G and H are a glossary and a selected bibliography of further readings.

Neither SAS No. 39 nor this guide requires the auditor using nonstatistical sampling to compare the sample size for the nonstatistical sampling application to a corresponding sample size calculated using statistical theory. However, this guide provides several quantitative illustrations of sample sizes based on statistical theory that should be helpful to an auditor applying professional judgment and experience in considering the effect of various planning considerations on sample size.

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Introduction

Statement on Auditing Standards No. 39, *Audit Sampling*, provides guidance on the use of sampling in an audit of financial statements. The statement includes guidance for planning, performing, and evaluating the two general approaches to audit sampling: nonstatistical and statistical. SAS No. 39 recognizes that auditors are often aware of items in account balances or classes of transactions that might be likely to contain errors.[1] Auditors consider this knowledge in planning procedures, including audit sampling. Auditors usually will have no special knowledge about other items in account balances or classes of transactions that, in their judgment, will need to be tested to fulfill the audit objectives. Auditors might apply audit sampling to such balances or classes. This document provides guidance to help auditors apply audit sampling in accordance with SAS No. 39. Alternatively, auditors might apply procedures not involving audit sampling to such balances or classes. Neither this document nor SAS No. 39 provides guidance on planning, performing, and evaluating audit procedures *not* involving audit sampling.

Procedures Not Involving Sampling

An auditor generally does not rely solely on the results of a single procedure to reach a conclusion with respect to an account balance, a class of transactions, or the extent of compliance with internal accounting control procedures. Rather, audit conclusions are usually based on evidence obtained from several sources as a result of

1. For purposes of this guide, *errors* include both errors and irregularities as defined in SAS No. 16, *The Independent Auditor's Responsibility for the Detection of Errors or Irregularities*.

applying a number of procedures. The combined satisfaction obtained from the various procedures is considered in reaching an opinion on the financial statements.

Some procedures may involve audit sampling. According to SAS No. 39, audit sampling is "the application of an audit procedure to less than 100 percent of the items within an account balance or class of transactions for the purpose of evaluating some characteristic of the balance or class." Procedures not involving audit sampling are not the subject of SAS No. 39 or this guide. However, because distinguishing between audit sampling and procedures not involving audit sampling might be difficult, this introduction discusses the distinction between procedures that do and do not involve audit sampling.

In general, procedures that do *not* involve sampling may be grouped into the following categories.

Inquiry and observation. Auditors ask many questions during the course of their examinations. Auditors also observe the operations of their clients' businesses and the operations of their systems of internal accounting control. Both inquiry and observation provide auditors with evidential matter. Inquiry and observation include such procedures as these:

- Interview management and employees.
- Obtain written representations from management.
- Complete internal accounting control questionnaires.
- Scan accounting records for unusual items.
- Examine one or a few transactions from an account balance or class of transactions to obtain an understanding of how the accounting system operates and how transactions and documents are processed or to clarify an understanding of the entity's system of internal accounting control (often referred to as a *walk through*).
- Observe the behavior of personnel and the functioning of business operations.
- Observe cash-handling procedures.
- Inspect land and buildings.

Analytical review procedures. According to SAS No. 23, *Analytical Review Procedures*, such procedures are "substantive tests of financial information made by a study and comparison of relationships among data." Analytical review procedures include—

- Comparison of the financial information with information for comparable prior period(s).
- Comparison of the financial information with anticipated results (for example, budgets and forecasts).
- Study of the relationships of elements of financial information that would be expected to conform to a predictable pattern based on the entity's experience.
- Comparison of the financial information with similar information regarding the industry in which the entity operates.
- Study of relationships between the financial information and relevant nonfinancial information.

One-Hundred-Percent examination. In some circumstances an auditor might decide to examine every item constituting an account balance or a class of transactions. Because the auditor is examining the entire balance or class, rather than only a portion, to reach a conclusion about the balance or class taken as a whole, 100-percent examination is not a procedure that involves audit sampling.

Untested balances. The auditor might decide that he need not apply any audit procedures to an account balance or class of transactions if he believes that there is an acceptably low risk of material errors existing in the account or class. Untested balances are not the subject of audit sampling.

The determination of whether the application of a procedure to less than 100 percent of an account balance or class of transactions involves audit sampling generally depends on the audit objective to be achieved by the procedure. For example, an auditor might decide to supplement other audit procedures designed to test the recorded amount of inventory by testing the recorded amount of several items included in the inventory balance. If the objective of that procedure is to project the results to the entire inventory balance, the auditor should use audit sampling, subject to the guidance in SAS No. 39. On the other hand, if the auditor's objective is to search for misstatement in only those few items without evaluating that characteristic of the inventory as a whole, the procedure does not involve audit sampling.

Combination of Audit Procedures

An account balance or class of transactions may be examined by a combination of several audit procedures. These procedures might include audit sampling. For example, an auditor might wish to determine whether recorded inventory quantities are complete by a combination of such audit procedures as —

- Observing the entity's personnel as they make a physical count of inventory.
- Applying analytical review procedures to the relationship between inventory balances and recent purchasing, production, and sales activities.
- Selecting several quantities on hand to be agreed with the physical inventory count.

If the auditor wishes to use the examination results of the few selected inventory quantities on hand to evaluate the entire population of inventory counts, then the auditor would use audit sampling. On the other hand, the auditor might have divided the physical inventory counts into two groups: those items considered individually significant and other items considered individually insignificant. For the individually insignificant items, the auditor might decide that sufficient evidential matter has been obtained from the procedures not involving sampling and that there is no need to apply audit sampling to those items. The individually significant items might include, for example, items with large balances or unusual items that would be examined 100 percent. In that case the examination of the physical inventory would not include any procedure involving audit sampling and would not be the subject of SAS No. 39 or this guide.

Another illustration can help to clarify the distinction between procedures that do or do not involve audit sampling. An auditor might be examining fixed-asset additions of $2 million. These might include 5 additions totaling $1.6 million related to a plant expansion program and 400 smaller additions constituting the remaining $400,000 recorded amount. The auditor might decide that the 5 large additions are individually significant and need to be examined 100 percent and might then consider whether audit sampling should be applied to the remaining 400 items. This decision is based on the auditor's assessment of the risk of material misstatement in the $400,000 of the remaining 400 items, not on the percentage of the $2 million individually examined. Several possible approaches are discussed in the following three situations.

Situation 1. The auditor has performed other procedures related to fixed-asset additions, including —

- A study and evaluation of related internal accounting controls, which supported substantial reliance on the controls.
- A review of the entries in the fixed-asset ledger, which revealed no unusual items.
- An analytical review procedure, which suggested the $400,000 recorded amount does not contain a material error.

In this situtation the auditor might decide that sufficient evidential matter regarding fixed-asset additions has been obtained without applying audit sampling to the remaining individually insignificant items. Therefore, the guidance in SAS No. 39 and this guide would not apply.

Situation 2. The auditor has not performed any procedures related to the remaining 400 items but nonetheless decides that any misstatement in those items would be immaterial. The consideration of untested balances is not the subject of SAS No. 39 or this guide.

Situation 3. The auditor has performed some or all of the same procedures in situation 1 but concludes that some additional evidential matter regarding the 400 individually insignificant additions should be obtained through audit sampling. In this case the information in SAS No. 39 and this guide should assist the auditor in planning, performing, and evaluating the audit sampling application.

The Development of Audit Sampling

At the beginning of the twentieth century, the rapid increase in the size of American companies created a need for audits based on selected tests of items constituting account balances or classes of transactions. Previously, many audits had included an examination of every transaction in the period covered by the financial statements.

At this time professional literature paid little attention to the subject of sampling. A program of audit procedures printed in 1917 in the *Federal Reserve Bulletin* included some early references to sampling, such as selecting "a few book items" of inventory. The program was prepared by a special committee of the AICPA's earliest predecessor, the American Association of Public Accountants.

For the first few decades of the century, auditors often applied sampling, but the extent of sampling was not related to the effectiveness of an entity's system of internal accounting control. Some auditing articles and textbooks in the 1910s and 1920s referred to reducing the extent of tests of details based on reliance on the entity's *internal check,* as internal accounting control was first called. However, there was little acceptance of this relationship in practice until the 1930s.

In 1955 the American Institute of Accountants (later to become the AICPA) published *A Case Study of the Extent of Audit Samples,* which summarized audit programs prepared by several CPAs to indicate the extent of audit sampling each considered necessary for a case study audit. The study was important because it was one of the first professional publications on sampling. It also acknowledged some relationship between the extent of tests of details and reliance on internal accounting control. The 1955 study concluded, "Although there was some degree of similarity among the views expressed as to the extent of sampling necessary with respect to most items in the financial statements, no clear-cut pattern resulted."

During the 1950s some interest developed in applying statistical principles to sampling in auditing. Some auditors succeeded in developing methods for applying statistical sampling; however, other auditors questioned whether those techniques should be applied in auditing.

The first pronouncement on the subject of statistical sampling in auditing was a special report, *Statistical Sampling and the Independent Auditor*, issued by the AICPA's Committee on Statistical Sampling in 1962. The report concluded that statistical sampling was permitted under generally accepted auditing standards. A second report, *Relationship of Statistical Sampling to Generally Accepted Auditing Standards*, issued by the committee in 1964, illustrated the relationship between precision and reliability in sampling and generally accepted auditing standards. The 1964 report was later included as Appendix A of Statement on Auditing Procedures (SAP) No. 54, *The Auditor's Study and Evaluation of Internal Control* (later codified as SAS No. 1, section 320). The statement elaborated on the guidance provided by the earlier report. An Auditing Procedures Committee report, *Precision and Reliability for Statistical Sampling in Auditing,* was issued in 1972 as Appendix B of SAP No. 54.

Two other statements on auditing procedure included references to sampling applications in auditing. SAP No. 33, issued in 1963, indicated that a practitioner might consider using statistical sampling in appropriate circumstances. SAP No. 36, issued in 1966, provided guidance on the auditor's responsibility when a client uses a sampling procedure, rather than a complete physical count, to determine inventory balances.

From 1967 to 1974 the AICPA published a series of volumes on statistical sampling prepared by the Statistical Sampling Subcommittee. The series, entitled *An Auditor's Approach to Statistical Sampling*, was designed for use in continuing professional education. The AICPA also published a book, *Statistical Auditing*, by Donald M. Roberts (1978), explaining the theory underlying statistical sampling in auditing.

In 1981 the AICPA's Auditing Standards Board issued SAS No. 39, *Audit Sampling*. That SAS provides general guidance on both nonstatistical and statistical sampling in auditing and supersedes both Appendixes A and B of SAS No. 1, section 320.

Purpose of This Guide

This audit guide is designed to assist the auditor in applying audit sampling in accordance with SAS No. 39. It provides practical guidance on the use of nonstatistical and statistical sampling in auditing. The terms used in this guide are consistent with those in SAS No. 39. Some auditors may be familiar with other terms, including *precision*, *confidence level*, *reliability*, *alpha risk*, and *beta risk*, often used in discussions of statistical sampling. SAS No. 39 does not use those terms because the statement applies to both statistical and nonstatistical sampling, and therefore nontechnical terms are more appropriate. In addition, certain statistical terms, such as *reliability* and *precision*, have each been used with different meanings. Auditors may, of course, use whatever terms they prefer as long as they understand the relationship of those terms to the concepts in SAS No. 39 and this guide. Some of those relationships follow.

Reliability, or confidence level. SAS No. 39 uses the concept of risk instead of reliability, or confidence level. Risk is the complement of reliability, or confidence level. For example, if an auditor desires a 10-percent sampling risk, the reliability, or confidence level, is specified as 90 percent. The term *risk* is more consistent with the auditing framework described in the Statements on Auditing Standards.

Alpha and beta risks (sometimes referred to as risks of Type I and Type II errors). SAS No. 39 uses the terms *risk of overreliance on* *internal accounting control* (when sampling for compliance testing purposes) and *risk of incorrect acceptance* (for substantive testing purposes) instead of *beta risk*. SAS No. 39 also uses the terms *risk of underreliance on internal accounting control* and *risk of incorrect rejection* instead of *alpha risk*. Both *alpha risk* and *beta risk* are statistical terms that have not been consistently applied among auditors.

Precision. Precision might be used as a planning concept for audit sampling. SAS No. 39 uses the concept of tolerable error. Precision might also be used in audit sampling as an evaluation concept. SAS No. 39 uses the concept of an allowance for sampling risk.

This guide discusses several approaches to the application of sampling in auditing. It does not discuss the use of sampling if the objective of the application is to develop an original estimate of quantities or amounts. To avoid a complex, highly technical presentation, this document does not include guidance on every possible method of applying sampling. It also does not discuss the mathematical formulas underlying statistical sampling because knowledge of complex statistical sampling formulas, which was once required to apply statistical sampling in auditing, is generally no longer necessary. Now, there are well-designed tables and computer software programs that allow the use of statistical sampling in auditing without such knowledge. However, these formulas can be obtained from reference sources included in the bibliography.[2] In this guide it is generally assumed that the auditor will be using computer programs or tables to perform the calculations and selections necessary for statistical sampling. Appendix E describes types of time-sharing and batch programs and considerations in selecting appropriate programs.

This guide may be used both as a reference source for those who are knowledgeable in audit sampling and as initial background for those who are new to this area. Auditors who are unfamiliar with technical sampling considerations might benefit by combining use of this guide with a continuing education course in audit sampling. Training is available from sources such as the AICPA, the various state CPA societies, colleges and universities, and some CPA firms.

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2. Auditors interested in familiarizing themselves with these formulas should see Donald Roberts, Appendix 2 in *Statistical Auditing* (New York: AICPA, 1978).

Chapter 1

The Audit Sampling Process

Purpose and Nature of Audit Sampling

Audit sampling is the application of an audit procedure to less than 100 percent of the items within an account balance or class of transactions for the purpose of evaluating some characteristic of the balance or class. Auditors frequently use sampling procedures to obtain audit evidence. Auditors may use either nonstatistical or statistical sampling. The portion of the account balance or class of transactions to be examined is the *sample*. The items constituting the account balance or class of transactions of interest are the *population*.

The following questions apply to planning any audit sampling procedure, whether it is nonstatistical or statistical:

1. What is the objective of the test? (What do you want to learn or be able to infer about the population?)
2. What is to be sampled? (How is the population defined?)
3. What is the auditor looking for in the sample? (How is an error defined?)
4. How is the population to be sampled? (What is the sampling plan, and what is the method of selection?)
5. How much is to be sampled? (What is the sample size?)
6. What do the results mean? (How are the sample results evaluated and interpreted?)

As discussed in the introduction, sampling may not always be appropriate. For example, the auditor might decide that it is more efficient to test an account balance or class of transactions by applying analytical review procedures. In some cases legal requirements might necessitate 100-percent examination. In other situations the auditor might decide that some items should be examined 100 percent because he does not believe acceptance of sampling risk is justified or he believes 100-percent examination is cost-effective in the circumstances. The auditor uses professional judgment to determine whether audit sampling is appropriate.

Risk

The justification for reasonable assurance rather than certainty regarding reliability of financial information is based on the third standard of field work: "Sufficient competent evidential matter is to be obtained . . . to afford a reasonable basis for an opinion. . . ." According to SAS No. 39, the justification for accepting some uncertainty arises from the relationship between the cost and time required to examine all of the data and the adverse consequences of possible erroneous decisions based on the conclusions resulting from examining only a sample of such data. The uncertainty inherent in performing auditing procedures is ultimate risk. *Ultimate risk* (some people refer to ultimate risk as *audit risk*) is a combination of the risk that material errors will occur in the accounting process by which the financial statements are developed and the risk that those material errors will not be detected by the auditor.[1] Ultimate risk includes both uncertainties due to sampling and uncertainties due to other factors. These are sampling risk and nonsampling risk, respectively.

Nonsampling risk includes all the aspects of ultimate risk that are not due to sampling. An auditor might apply a procedure to all transactions or balances and still fail to detect a material misstatement or a material internal accounting control weakness. Nonsampling risk includes the possibility of selecting audit procedures that are not appropriate to achieve the specific objective. For example, the auditor cannot rely on confirmation of recorded receivables to reveal unrecorded receivables. Nonsampling risk also arises because the auditor might fail to recognize errors included in documents that he examines. In that situation the audit procedure would

1. When this guide was published, the AICPA Auditing Standards Board had exposed for comment a proposed Statement on Auditing Standards entitled *Materiality and Audit Risk in Conducting an Audit*, which used different terminology to express the various risks discussed in this guide. See the footnote in Appendix F for further discussion.

be ineffective even if *all* items in the population were examined.

No sampling method will allow the auditor to measure the nonsampling risk. This risk can, however, be reduced to a negligible level by adequate planning and supervision of audit work (see SAS No. 22, *Planning and Supervision*) and proper conduct of an auditor's practice (see SAS No. 25, *The Relationship of Generally Accepted Auditing Standards to Quality Control Standards*). The subject of controlling nonsampling risk is beyond the scope of this guide. However, the section of this chapter entitled "General Implementation Considerations" might be helpful to the auditor in controlling some aspects of nonsampling risk.

Sampling risk arises from the possibility that when a compliance or substantive test is restricted to a sample, the auditor's conclusions might be different from those that would have been reached if the test were applied in the same way to all the items in the account balance or class of transactions—that is, a particular sample might contain proportionately more or less monetary errors or compliance deviations than exist in the account balance or class of transactions as a whole. Sampling risk includes the risk of overreliance on internal accounting control and the risk of underreliance on internal accounting control (see discussion in chapter 2) and the risk of incorrect acceptance and the risk of incorrect rejection (see discussion in chapter 3).

How Audit Sampling Differs From Sampling in Other Professions

Auditing is not the only profession that uses sampling. For example, sampling is used in opinion surveys, market analyses, and scientific and medical research in which someone desires to reach a conclusion about a large body of data by examining only a portion of that data. There are major differences, though, between audit sampling and these other sampling applications.

Accounting populations differ from most other populations because before the auditor's testing begins, the data have been accumulated, compiled, and summarized. Rather than using the sample to estimate an unknown, the auditor's objective is generally to corroborate the accuracy of certain client data, such as data about account balances or classes of transactions, or to evaluate the internal accounting controls over the processing of the data. The audit process is generally an evaluation of whether an amount is substantially correct rather than a determination of original amounts.

The distribution of amounts in accounting populations generally differs from other populations. In typical nonaccounting populations the amounts tend to cluster around the average amount of the items in the population. In contrast, accounting populations tend to include a few very large amounts, a number of moderately large amounts, and a large number of small amounts. The auditor may need to consider the distribution of accounting amounts when planning audit samples for substantive tests.

In addition, the evidence obtained from each audit test is just one element of the total evidence that the auditor obtains. The auditor generally does not rely on a single audit test, as might a market researcher or another sampler, but reaches an overall conclusion based on the results of numerous interrelated tests that are performed. Therefore, an auditor plans and evaluates an audit sample with the knowledge that the overall conclusion about the population characteristic of interest will be based on more than the results of that audit sample.

Types of Audit Tests

SAS No. 39 describes three types of audit tests: compliance tests, substantive tests, and dual-purpose tests. The type of test to be performed is important to an understanding of audit sampling.

Compliance Tests

Compliance tests are intended to provide reasonable assurance that internal accounting control procedures are being applied as prescribed. Compliance testing is necessary if a prescribed procedure is to be relied on in determining the nature, timing, and extent of substantive tests.

A specific internal accounting control procedure is expected to be applied in the same way to all transactions subject to that control, regardless of the magnitude of the transaction. Therefore, if the auditor is using audit sampling, it is generally not appropriate to select only high dollar amounts in testing compliance. All samples should be selected in such a way that the sample can be expected to be representative of the population.

Substantive Tests

Substantive tests are audit procedures designed to obtain evidence about the validity and propriety of the accounting treatment of transactions and balances or to detect errors. Substantive tests differ from compliance tests in that the auditor is interested primarily in a conclusion as to dollars. Substantive tests include (1) tests of details of transactions and balances and (2) analytical review procedures.

Dual-Purpose Tests

In some circumstances an auditor might design a test that will have a *dual purpose:* testing for compliance with prescribed internal accounting control procedures and testing whether a recorded balance or class of transactions is correct. An auditor will have begun substantive procedures before determining whether the compliance test supports the planned degree of reliance on internal accounting control. Therefore, an auditor planning to use a dual-purpose sample would have made a preliminary assessment that there is an acceptably low risk that the rate of compliance deviations in the population exceeds the maximum rate of deviations the auditor is willing to accept without altering his planned reliance. For example, an auditor designing a compliance test of a control procedure for entries in the voucher register might plan a related substantive test at a risk level that anticipates reliance on that internal accounting control procedure.

The size of a sample designed for a dual purpose should be the larger of the samples that would otherwise have been designed for the two separate purposes. The auditor should evaluate deviations from pertinent control procedures and monetary errors separately, using the risk level applicable for the respective purposes when evaluating dual-purpose samples. The guidance provided in chapters 2 and 3 for evaluating results of compliance and substantive tests, respectively, is also applicable to the evaluation of dual-purpose samples.

Nonstatistical and Statistical Sampling

Audit sampling involves examining less than the entire body of data to express a conclusion about the entire body of data. All audit sampling involves judgment in planning and performing the sampling procedure and evaluating the results of the sample. The audit procedures performed in examining the selected items in a sample generally do not depend on the sampling approach used.

Once a decision has been made to use audit sampling, the auditor must choose between statistical and nonstatistical sampling. This choice is primarily a cost-benefit consideration. Statistical sampling helps the auditor (1) design an efficient sample, (2) measure the sufficiency of the evidential matter obtained, and (3) evaluate the sample results. If audit sampling is used, some sampling risk is always present. Statistical sampling uses the laws of probability to measure sampling risk. Any sampling procedure that does not measure the sampling risk is a nonstatistical sampling procedure. If the auditor rigorously selects a random sample but does not make a statistical evaluation of the sample results, the sampling procedure is a nonstatistical application.

A properly designed nonstatistical sampling application can provide results that are as effective as those from a properly designed statistical sampling application. But there is one difference: Statistical sampling measures the sampling risk associated with the sampling procedure.

Statistical sampling might involve additional costs to train auditors because it requires more specialized expertise. Statistical sampling might also involve additional costs (1) to design individual samples that meet the statistical requirements and (2) to select the items to be examined. For example, if the individual balances constituting an account balance to be tested are not maintained in an organized pattern, it might not be cost-effective for an auditor to select items in a way that would satisfy the requirements of a properly designed statistical sample. To illustrate: An auditor plans to use audit sampling to test a physical inventory count. Although the auditor can select a sample in such a way that the sample can be expected to be representative of the population, it might be difficult to satisfy certain requirements for a statistical sample if priced inventory listings or detailed prenumbered quantity listings cannot be used in the selection process. (See "Determining the Method of Selecting the Sample" in chapter 2.) Because either nonstatistical or statistical sampling can provide sufficient evidential matter, the auditor chooses between them after considering their relative cost and effectiveness in the circumstances.

When an auditor plans any audit sampling application, the first consideration is the specific account balance or class of transactions and the circumstances in which the procedure is to be applied. The auditor generally identifies items or groups of items that have significance with respect to an audit objective. For example, an auditor planning to use audit sampling as part of the tests of an inventory balance in conjunction with an observation of the physical inventory would generally identify those items that have significantly large balances or those items that might have other special characteristics (such as higher susceptibility to obsolescence or damage). In testing accounts receivable, an auditor might identify accounts with large balances, unusual balances, or unusual patterns of activity as individually significant items.

The auditor considers all special knowledge about the items constituting the balance or class before designing audit sampling procedures. For example, the auditor might identify 20 products included in the inventory that make up 25 percent of the account balance. In addition, he might have identified several items, constituting an additional 10 percent of the balance, that are especially susceptible to damage. The auditor might decide that those items should be examined 100 percent and therefore should be excluded from the inventory subject to audit sampling.

After the auditor has applied all his special knowledge about the account balance or class of transactions in designing an appropriate procedure, there is often a remaining group of items that need to be evaluated to achieve the audit objective. Thus, the auditor might apply audit sampling — either nonstatistical or statistical — to the remaining 65 percent of the account balance. The considerations just described would not be influenced by the auditor's intentions to use either nonstatistical or statistical sampling on the remaining items.

Statistical sampling provides the auditor with a tool that assists in applying experience and professional judgment to more explicitly control sampling risk. Because this risk, like the other factors affecting sample size, is present in both nonstatistical and statistical sampling plans, there is no conceptual reason to expect a nonstatistical sample to provide greater assurance than a well-designed statistical sample of equal size for the same sampling procedure.[2]

Types of Statistical Sampling Plans

Attributes Sampling

Attributes sampling is used to reach a conclusion about a population in terms of a rate of occurrence. Its most common use in auditing is to test the rate of deviation from a prescribed internal

2. Chapters 2 and 3 provide several quantitative illustrations of sample sizes based on statistical theory. They might be helpful to an auditor applying professional judgment and experience in considering the effect of various planning considerations on sample size. However, neither SAS No. 39 nor this guide requires the auditor using nonstatistical sampling to compare the sample size for the nonstatistical sampling application to a corresponding sample size calculated using statistical theory.

accounting control procedure to determine whether planned reliance on that control is appropriate. In attributes sampling each occurrence of, or deviation from, a prescribed control procedure is given equal weight in the auditor's evaluation, regardless of the dollar amount of the transaction.

The following are some examples of tests in which attributes sampling is typically used:

- Tests of controls for voucher processing
- Tests of controls for billing systems
- Tests of controls for payroll and related personnel policy systems
- Tests of controls for inventory pricing
- Tests of controls for fixed-asset additions
- Tests of controls for depreciation computations

In addition to tests of compliance with prescribed control procedures, attributes sampling may be used for substantive procedures such as tests for underrecording shipments or demand deposit accounts. However, if the audit objective is to directly obtain evidence about a monetary amount being examined, the auditor generally designs a variables sampling application.

Variables Sampling

Variables sampling is used if the auditor desires to reach a conclusion about a population in terms of a dollar amount. Variables sampling is generally used to answer either of these questions: (1) How much? (generally described as *dollar-value estimation*) or (2) Is the account materially misstated? (generally described as *hypothesis testing*).

The principal use of variables sampling in auditing is for substantive tests of details to determine the reasonableness of recorded amounts. However, it would also be used if the auditor chooses to measure the dollar amount of transactions containing deviations from an internal accounting control procedure. (See chapter 3, section 3, "Probability-Proportional-to-Size Sampling," for a discussion of one variables sampling technique used for testing compliance in dollar amounts.)

The following are some examples of tests for which variables sampling is typically used:

- Tests of the amount of receivables
- Tests of inventory quantities and amounts
- Tests of recorded payroll expense

- Tests of the amount of fixed-asset additions
- Tests of transactions to determine the amount that is not supported by proper approval

As was just discussed, attributes sampling is generally used to reach a conclusion about a population in terms of a rate of occurrence; variables sampling is generally used to reach conclusions about a population in terms of a dollar amount. However, one statistical sampling approach, *probability-proportional-to-size (PPS) sampling*, uses attributes sampling theory to express a conclusion in dollar amounts.

General Implementation Considerations

Consideration of the following factors might be helpful to the auditor in implementing audit sampling procedures.

Continuing Professional Education

The auditor might better understand the concepts of audit sampling by combining live instruction with this guide or a textbook. Some firms develop their own educational programs; others use programs developed by the AICPA, a state society of CPAs, a college or university, or another CPA firm.

Continuing education programs should be directed to appropriate staff levels. For example, an auditor might decide to train all assistants to select samples, to determine sample sizes, and to evaluate sample results for attributes sampling procedures. More experienced staff might be trained to design and evaluate variables sampling applications.

Practice Guidelines

Some auditors achieve consistent sampling applications throughout their practice by establishing guidelines to be used by assistants. For example, guidelines might include standards for establishing acceptable risk levels, minimum sample sizes, and appropriate levels of tolerable error.

Documentation

SAS No. 41, *Working Papers*, provides guidance on documentation of audit procedures. While neither SAS No. 39 nor this guide requires specific documentation of audit sampling applications, examples of items that the auditor might consider including in documentation for compliance and substantive testing are listed in chapters 2 and 3, respectively.

Use of Specialists

Some auditors designate selected individuals as audit sampling specialists.[3] These specialists may consult with the auditors on the design and execution of planned sampling procedures. In addition, some specialists teach continuing professional education courses on audit sampling. Some auditors train all assistants in the essential concepts of designing and executing sampling procedures, thus minimizing the need for specialists.

Furthermore, some auditors engage a statistician or professor to consult on statistical applications. The consultant might be used (1) to solve difficult statistical problems, (2) to review the firm's practice guidelines, (3) to assist in designing continuing education programs, (4) to review the coding of time-sharing programs, and (5) to teach courses for specialists. Typically, auditors confer frequently with a consultant when they begin to use statistical sampling and reduce the frequency as they gain experience.

Supervision and Review

The first standard of field work requires that assistants be properly supervised. Quantified measurements of risk and tolerable error in auditing are primarily used to establish an overall audit strategy and to provide a structure for supervising the conduct of an examination. Use of quantifiable concepts, even though subjective, can be useful in communicating audit objectives to the auditor's assistants.

The auditor might review documentation of sampling procedures designed by assistants. Review in the planning stage helps to assure that the application has been well planned and can be successfully implemented. Review after performance helps to assure that the work has been done properly.

In reviewing audit sampling applications, the auditor might consider the following:

3. Employing the services of an audit sampling specialist who is functioning as a member of the audit team is not covered by SAS No. 11, *Using the Work of a Specialist*. The auditor's responsibilities when using the work of an audit sampling specialist are the same as when using the work of assistants.

- Were the population and sampling unit defined appropriately for the test objectives?
- Were tests performed to provide reasonable assurance that the sample was selected from the appropriate population?
- Did the design of the sampling application provide for an appropriate risk level? For example, did the design reflect planned reliance on related internal accounting controls or related substantive tests?
- If additional audit tests were planned in designing the sampling procedure, did these tests support the recorded amount of the account being tested?
- Were planned procedures applied to all sample items? If not, how were those unexamined items in the sample considered in the evaluation?
- Were all errors discovered properly evaluated?
- If the test was a compliance test, did it support the planned reliance on the internal accounting control procedure? If not, were related substantive tests appropriately modified?
- Was the audit objective of the test met?

The general concepts discussed in this chapter are applied to compliance and substantive tests in chapters 2 and 3, respectively.

Chapter 2

Sampling in Compliance Tests of Internal Accounting Controls

This chapter provides guidance on the use of audit sampling for compliance tests of internal accounting control procedures.[1] Unless otherwise indicated, the guidance in this chapter applies equally to nonstatistical and statistical sampling.

Audit sampling for compliance tests generally involves the following:

1. Determining the objectives of the test
2. Defining the deviation conditions
3. Defining the population
   a. Defining the period covered by the test
   b. Defining the sampling unit
   c. Considering the completeness of the population
4. Determining the method of selecting the sample
   a. Random-Number sampling
   b. Systematic sampling
   c. Other sampling
5. Determining the sample size
   a. Considering the acceptable risk of overreliance on internal accounting control

1. If the auditor chooses to measure the dollar amount of transactions containing deviations from an internal accounting control procedure, the auditor would use variables sampling. See chapter 3, section 3, "Probability-Proportional-to-Size Sampling," for a discussion of one variables sampling technique used for testing compliance in dollar amounts.

   b. Considering the tolerable rate
   c. Considering the expected population deviation rate
   d. Considering the effect of population size
   e. Considering a sequential or a fixed sample-size approach
6. Performing the sampling plan
7. Evaluating the sample results
   a. Calculating the deviation rate
   b. Considering sampling risk
   c. Considering the qualitative aspects of the deviations
   d. Reaching an overall conclusion
8. Documenting the sampling procedure

Determining the Objectives of the Test

As mentioned in chapter 1, the objective of compliance tests is to provide reasonable assurance that internal accounting control procedures are being applied as prescribed. The auditor tests compliance with the controls he plans to rely on in determining the nature, timing, and extent of substantive tests. Tests of compliance, therefore, are concerned primarily with these questions: Were the necessary procedures performed; how were they performed; and by whom were they performed? SAS No. 1, section 320, "The Auditor's Study and Evaluation of Internal Control," and SAS No. 30, *Reporting on Internal Accounting Control*, provide guidance on identifying specific control objectives and related specific control procedures.

Audit sampling for compliance tests is generally used if there is a trail of documentary evidence. Sampling for testing compliance with control procedures that do not leave such a trail might be appropriate, however, when the auditor is able to plan the sampling procedures early in the engagement. For example, the auditor might wish to observe compliance with prescribed control procedures for bridge toll collections. In that case a sample of days and locations for observation of actual procedures should be selected. The auditor needs to plan the sampling procedure to allow for observation of compliance with such procedures on days selected from the period under audit.

Defining the Deviation Conditions

On the basis of knowledge about the internal accounting control system, the auditor should identify the characteristics that would indicate compliance with the internal accounting control procedure on which he plans to rely. The auditor then defines the possible deviation conditions. For compliance testing, a *deviation* is a departure from the prescribed internal accounting control procedure. The procedure consists of all the steps the auditor believes are necessary to achieve the specific internal accounting control objective. For example, if the prescribed procedure requires that each paid invoice be stamped "Paid," but it does not require that vouchers, receiving reports, or purchase orders be stamped, the deviation may be defined as "a paid invoice that has not been stamped 'Paid.' " Definitions such as "lack of effective cancellation of supporting documents" are not appropriate since these are not departures from the entity's prescribed internal accounting control procedure.

In some circumstances the entity's system might prescribe a control procedure that requires more action by the entity's personnel than the auditor believes necessary to support the planned reliance on that control. For example, if a purchase order requires four approvals, but the auditor believes only one approval is necessary to support planned reliance on the control procedure, the absence of the other three need not be defined as a deviation for the auditor's purposes.

Defining the Population

The population, as defined earlier, consists of the items constituting the account balance or class of transactions of interest. The auditor should determine that the population from which the sample is selected is appropriate for the specific audit objective, because sample results can be projected to only the population from which the sample was selected. For example, if the auditor wishes to test compliance with a prescribed internal accounting control procedure designed to ensure that all shipments are billed, the auditor would not detect deviations by sampling billed items because some orders might have been shipped but not billed. An appropriate population for detecting such deviations is usually the population of all shipped items.

An auditor should be aware that an entity might change a specific control procedure during the period under audit. If one control procedure is superseded by another control procedure designed to achieve the same specific control objective, the auditor needs to decide whether he should design one sample of all transactions executed throughout the period or separate samples of transactions subject to the different control procedures. The appropriate decision depends on the overall objective of the auditor's tests. For example, if the auditor wishes to rely on both the new and the superseded control procedures in reducing the extent of substantive tests of sales transactions throughout the period under audit, one sample of all sales transactions may be appropriate. However, if the auditor wishes to rely on the control procedures in reducing the extent of substantive tests of accounts receivable primarily from sales in the *latter* part of the period, he might wish to place substantial reliance on the specific control procedure operating during that latter portion of the period and little or no reliance on the other, superseded, control procedure. The auditor also considers what is effective and efficient in the circumstances. For example, it may be more efficient for the auditor to design one sample of all such transactions executed throughout the period than to design separate tests of the transactions subject to different control procedures.

Defining the Period Covered by the Test

According to SAS No. 1, paragraph 320.61, "Tests of compliance . . . ideally should be applied to transactions executed throughout the period under audit because of the general sampling concept that the items to be examined should be selected from the entire set of data to which the resulting conclusions are to be applied."

However, it is not always efficient to include in the population to be sampled all transactions executed throughout the period under audit. In some cases it might be more efficient to use alternative approaches, rather than audit sampling, to test transactions executed during a portion of the period under audit. For example, the auditor might define the population to include transactions for the period from the beginning of the year to an interim date. SAS No. 1, paragraph 320.61 provides guidance to be considered in this circumstance:

> Independent auditors often make such tests during interim work. When this has been done, application of such tests throughout the remaining period may not be necessary. Factors to be considered in this respect include (a) the results of the tests during the interim period, (b) responses to inquiries concerning the remaining period, (c) the length of the remaining period, (d) the nature and amount of the transactions or balances involved, (e) evidence of compliance within the remaining period that may be obtained from substantive tests performed by the independent auditor or from tests performed by internal auditors, and (f) other matters the auditor considers relevant in the circumstances.

When the auditor decides to define the period covered by the test as less than the period under audit, the auditor might use audit sampling to reach a conclusion about compliance with the prescribed procedure for the period up to the interim date. The auditor might then obtain reasonable assurance regarding the remaining period by performing additional procedures such as those discussed in the preceding paragraph.

The auditor might define the population to include transactions from the entire period under audit but perform initial testing during an interim period. In such circumstances the auditor might estimate the number of transactions to be executed in the population for the remaining period. Any sampled transactions that were not executed before the interim period would be examined during the completion of the audit. For example, if in the first ten months of the year the entity issued invoices numbered from 1 to 10,000, the auditor might estimate that based on the company's business cycle, 2,500 invoices will be issued in the last two months; the auditor will thus use 1 to 12,500 as the numerical sequence for selecting the desired sample. Invoices with numbers of 10,000 or less that are selected would be examined during the interim work, and the remaining sampling units would be examined during the completion of the audit.

In estimating the size of the population, the auditor might consider such factors as the actual usage in the similar period of the prior year, the trend of usage, and the nature of the business. As a practical consideration, the auditor might overestimate the remaining volume. If at year end some of the selected document numbers do not represent transactions (because fewer transactions were executed than estimated), they may be replaced by other transactions. To provide for this possibility, the auditor might wish to select a slightly larger sample; the additional items would be examined only if they are used as replacement items.

If, on the other hand, the remaining usage is underestimated, some transactions will not have a chance of being selected, and, therefore, the sample might not be representative of the population defined by the auditor. In this case the auditor may redefine the population to exclude those items not subject to inclusion in the sample. The auditor may perform alternative procedures to reach a conclusion about the items not included in the redefined population. Such tests might include testing the items as part of a separate sample (either nonstatistical or statistical), examining 100 percent of the items, or making inquiries concerning the remaining period. The auditor selects an appropriate approach based on his judgment about which procedure would be most effective and efficient in the circumstances.

In some cases the auditor might not need to wait until the end of the period under audit to form a conclusion about whether compliance with a prescribed control procedure is adequate as a basis for reliance. During the interim testing of selected transactions, the auditor might discover enough deviations to reach the conclusion that even if no deviations are found in transactions to be executed after the interim period, the control procedure cannot be relied on in determining the nature, timing, and extent of related substantive procedures. In that case the auditor might decide not to examine the selected transactions to be executed after the interim period and would modify planned substantive tests accordingly.

Defining the Sampling Unit

A *sampling unit* is any of the individual elements constituting the population. A sampling unit may be, for example, a document, an entry, or a line item. Each sampling unit constitutes one item in the population. The auditor should define the sampling unit in light of the control procedure being tested. For example, if the objective of the test is to determine whether disbursements have been authorized and the prescribed control procedure requires an authorized signature on the voucher before processing, the sampling unit might be defined as the voucher. On the other hand, if one voucher pays several invoices and the prescribed control procedure requires each invoice to be authorized individually, the line item on the voucher representing the invoice might be defined as the sampling unit.

An overly broad definition of the sampling unit might not be efficient. For example, if the auditor is testing a control over pricing of invoices and each invoice contains up to 10 items, the auditor could define the sampling unit as an individual invoice or as a line item on the invoice. If the auditor defines the invoice as the sampling unit, it is necessary to test all the line items on the invoice. If the auditor defines the line items as the sampling units, only the selected line item need be tested. If either sampling unit definition is appropriate to achieve the test objective, it might be more efficient to define the sampling unit as a line item.

An important efficiency consideration in selecting a sampling unit is the manner in which the documents are filed and cross-referenced. For example, if a test of purchases starts from the purchase order, it might not be possible to locate the voucher and cancelled check in some systems because the systems have been designed to provide an audit trail from voucher to purchase order but not vice versa.

Considering the Completeness of the Population

The auditor actually selects sampling units from a physical representation of the population. For example, if the auditor defines the population as all customer receivable balances as of a specific date, the physical representation might be the printout of the customer accounts receivable trial balance as of that date.

The auditor should consider whether the physical representation includes the entire population. Because the physical representation is what the auditor actually selects a sample from, any conclusions based on the sample relate only to that physical representation. If the physical representation and the population differ, the auditor might make erroneous conclusions about the population. For example, if the auditor wishes to test compliance with a prescribed control over the vouchers issued in 19XX, such vouchers would be the population. If the auditor physically selects the vouchers from a filing cabinet, the vouchers in the filing cabinet are the physical representation. If the vouchers in the cabinet represent all the vouchers issued in 19XX, then the physical representation and the population are the same. If they are not the same because vouchers have been removed or vouchers issued in other years have been added, the conclusion applies only to the vouchers in the cabinet.

Making selections from a controlled source should minimize differences between the physical representation and the population. For example, an auditor sampling vouchers might make selections from a voucher register or a cash disbursements journal that has been reconciled with issued checks by a comparison with open vouchers or through a bank reconciliation. The auditor might test the footing to obtain reasonable assurance that the source of selection contains the same transactions as the population.

If the auditor reconciles the selected physical representation and the population and determines that the physical representation has omitted items in the population that should be included in the overall evaluation, the auditor should select a new physical representation or perform alternative procedures on the items excluded from the physical representation.

Determining the Method of Selecting the Sample

Sample items should be selected in such a way that the sample can be expected to be representative of the population. Therefore, all items in the population should have an opportunity to be selected. An overview of selection methods follows.

Random-Number Sampling

The auditor may select a random sample by matching random numbers generated by a computer or selected from a random-number table with, for example, document numbers. With this method every sampling unit has the same probability of being selected as every other sampling unit in the population; and every combination of sampling units has the same probability of being selected as every other combination of the same number of sampling units. This approach is appropriate for both nonstatistical and statistical sampling applications. Because statistical sampling applications require the auditor to select the sample in a manner that allows him to measure the probability of selecting the combination of sampling units actually chosen, this approach is especially useful for statistical sampling.

Systematic Sampling

For this method the auditor determines a uniform interval by dividing the number of physical units in the population by the sample size. A starting point is selected in the first interval, and 1 item is selected throughout the population at each of the uniform intervals from the starting point. For example, if the auditor wishes to select 100 items from a population of 20,000 items, the uniform interval is every 200th item. First the auditor selects a starting point and then selects every 200th item from the random start, including the starting point.

When a random starting point is used, the systematic method provides a sample that allows every sampling unit in the population an equal chance of being selected. If the population is arranged randomly, systematic selection is essentially the same as random-number selection. However, unlike random-number sampling, this method does not give every possible combination of sampling units the same probability of being selected. For example, a population of employees on a payroll for a construction company might be organized by teams; each team consists of a crew leader and 9 other workers. A selection of every 10th employee will either list every crew leader or no crew leaders, depending on the random start. No combination would include both crew leaders and other employees. In these circumstances the auditor may consider using a different sample selection method, such as random-number selection, or making a systematic selection using an interval that does not coincide with the pattern in the population. Systematic selection is useful for nonstatistical sampling, and if the starting point is a random number, it might be useful for statistical sampling.

Other Sampling Methods

Two other sampling techniques, block sampling and haphazard sampling, are sometimes used by auditors. A *block sample* consists of contiguous transactions.[2] For example, a block sample from a population of all vouchers processed for the year 19XX might be all vouchers processed on February 3, May 17, and July 19, 19XX. This sample includes only 3 sampling units out of 250 business days because the sampling unit, in this case, is a period of time rather than an individual transaction. A sample with so few blocks is generally not adequate to reach a reasonable audit conclusion. Although a block sample might be designed with enough blocks to minimize this limitation, using such samples might be inefficient. If an auditor decides to use a block sample, he should exercise special care to control sampling risk in designing that sample.

A *haphazard sample* consists of sampling units selected without any conscious bias, that is, without any special reason for including or omitting items from the sample. It does not consist of sampling units selected in a careless manner, and it is selected in a manner that can be expected to be representative of the population. For example, where the physical representation of the population is a file cabinet drawer of vouchers, a haphazard sample of all vouchers processed for the year 19XX might include any of the vouchers that

2. A variation of block sampling that can be designed to yield an adequate statistical sampling approach is called *cluster sampling*. The considerations for designing a cluster sample are beyond the scope of this guide. Such guidance can be found in technical references on statistical sampling.

the auditor pulls from the drawer, regardless of each voucher's size, shape, location, or other physical features.

The auditor using haphazard selection should be careful to avoid distorting the sample by selecting, for example, only unusual or physically small items or by omitting items such as the first or last items in the physical representation of the population. While haphazard sampling is useful for nonstatistical sampling, it is not used for statistical sampling because it does not allow the auditor to measure the probability of selecting the combination of sampling units.

Determining the Sample Size

This section discusses the factors that auditors consider when using judgment to determine appropriate sample sizes. Auditors using nonstatistical sampling do not need to quantify these factors; rather, they might consider using estimates in qualitative terms such as none, few, or many. Appendix A includes additional guidance, along with several tables that should help auditors apply the following discussion to statistical sampling applications.

Considering the Acceptable Risk of Overreliance on Internal Accounting Control

The auditor is concerned with two aspects of sampling risk in performing compliance tests of internal accounting control. The *risk of overreliance on internal accounting control* is the risk that the sample supports the auditor's planned degree of reliance on the control when the true compliance rate for the population does not justify such reliance. The *risk of underreliance on internal accounting control* is the risk that the sample does not support the auditor's planned degree of reliance on the control when the true compliance rate supports such reliance.

The risk of underreliance on internal accounting control relates to the efficiency of the audit. For example, if the auditor's evaluation of a sample leads him to unnecessarily reduce his planned degree of reliance on internal accounting control, he would ordinarily increase the scope of substantive tests to compensate for the perceived inability to rely on internal accounting control to the extent originally planned. Although the audit might be less efficient in this circumstance, it is, nevertheless, effective. Therefore, the discussion of sampling risk in the following paragraphs relates primarily to the risk of overreliance on internal accounting control.

Samples taken for compliance tests are intended to provide reasonable assurance that internal accounting control procedures are being applied as prescribed. Regardless of how a control procedure has been designed to achieve the related internal accounting control objectives, the auditor should not rely on a control procedure that is not being applied as prescribed. Because the compliance test is the primary source of evidence of whether the control procedure is being applied as prescribed, the auditor generally wishes to obtain a high degree of assurance that the conclusions about the application of the control procedure, based on a sample of transactions subject to the control procedure, would not differ from the conclusions that would be reached if the test were applied in the same way to all transactions. Therefore, the auditor should allow for a low level of risk of overreliance. Although consideration of risk is implicit in all audit sampling applications, an auditor should explicitly state an acceptable risk of overreliance for a statistical sampling application.

There is an inverse relationship between the risk of overreliance on internal accounting control and sample size. If the auditor is willing to accept only a low risk of overreliance, the sample size would ordinarily be larger than if a higher risk were acceptable. Although the auditor need not quantify this risk (for example, it may be assessed as low, moderate, or high), the following table illustrates the relative effect on sample size of various levels of the risk of overreliance on internal accounting control. Computations use statistical theory and assume a tolerable rate of 5 percent, a large population size, and an expected population deviation rate of approximately 1 percent.

Risk of Overreliance	*Sample Size*
10%	77
5%	93
1%	165

Some auditors find it practical to select one level of risk for all compliance tests and to assess, for each separate test, a tolerable rate based on the planned degree of reliance on the internal accounting control.

Considering the Tolerable Rate

In designing substantive tests, auditors consider the reliance that they plan to place on related internal accounting controls. The tolerable rate is the maximum rate of deviation from a prescribed control procedure that auditors are willing to accept without altering planned reliance on a control. Auditors consider the nature, timing, and extent of planned substantive tests in determining the tolerable rate. If, after performing the sampling application, the auditor finds that the rate of deviation from the prescribed control procedure is close to or exceeds the tolerable rate, the auditor might decide that there is an unacceptably high sampling risk that the deviation rate for the population exceeds the tolerable rate. In such cases the auditor should modify planned reliance on the prescribed control.

An auditor using statistical sampling generally calculates an allowance for sampling risk. If the auditor finds that the rate of deviation from the prescribed control procedure plus the allowance for sampling risk exceeds the tolerable rate, he should modify planned reliance on the prescribed control.

Sometimes the auditor specifies a high tolerable rate because he plans to place little reliance on the control procedure. A very high tolerable rate often indicates that the planned reliance on the control procedure does not significantly reduce the extent of related substantive tests. In that case the particular compliance test might be unnecessary and may be omitted.

The tolerable rates shown in the following table are intended only to be illustrative of the relative reliance some auditors might place on an internal accounting control procedure. Overlapping ranges are presented.

Planned Degree of Reliance	*Tolerable Rate*
Substantial reliance on the internal accounting control	2%–7%
Moderate reliance on the internal accounting control	6%–12%
Little reliance on the internal accounting control	11%–20%
No reliance	omit test

In assessing the tolerable rate, the auditor should consider that while deviations from pertinent control procedures increase the risk of material errors in the accounting records, such deviations do not necessarily result in errors. A recorded disbursement that does not show evidence of required approval might nevertheless be a transaction that is properly authorized and recorded. Therefore, a tolerable rate of 5 percent does not necessarily imply that 5 percent of the dollars are in error. Auditors usually assess a tolerable rate for compliance tests that is greater than the tolerable rate of dollars in error. This conclusion is based on the fact that deviations would result in errors in the accounting records only if the deviations and the errors occurred on the same transactions.

There is an inverse relationship between the tolerable rate and sample size. The following table illustrates the relative effect of tolerable rate on sample size. Computations use statistical theory and assume a 5-percent risk of overreliance, a large population size, and an expected population deviation rate of zero percent.

Tolerable Rate	*Sample Size*
2%	149
4%	74
6%	49
8%	36
10%	29
20%	14

When performing compliance tests, generally the auditor is concerned only that the *actual* rate of deviations in the population does not exceed the *tolerable* rate; that is, if the auditor is evaluating the sample results and finds the sample deviation rate to be less than the tolerable rate for the population, the auditor needs to consider only the risk that such a result might be obtained even if the actual deviation rate in the population exceeds the tolerable rate. The sample-size illustrations in this chapter assume that the sample is designed to measure only the risk that the estimated deviation rate is understated. This is sometimes referred to as an *upper-limit approach*.[3]

Considering the Expected Population Deviation Rate

The auditor might control the risk of underreliance on internal accounting control by adjusting the sample size for his assessment of the deviation rate he expects to find in the population. As the

3. For a discussion of interval estimates, see Donald Roberts, *Statistical Auditing* (New York: AICPA, 1978), p. 53.

expected population deviation rate approaches the tolerable rate, the need arises for more precise information from the sample. Therefore, for a given tolerable rate, the auditor selects a larger sample size as the expected population deviation rate increases. The *expected population deviation rate* is sometimes referred to as the *expected error rate* or the *expected rate of occurrence*.

The expected population deviation rate should not equal or exceed the tolerable rate. If the auditor believes that the actual deviation rate is higher than the tolerable rate, he generally omits compliance testing of that control procedure and designs substantive tests without relying on that control procedure.

Using judgment, the auditor estimates the expected population deviation rate by considering such factors as results of the prior year's tests and the overall control environment. The prior year's results should be considered in light of changes in the entity's system of internal accounting control and changes in personnel.

There is a direct relationship between expected population deviation rate and sample size. The following table illustrates the relative effect of the expected population deviation rate on sample size. Computations use statistical theory and assume a 5-percent tolerable rate, a large population size, and a 5-percent risk of overreliance.[4]

Expected Population Deviation Rate (approximate)	*Sample Size*
0.0%*	59
1.0%	93
1.5%	124
2.0%	181
2.5%	234
3.0%	361

* Some auditors use a sampling approach referred to as discovery sampling. *Discovery sampling* is essentially the same as the approach described in this chapter when the auditor assumes an expected population deviation rate of zero.

4. Large sample sizes, such as 234 and 361, are included for illustrative purposes and not to suggest that it would be cost-beneficial to test compliance with internal accounting control by using such large sample sizes.

Considering the Effect of Population Size

The size of the population has little or no effect on the determination of sample size except for very small populations. For example, it is generally appropriate to treat any population over 5,000 sampling units as if it were infinite. If the population size is under 5,000 sampling units, the population size may have a small effect on the calculation of sample size.

The following table illustrates the limited effect of population size on sample size. Computations use statistical theory and assume a 5-percent risk of overreliance, a 1-percent expected population deviation rate, and a 5-percent tolerable rate.

Population Size	*Sample Size*
50	45
100	64
500	87
1,000	90
2,000	92
5,000	93
100,000	93

Because population size has little or no effect on sample size, all other illustrations of sample sizes for compliance tests assume a large population size.

Considering a Sequential or a Fixed Sample-Size Approach

Audit samples may be designed using either a fixed sampling plan or a sequential sampling plan. Under a *fixed sampling plan* the auditor examines a single sample of a specified size. In *sequential sampling* (sometimes referred to as *stop-or-go sampling*) the sample is taken in several steps, with each step conditional on the results of the previous step. Guidance on sequential sampling plans is included in Appendix B.

Performing the Sampling Plan

After the sampling plan has been designed, the auditor selects the sample and examines the selected items to determine if they contain deviations from the prescribed control procedure.[5] When selecting the sampling units, it is often practical to select several additional ones as extras. If the size of the remaining sample is inadequate to meet the auditor's objectives, the auditor may use the extra sampling units. If the auditor has selected a random sample, any additional items used as replacements should be used in the same order in which the numbers were generated. The auditor who uses a systematic sampling selection would ordinarily need to examine all extra selected items so that each item in the entire population has a chance of selection.

Voided documents. An auditor might select a voided item to be included in a sample. For example, an auditor testing compliance with an internal accounting control procedure that is evidenced on the entity's vouchers might match random numbers with voucher numbers for the period included in the population definition. However, a random number might match with a voucher that has been voided. If the auditor obtains reasonable assurance that the voucher has been properly voided and does not represent a deviation from the prescribed internal accounting control procedure, the voided voucher should be replaced and, if random sampling is used, a replacement number should be matched with the appropriate voucher.

Unused or inapplicable documents. The auditor's consideration of unused or inapplicable documents is similar to the consideration of voided documents. For example, a sequence of vouchers might include unused vouchers or an intentional omission of certain numbers. If the auditor selects such a document, he should obtain reasonable assurance that the voucher number actually represents an unused voucher and does not represent a deviation from the prescribed control procedure. The unused voucher might then be replaced with an additional voucher. Sometimes a selected item is inapplicable for a given definition of a deviation. For example, a telephone expense selected as part of a sample for which an error has been defined as "transaction not supported by receiving report" may not be expected to be supported by a receiving report. If the auditor has obtained reasonable assurance that the transaction is not applicable and does not represent a deviation from the prescribed

5. Some auditors find it practical to select a single sample for more than one sampling objective. This approach is appropriate if the sample size is adequate and selection procedures are appropriate for each of the related sampling objectives.

control procedure, he might replace the item with another transaction.

Errors in estimating population sequences. If the auditor is using random-number sampling to select sampling units, the population size and numbering sequence might be estimated before the documents have been used. The most common example of this situation is where the auditor has defined the population to include the entire period under audit but plans to perform a portion of the sampling procedure before the end of the period. If the auditor overestimates the population size and numbering sequence, any numbers that are selected as part of the sample and that exceed the actual numbering sequence used would be treated as unused documents. Such numbers would be replaced by matching extra random numbers with appropriate documents.

In planning and performing an audit sampling procedure, the auditor should also consider the two following special situations that may occur.

Stopping the test before completion. Occasionally the auditor might find a large number of deviations in auditing the first part of a sample. As a result, he might believe that even if no additional deviations were to be discovered in the remainder of the sample, the results of the sample would not support the planned reliance on the internal accounting control. Under these circumstances the auditor could evaluate the sample by using a best-case assumption (that is, by assuming no additional deviations exist in the sample). If the sample results obtained by using a best-case assumption were unacceptable, the auditor need not continue examining items in the sample and should alter the nature, timing, or extent of related planned substantive tests. However, if the results obtained by using this best-case assumption were acceptable or supported a reduced level of reliance, he ordinarily would continue to examine all selected sample items to reach an appropriate conclusion.

Inability to examine selected items. The auditor should apply to each sampling unit auditing procedures that are appropriate to achieve the objective of the compliance tests. In most circumstances compliance with the prescribed control procedure being tested is evidenced only on the document selected as part of the sample. If that document cannot be located or if for any other reason the auditor is unable to examine the selected item, he generally will be unable to use alternative procedures to test whether that control procedure was applied as prescribed. If the auditor is not able to apply the planned audit procedures or appropriate alternative procedures to selected items, he should ordinarily consider those selected items to be deviations from the control procedures for the purpose of evaluating the sample. In addition, the auditor should consider the reasons for this limitation and the effect that such limitations might have on his understanding of, and reliance on, the entity's system of internal accounting control.

Evaluating the Sample Results

After completing the examination of the sampling units and summarizing the deviations from prescribed control procedures, the auditor evaluates the results. Whether the sample is statistical or nonstatistical, the auditor uses judgment in evaluating the results and reaching an overall conclusion.

Calculating the Deviation Rate

Calculating the deviation rate in the sample involves dividing the number of observed deviations by the sample size. The deviation rate in the sample is the auditor's best estimate of the deviation rate in the population from which it was selected.

Considering Sampling Risk

As discussed in chapter 1, sampling risk arises from the possibility that when compliance testing is restricted to a sample, the auditor's conclusions might differ from those he would have reached if the test were applied in the same way to all items in the account balance or the class of transactions. When the auditor evaluates a sample for a compliance test, he should consider sampling risk. If the estimate of the population deviation rate is less than the tolerable rate for the population, the auditor should consider the risk that such a result might be obtained even if the deviation rate for the population exceeds the tolerable rate for the population. SAS No. 39 provides the following general example of how an auditor might consider sampling risk for compliance tests:

> If the tolerable rate for a population is 5 percent and no deviations are found in a sample of 60 items, the auditor may conclude that there is an acceptably low sampling risk that the true deviation rate in the population exceeds the tolerable rate of 5 percent. On the other hand, if the sample includes, for example, two or more deviations, the auditor may conclude that there is an unacceptably high sampling risk that the rate of deviations in the population exceeds the tolerable rate of 5 percent.

If an auditor is performing a statistical sampling application, he often uses a table or time-sharing program to assist in measuring the allowance for sampling risk. For example, most time-sharing programs used to evaluate sampling applications calculate an estimate of the upper limit of the possible deviation rate based on the sample size and the sample results at the auditor's specified risk of overreliance.

If the auditor is performing a nonstatistical sampling application, sampling risk cannot be measured directly. However, it is generally appropriate for the auditor to assume that the sample results do not support the planned reliance if the rate of compliance deviation identified in the sample exceeds the expected population deviation rate used in designing the sample. In that case there is likely to be an unacceptably high risk that the true deviation rate in the population exceeds the tolerable rate. If the auditor concludes that there is an unacceptably high risk that the true population deviation rate could exceed the tolerable rate, it might be practical to test compliance on sufficient additional items to reduce the risk to an acceptable level. Rather than testing additional items, however, it is generally more efficient to modify planned reliance on the control procedure because the results of the sample would generally support a lesser level of reliance on the control.

Appendix A includes statistical sampling tables that should help the auditor in using professional judgment to evaluate the results of statistical samples for compliance tests. The tables might also be useful to auditors using nonstatistical sampling.

Considering the Qualitative Aspects of the Deviations

In addition to evaluating the frequency of deviations from pertinent procedures, the auditor should consider the qualitative aspects of the deviations. These include (1) the nature and cause of the deviations, such as whether they are errors or irregularities or are due to misunderstanding of instructions or to carelessness and (2) the possible relationship of the deviations to other phases of the audit. The discovery of an irregularity ordinarily requires a broader consideration of the possible implications than does the discovery of an error.

Reaching an Overall Conclusion

The auditor uses professional judgment to reach an overall conclusion about the effect that the evaluation of the compliance test will have on the nature, timing, and extent of planned substantive tests. If the sample results, along with other relevant evidential matter, support the planned reliance on internal accounting control, the auditor generally does not need to modify planned substantive tests. If the planned reliance is not supported, the auditor would ordinarily either test compliance with other internal accounting controls on which he may rely or modify the related substantive tests to reflect reduced or eliminated reliance.

Documenting the Sampling Procedure

SAS No. 41, *Working Papers*, provides guidance on documentation of audit procedures. While neither SAS No. 39 nor this guide requires specific documentation of audit sampling applications, examples of items that the auditor might consider including in documentation of compliance testing are —

- A description of the prescribed control procedure being tested.
- The objectives of the application, including its relationship to planned substantive testing.
- The definition of the population and the sampling unit, including how the auditor considered completeness of the population.
- The definition of the deviation condition.
- The rationale for (1) the risk of overreliance, (2) the tolerable deviation rate, and (3) the expected population deviation rate used in the application.
- The method of sample-size determination.
- The method of sample selection.
- A description of how the sampling procedure was performed and a list of compliance deviations identified in the sample.
- The evaluation of the sample and a summary of the overall conclusion.

The evaluation and summary might contain the number of deviations found in the sample, an explanation of how the auditor considered sampling risk, and a determination of whether the sample results support planned reliance on the control procedure. For sequential samples each step of the sampling plan, including the preliminary evaluation made at the completion of each step, might be documented. The working papers might also document the nature of the deviations, the auditor's consideration of the qualitative aspects of the deviations, and the effect of the evaluation on related planned substantive tests.

Chapter 3

Sampling in Substantive Tests of Details

Introduction

The purpose of substantive tests of details of transactions and balances is "to obtain evidence as to the validity and the propriety of accounting treatment of transactions and balances or, conversely, of errors or irregularities therein" (SAS No. 1, paragraph 320.70). As discussed in SAS No. 39, an auditor relies on a combination of internal accounting controls, analytical review procedures, and substantive tests of details to obtain reasonable assurance that the financial statements being audited are not materially misstated. When testing the details of an account balance or class of transactions, the auditor might use audit sampling to obtain substantive evidence about the reasonableness of monetary amounts.

This chapter is divided into four sections. The first section introduces the general concepts of audit sampling applicable to both nonstatistical and statistical sampling for substantive tests. The next three sections examine concepts related to nonstatistical sampling, probability-proportional-to-size (PPS) statistical sampling, and classical variables statistical sampling, respectively.

Section 1: General Considerations

The use of audit sampling for substantive tests of details generally includes the following:

1. Determining the audit objective of the test
2. Defining the population
   a. Defining the sampling unit

   b. Considering the completeness of the population
   c. Identifying individually significant items
3. Choosing an audit sampling technique
4. Determining the sample size
   a. Considering variation within the population
   b. Considering the acceptable level of risk
   c. Considering the tolerable error
   d. Considering the expected amount of error
   e. Considering the population size
5. Determining the method of selecting the sample
6. Performing the sampling plan
7. Evaluating the sample results
   a. Projecting the error to the population and considering sampling risk
   b. Considering the qualitative aspects of errors and reaching an overall conclusion
8. Documenting the sampling procedure

Determining the Audit Objective of the Test

A sampling plan for substantive tests of details might be designed (1) to test the reasonableness of an amount (for example, the balance in accounts receivable) or (2) to make an independent estimate of some amount (for example, the LIFO index for a LIFO inventory). The first approach, often referred to as *hypothesis testing*, is generally used by an auditor performing a substantive test as part of an examination of financial statements. In that case the auditor desires to accept an amount if it is reasonably correct. The second approach, generally referred to as *dollar-value estimation*, might be appropriate when a CPA has been engaged to assist management in developing independent estimates of quantities or amounts. For example, a CPA might assist management in estimating the value of LIFO inventory that was previously recorded on a FIFO basis. This document does not provide guidance on the use of sampling if the objective of the application is to develop an original estimate of quantities or amounts.

It is important that an auditor carefully identify the characteristic of interest for the sampling application that is consistent with the audit objective. For example, a characteristic of interest might be defined as certain differences between the recorded amount and the amount the auditor determines to be correct, in which case the characteristic of interest might be called an error. Some differences might not involve the characteristic of interest. For example, differences in posting to the correct detail account might not result in misstatement of the aggregate account balance. The auditor might also decide to exclude errors the entity has independently detected and corrected in the proper period.

Defining the Population

The *population* consists of the items constituting the account balance or class of transactions of interest. The auditor should determine that the population from which he selects the sample is appropriate for the specific audit objective because sample results can only be projected to the population from which the sample was selected. For example, an auditor cannot detect understatements of an account that result from omitted items by sampling the recorded items. An appropriate plan for detecting such understatements would involve selecting from a source in which the omitted items are included. To illustrate: The auditor might (1) sample subsequent cash disbursements to test recorded accounts payable for understatement resulting from omitted purchases or (2) sample shipping documents for understatement of sales resulting from shipments that were made but not recorded as sales.

Because the nature of the transactions resulting in debit balances, credit balances, and zero balances are generally different, the audit considerations might also differ. Therefore, the auditor should consider whether the population to be sampled should include all those items. For example, a retailer's accounts receivable balance may include both debit and credit balances. The debit balances generally result from customer sales on credit, while the credit balances might result from advance payments and, therefore, represent liabilities. The audit objectives for testing those debit and credit balances might be different. If the amount of credit balances is significant, the auditor might find it more effective and efficient to perform separate tests of the debit balances and the credit balances. In that case the debit and credit balances would be defined as separate populations for the purpose of audit sampling.

Defining the Sampling Unit

A *sampling unit* is any of the individual elements that constitute the population. The auditor selects a sampling unit for a particular audit sampling application. A sampling unit might be, for example, a customer account balance, an individual transaction, or an individual entry in a transaction.

The definition of a sampling unit depends on the nature of the audit procedures to be applied. For example, if the objective of the sampling application is to test the recorded amount of accounts receivable, the auditor might choose customer balances, customer invoices, or individual items constituting an invoice as the sampling unit. In making that judgment, the auditor might consider which sampling unit leads to a more effective and efficient sampling application in the circumstances. For example, if the auditor's procedure is positive confirmation of receivable amounts with the entity's customers, he selects a sampling unit that he believes the customers would be most likely to confirm. The auditor also considers the definition of the sampling unit on the basis of ease in applying planned or alternative procedures. In the above example, if the auditor defines the sampling unit as a customer balance, he may need to test each individual transaction supporting that balance if the customer does not confirm the balance. Therefore, it might be more efficient to define the sampling unit as an individual transaction that is part of the accounts receivable balance.

Considering the Completeness of the Population

The auditor actually selects sampling units from a physical representation of the population. If the auditor defines the population as all customer receivable balances as of a specific date, the physical representation might be the customer accounts receivable subsidiary ledger as of that date.

The auditor should consider whether the physical representation includes the entire population. Because the physical representation is what the auditor actually selects a sample from, any conclusions based on the sample relate only to that physical representation. If the physical representation and the population differ, the auditor might draw erroneous audit conclusions.

If after footing the physical representation and reconciling it to the population the auditor determines that the physical representation has omitted items in the population that he wishes to include in his overall evaluation, he should select a new physical representation or perform alternative procedures on the items excluded from the physical representation.

Identifying Individually Significant Items

As discussed in SAS No. 1, paragraph 150.04, the sufficiency of tests of details for a particular account balance or class of transactions relates to the individual importance of the items examined, as well as to the potential for material error. When planning a sample for a substantive test of details, the auditor uses his judgment to determine which items, if any, in an account balance or class of transactions should be individually tested and which should be subject to sampling. The auditor should examine each item for which acceptance of some sampling risk is not justified. These might include items for which potential errors could individually equal or exceed the tolerable error. Any items that the auditor has decided to test 100 percent are not part of the population subject to sampling. If there are other items that, in the auditor's judgment, need to be tested to fulfill the audit objective but need not be examined 100 percent, they would be subject to sampling.

Choosing an Audit Sampling Technique

Once the auditor has decided to use audit sampling, either nonstatistical or statistical sampling is appropriate for substantive tests of details. Chapter 1 discusses the general considerations in choosing between a nonstatistical and a statistical sampling approach. Additional considerations in selecting among the alternative approaches for sampling applications for substantive tests are discussed in sections 2 to 4 of this chapter.

The most common statistical approaches are classical variables sampling and probability-proportional-to-size (PPS) sampling. Classical variables techniques use normal distribution theory to evaluate the sample results; the PPS approach described in this guide uses attributes sampling theory.

Determining the Sample Size

Considering Variation Within the Population

The characteristics (such as amounts) of individual items in a population often vary significantly; accounting populations tend to include a few very large amounts, a number of moderately large amounts, and a large number of small amounts. Auditors consider the variation among characteristics when they determine an appropriate sample size for a substantive test. Auditors generally consider the variation of the items' recorded amounts as a means of estimating the variation of the audit amounts of the items in the population. A measure of this variation, or scatter, is called the *standard deviation.* Auditors using nonstatistical sampling do not need to quantify the expected population standard deviation; rather, they might consider estimating the variation in qualitative terms such as small or large.

Sample sizes generally decrease as the variation becomes smaller. A population can be separated, or stratified, into relatively homogeneous groups to reduce the sample size by minimizing the effect of the variation of amounts for items in the population. Sample sizes for unstratified populations with high variation are generally very large. To be most efficient, stratification should be based on some characteristic of the items in the population that is expected to reduce variation. Common bases for stratification for substantive tests may be, for example, the recorded amounts of the items, the nature of internal accounting controls related to processing the items, or special considerations associated with certain items (such as portions of the population that might be more likely to contain errors). Each group into which the population has been divided is called a *stratum.* Separate samples are selected from each stratum. The auditor combines the results for all strata in reaching an overall conclusion about the population.[1]

Auditors using a nonstatistical sampling approach subjectively consider variation within the population. Auditors using a classical variables sampling approach explicitly consider this variability in designing a sampling application. Auditors using PPS sampling do not directly consider this factor because a PPS sample indirectly considers it in the method of sample selection.

Auditors using a classical variables sampling approach often use a computer in estimating the variation of a population's audited amounts by measuring the variation of recorded amounts. Another method of measuring the variation of the items' amounts is to select a pilot sample. A *pilot sample* is an initial sample of items in the population. If the auditor is stratifying the population, the pilot sample is selected by strata. The auditor performs planned audit procedures on sampling units of the pilot sample and evaluates the

1. While projected error results from each stratum are added, the allowances for sampling risk related to each stratum are not added. See Donald Roberts, *Statistical Auditing* (New York: AICPA, 1978), p. 101.

pilot sample to gain a better understanding of the variation of both recorded amounts and audited amounts in the population. Although the appropriate size of a pilot sample differs according to the circumstances, it generally consists of 30 to 50 sampling units. The pilot sample can often be designed in a way that allows the auditor to use it as part of the main sample.

It is not always necessary to use a pilot sample to gain a better understanding of the variation in a population. The results of prior years' tests and an adequate understanding of the entity's business and accounting records might provide the auditor with sufficient understanding of the variation of amounts without incurring the additional cost of using a pilot sample.

Considering the Acceptable Level of Risk

The auditor is concerned with two aspects of sampling risk in performing substantive tests of details. The *risk of incorrect acceptance* is the risk that the sample supports the conclusion that the recorded account balance is not materially misstated when it is materially misstated. The *risk of incorrect rejection* is the risk that the sample supports the conclusion that the recorded account balance is materially misstated when it is not. The risk of incorrect acceptance and the risk of incorrect rejection are related to the statistical concepts of beta and alpha risk, respectively, as explained in many textbooks on statistical sampling.

The Risk of Incorrect Acceptance

In assessing an acceptable level of the risk of incorrect acceptance, the auditor considers (1) the level of ultimate risk that he is willing to accept and (2) the level of assurance to be provided by reliance on internal accounting control and other audit procedures, including analytical review procedures.

With respect to a particular account balance or class of transactions, *ultimate risk* is the risk that there is monetary error greater than tolerable error in the balance or class and that the auditor fails to detect it. Auditors use professional judgment in determining the acceptable ultimate risk for a particular test after considering such factors as the risk of material misstatement in the financial statements, the cost to reduce the risk, and the effect of the potential misstatement on the use and understanding of the financial statements.

After assessing the acceptable ultimate risk, auditors decide the extent of assurance to be provided by reliance on internal accounting control and other audit procedures. The second standard of field work recognizes that the extent of substantive tests required to obtain sufficient evidential matter under the third standard should vary inversely with the auditor's reliance on internal accounting control.

These standards, taken together, imply that the combination of the auditor's reliance on internal accounting control and his reliance on substantive tests should provide a reasonable basis for his opinion, although the portion of reliance derived from the respective sources may vary. The greater the reliance on internal accounting control or on other substantive tests directed toward the same specific audit objective, the greater the allowable risk of incorrect acceptance for the substantive test of details being planned and, thus, the smaller the required sample size for the substantive test of details. For example, if the auditor can rely on neither internal accounting control nor other substantive tests directed toward the same specific audit objective, he should assess a low risk of incorrect acceptance for the substantive test of details. Thus, the auditor would select a larger sample for the test of details than if he assessed a higher risk of incorrect acceptance.

The appendix of SAS No. 39 provides a planning model expressing the general relationship of ultimate risk to the extent of planned reliance the auditor places on a substantive test of details, internal accounting control, and other substantive tests, such as analytical review procedures, directed toward the same specific audit objective. Appendix F of this guide discusses how the auditor might use that planning model in considering the acceptable level of risk of incorrect acceptance.

The Risk of Incorrect Rejection

The risk of incorrect rejection is related to the efficiency of the audit. For example, if the auditor's evaluation of a sample leads him to an initially erroneous conclusion that a balance is materially misstated when it is not, the consideration of other audit evidence and performance of additional audit procedures would ordinarily lead the auditor to the correct conclusion. When auditors decide to accept a higher risk of incorrect rejection, they reduce the appropriate sample size for the substantive test; however, they also increase the risk that they might incur costs for performing additional procedures to resolve differences between a correct recorded amount and an erroneous estimate resulting from an inadequately controlled risk of incorrect rejection. Although the audit might be less efficient in this circumstance, it is, nevertheless, effective.

Although it is still an efficiency consideration, the auditor is generally more concerned with the risk of incorrect rejection when planning a sampling application for substantive testing than with the risk of underreliance on internal accounting control when planning a sampling application for compliance testing. If the sample results for a compliance test do not support the auditor's planned reliance on a particular internal accounting control, the auditor considers relying on other internal accounting controls or modifying planned substantive tests to compensate for the reduction or elimination of reliance on that particular internal accounting control. Because an alternative audit approach is readily available, the inconvenience to the auditor and the entity resulting from underreliance on internal accounting control is generally relatively small. However, if the sample results for a substantive test support the conclusion that the recorded account balance or class of transactions is materially misstated when it might not be, the alternative approaches available to the auditor might be more costly. Ordinarily, the auditor will need to have further discussions with the entity's personnel and to perform subsequent additional audit procedures. The cost of this additional work might be substantial. Further consideration of the risk of incorrect rejection is discussed in sections 3 and 4 of this chapter.

Considering the Tolerable Error

When planning a sample for a substantive test of details, the auditor should consider how much monetary error in the related account balance or class of transactions may exist without causing the financial statements to be materially misstated. This maximum monetary error for the balance or class is called *tolerable error* for the sample. Tolerable error is related to the auditor's preliminary estimates of materiality levels in such a way that tolerable error, combined for the entire audit plan, does not exceed these estimates. For a particular account balance or class of transactions, the sample size required to achieve the auditor's objective at a given risk of incorrect acceptance increases as the auditor's assessment of tolerable error for that balance or class decreases.

Considering the Expected Amount of Error

In determining the sample size, the auditor generally considers the rate and total amount of error he expects to find in the population. In general, as the expected amount of error approaches the tolerable error, there is a need for more precise information from the sample. Therefore, the auditor should select a larger sample size as the expected amount of error increases.

The auditor assesses the expected amount of error on the basis of his professional judgment after considering such factors as his understanding of the entity's business, prior years' tests of the account balance or class of transactions, results of the pilot sample, if any, any related substantive tests, and results of tests of related internal accounting controls.

Considering the Population Size

The effect of population size on the appropriate sample size varies according to the audit sampling method used (see sections 2 to 4 of this chapter).

Determining the Method of Selecting the Sample

The auditor should select the sample in such a way that the sample can be expected to be representative of the population or the stratum from which it is selected. An overview of basic selection methods is presented in chapter 2. In addition, PPS selection is discussed in section 3 of this chapter.

Performing the Sampling Plan

The auditor should apply, to each sample item, auditing procedures appropriate for the particular audit objective. In some circumstances the auditor might not be able to apply the planned procedures to selected sampling units (for example, because supporting documentation is missing). The auditor's treatment of those unexamined items depends on their effect on his evaluation of the sample. If the auditor's evaluation of the sample results would not be altered by considering those unexamined items to be in error, it is not necessary to examine the items. However, if considering those unexamined items to be misstated would lead to a preliminary conclusion that the balance or class is materially in error, the auditor should consider alternative procedures that would provide him with sufficient evidence to form a revised conclusion. The auditor should also consider whether the reasons for the inability to examine the items affect planned reliance on internal accounting control or the degree of reliance on management representations.

Some of the selected sampling units might be unused or voided items. The auditor should carefully consider how he has defined the population when he decides whether to include an item in his sample. For example, if the auditor is selecting a sample of customer balances to reach a conclusion about the recorded amount of the accounts receivable balance, a customer account with a zero balance could be a valid sampling unit. However, an account number that the auditor has determined is not assigned to any customer would not be a valid sampling unit and should be replaced by another sampling unit. In the first case the selected item is one of the customer balances constituting the population; in the second case the selected account number does not represent one of the customer balances constituting the population. To provide for this possibility, the auditor might wish to select a slightly larger sample. The additional items would be examined only if they were used as replacement items. Special considerations for performing the sampling techniques for substantive tests are discussed in sections 2 to 4.

Evaluating the Sample Results

Projecting the Error to the Population and Considering Sampling Risk

According to SAS No. 39 the auditor should project the error results of the sample to the population from which the sample was selected and should add that amount to the errors discovered in any items examined 100 percent. Regardless of whether the sample results support the assertion that the recorded amount is not misstated by an amount greater than tolerable error, the entity may adjust the recorded amount of the account because of the errors identified in the population. The total projected error after the recorded amount has been adjusted by the entity should be compared with the tolerable error for the account balance or class of transactions, and the auditor should consider the risk that such result might be obtained even though the true monetary error for the population exceeds the tolerable error. The auditor should also consider the projected error in the balance or class (after adjustments, if any) together with other relevant audit evidence when evaluating whether the financial statements taken as a whole may be materially misstated.

Although the general factors to be considered in making the projection and considering the effect of sampling risk are the same for all sampling techniques, the method of consideration differs according to the sampling technique used. The evaluation processes for each of the techniques discussed in this chapter are described in sections 2 to 4.

Considering the Qualitative Aspects of Errors and Reaching an Overall Conclusion

In addition to the evaluation of the frequency and amounts of errors, the auditor should consider their qualitative aspects. These aspects include (1) the nature and cause of misstatements, such as whether they are (a) differences in principle or in application, (b) errors or irregularities, or (c) due to misunderstanding of instructions or to carelessness and (2) the possible relationship of the misstatements to other phases of the audit. The discovery of an irregularity ordinarily requires a broader consideration of possible implications than does the discovery of an error.

If the sample results suggest that the auditor's planning assumptions were in error, appropriate action should be taken. For example, if the amounts or frequency of errors discovered in a substantive test of details is greater than that implied by the degree of reliance initially placed on internal accounting control, the auditor should consider whether the planned reliance is still appropriate. A large number of errors discovered in the confirmation of receivables might indicate the need to reconsider the initial evaluation of the reliance to be placed on internal accounting control related to sales or cash receipts. The auditor should also consider whether to modify the audit tests of other accounts that were designed with reliance being placed on those internal accounting controls. The auditor should relate the evaluation of the sample to other relevant audit evidence when forming a conclusion about the related account balance or class of transactions.

Documenting the Sampling Procedure

SAS No. 41, *Working Papers,* provides guidance on documentation of audit procedures. While neither SAS No. 39 nor this guide requires specific documentation of audit sampling applications, examples of items that the auditor might consider including in documentation of substantive testing are —

- The objectives of the test and a description of other audit procedures related to those objectives.
- The definition of the population and the sampling unit, including how the auditor considered completeness of the population.
- The definition of an error.
- The rationale for (1) the risk of incorrect acceptance, (2) the risk of incorrect rejection, (3) the tolerable error, and (4) the expected population error used in the application.
- The audit sampling technique used.
- The method of sample selection.
- A description of the performance of the sampling procedures and a list of errors identified in the sample.
- The evaluation of the sample and a summary of the overall conclusion.

The evaluation and summary might contain a projection of the errors found in the sample to the population, an explanation of how the auditor considered sampling risk, and an overall conclusion about the population. The working papers also might document the auditor's consideration of the qualitative aspects of the errors.

Section 2: Nonstatistical Sampling

This section provides further guidance on planning, performing, and evaluating a nonstatistical sample for substantive tests. Chapter 1 discussed the differences between nonstatistical and statistical sampling and how an auditor chooses between them after considering their relative costs and effectiveness in the circumstances.

Section 1 of this chapter provided general guidance applicable to all sampling applications for substantive tests, either nonstatistical or statistical. This section discusses some aspects of the factors to be considered by an auditor using nonstatistical sampling. In general, these factors relate to the following:

1. Identifying individually significant items
2. Determining the sample size
   a. Variation within the population
   b. Risk of incorrect acceptance
   c. Tolerable error and error expectation

   d. Population size
   e. Relating the factors to determine the sample size
3. Selecting the sample
4. Evaluating the sample results
   a. Projecting the error
   b. Considering sampling risk
   c. Considering qualitative characteristics

Identifying Individually Significant Items

When planning a nonstatistical sample for a substantive test of details, the auditor uses his judgment to determine which items, if any, in an account balance or class of transactions should be tested individually and which items, if any, should be subject to sampling. The auditor should test each item for which, in his judgment, acceptance of some sampling risk is not justified. These might include items, for example, in which potential errors could individually equal or exceed the tolerable error. The auditor might also identify unusual balances and transactions as individually significant items.

Any items that the auditor has decided to test 100 percent are not part of the items subject to sampling. For example, the auditor might be planning procedures to examine an accounts receivable balance where 5 large customer balances constitute 75 percent of the account balance. If the auditor decides to examine the 5 large customer balances 100 percent and decides that he needs no additional evidential matter with respect to the remaining 25 percent of the account balance, he does not need to use sampling, and the examination of that balance would not be the subject of SAS No. 39 or this guide. However, if, in the auditor's judgment, the remaining items need to be tested to fulfill the audit objective, the auditor might test those items using audit sampling.

Determining the Sample Size

As discussed in SAS No. 39, the sample size necessary to provide sufficient evidential matter depends on both the objectives and the efficiency of the sample. For a given objective the efficiency of the sample relates to its design; one sample is more efficient than another if it can achieve the same objectives with a smaller sample size. In general, careful design can produce more efficient samples.

If the auditor selects too small a sample, the sample results will not meet the planned objective. In this case the auditor ordinarily needs to perform additional procedures to gather sufficient evidential matter to achieve the planned objective. If the auditor selects too large a sample, more items than necessary will be examined to achieve the planned objective. In both cases the examination would be effective even though the auditor did not use sampling efficiently.

In determining an appropriate sample size for a substantive test of details, the auditor using nonstatistical sampling considers the factors discussed in section 1 of this chapter even though he might not be able to quantify his consideration explicitly. The following paragraphs discuss the relative effect of changes in the planning considerations on the determination of sample size.

Variation Within the Population

The characteristics (such as the amounts) of individual items in a population often vary significantly. The auditor subjectively considers this variation when determining an appropriate sample size for a substantive test. The appropriate sample size generally decreases as the variation becomes smaller.

By separating a population into relatively homogeneous groups, the auditor can minimize the effect of the variation of amounts for items in the population and thereby reduce the sample size. Common bases for stratification for substantive tests are, for example, the recorded amount of the items, the nature of internal accounting controls related to processing the items, and special considerations associated with certain items (for example, portions of the population that might be more likely to contain errors). The auditor selects separate samples from each group and combines the results for all groups in reaching an overall conclusion about the population.

Risk of Incorrect Acceptance

As discussed in SAS No. 39, an auditor may rely on the internal accounting controls, analytical review procedures, and substantive tests of details in whatever combination he believes adequately controls ultimate risk. If the auditor places greater reliance on internal accounting controls, he can accept a greater risk of incorrect acceptance for the planned substantive test. As the acceptable level of risk of incorrect acceptance increases, the appropriate sample size for the substantive test decreases. Conversely, if the auditor places less reliance on the internal accounting controls, the acceptable level of risk of incorrect acceptance decreases and the appropriate sample size increases. The same relationship is true for the auditor's reliance on other substantive tests, including analytical review procedures, related to the same audit objectives. As the auditor's reliance on the other related substantive tests increases, the acceptable level of risk of incorrect acceptance increases, and the appropriate sample size decreases. Conversely, as the auditor's reliance on the other related substantive tests decreases, the acceptable level of risk of incorrect acceptance decreases, and the appropriate sample size increases.

Tolerable Error and Error Expectation

The auditor also considers tolerable error in determining the appropriate sample size for a substantive test. For a given account balance or class of transactions, the sample size required to achieve the auditor's objectives at a given risk of incorrect acceptance increases as the tolerable error for that balance or class decreases. The auditor also considers the amount and frequency of errors that he expects to exist in the account balance or class of transactions when he determines the appropriate sample size for a substantive test of details. As the size or frequency of expected errors decreases, the appropriate sample size also decreases. Conversely, as the size or frequency of expected errors increases, the appropriate sample size increases.

Population Size

The number of items in the population should have little effect on the determination of an appropriate nonstatistical sample size for substantive tests. As a result, it is generally not efficient to determine a sample size as a fixed percentage of the population.

Relating the Factors to Determine the Sample Size

An understanding of the relative effect of various planning considerations on sample size is useful in designing an efficient sampling application. The auditor uses professional judgment and experience in considering those factors to determine a sample size. Neither SAS No. 39 nor this guide requires the auditor to compare the sample size for a nonstatistical sampling application with a corresponding sample size calculated using statistical theory. At times, however, an auditor might find familiarity with sample sizes based on statistical theory helpful when applying professional judgment and experience in considering the effect of various planning considerations on sample size. This section includes an illustrative sample-size table and an illustrative model for determining sample sizes. That table and model are provided only to illustrate the relative effect of different planning considerations on sample size; they are not intended as substitutes for professional judgment.

Table 1 illustrates various sample sizes based on a statistical sampling approach.[2] The auditor using this table as an aid in understanding the relative size of samples for substantive tests of details will need to apply professional judgment in—

- Assessing tolerable error.
- Quantifying the acceptable level of risk.
- Quantifying error expectation.
- Estimating the population amount after the removal of items to be examined 100 percent.
- Determining the appropriate sample size that would reflect differences in efficiency between the nonstatistical approach and the statistical sampling approach underlying the table. For example, the auditor should consider the extent of stratification used in the nonstatistical sampling plan. Table 1 is based on a statistically efficient, highly stratified sampling approach.

Table 1 might also help an auditor to understand the risk levels implied by a given sample size. For example, the auditor might be designing a nonstatistical sampling application to test a population of 2,000 accounts receivable balances with a total recorded amount of $1 million. The auditor may have—

- Considered selecting a sample of 140.
- Assessed tolerable error as $30,000.
- Expected the population might contain about $9,000 of errors.

Table 1 would indicate that the sample of 140 would imply at least a 10-percent[3] risk of incorrect acceptance.

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2. Table 1 is based on the statistical theory underlying probability-proportional-to-size sampling, which is discussed in section 3 of this chapter.

3. Based on the information provided, tolerable error as a percent of population's recorded amount would be equal to 3 percent ($30,000 ÷ $1,000,000) and expected error as a percent of tolerable error would be equal to 30 percent ($9,000 ÷ $30,000). The auditor would look in the 3-percent tolerable-error column for expected error rates of 30-percent of tolerable error. The auditor would find 200 for a 5-percent risk and 144 for a 10-percent risk. Since the sample of 140 is less than 144, the sample size would imply a risk of incorrect acceptance greater than 10 percent.

The auditor might also compare other sample sizes in the table to the sample size of 140 to gain a better understanding of how sample size affects the risk levels in the circumstances. The auditor using table 1 for this purpose will also need to apply professional judgment in assessing the factors described in the preceding paragraph.

TABLE 1
Illustrative Sample-Size Table

		Tolerable Error as % of Population										
		50	30	10	8	6	5	4	3	2	1	5
*Risk**	*Expected Error as % of Tolerable Error*					*Sample Sizes*						
5%	0%	6	10	30	38	50	60	75	100	150	300	600
	10%	8	12	37	46	61	73	91	121	182	364	727
	20%	10	16	46	58	77	92	115	154	230	460	920
	30%	12	20	60	75	100	120	150	200	300	600	1200
	40%	16	27	81	101	135	162	202	269	404	807	1614
	50%	23	39	116	144	192	231	288	384	576	1152	2304
10%	0%	5	8	23	29	39	46	58	77	115	230	460
	20%	7	12	34	43	57	68	85	113	169	338	675
	30%	9	15	44	54	72	87	108	144	216	431	862
	40%	12	19	57	72	95	114	143	190	285	570	1140
	50%	16	27	80	100	133	160	200	266	399	798	1596
30%	0%	3	4	12	15	20	24	30	40	60	120	240
	20%	4	6	16	20	27	32	40	54	80	160	319
	40%	5	8	24	30	40	48	60	80	119	238	476
	60%	9	14	43	53	71	85	106	142	212	424	848
50%	0%	2	3	7	9	12	14	18	23	35	69	138
	20%	2	3	9	11	15	18	22	29	44	87	173
	40%	3	4	12	15	20	23	29	39	58	115	230
	60%	4	6	18	22	29	35	43	58	86	173	345

*Acceptable level of risk of incorrect acceptance

The following model also illustrates a method of assisting an auditor in gaining an understanding of the relative size of samples for substantive tests of details.[4] The auditor using this model will need to apply professional judgment in—

4. This simplistic model is based on the statistical theory underlying probability-proportional-to-size sampling, which is described in section 3 of this chapter. The factors presented are based on certain judgments and may differ as auditors' judgments differ in the circumstances.

- Assessing tolerable error.
- Classifying the degree of audit assurance desired and the extent of error likely to exist in the population.
- Estimating the recorded amount of the population after items to be examined 100 percent have been removed.
- Determining the appropriate sample size that would reflect differences in efficiency between the nonstatistical approach and the statistical sampling approach underlying the model. For example, the auditor should consider the extent of stratification used in the nonstatistical sampling plan. This model is based on a statistically efficient, highly stratified sampling approach.

Steps to be taken in determining sample size by using this model are as follows:

1. Assess tolerable error. Tolerable error is a planning concept and is related to the auditor's preliminary estimates of materiality levels in such a way that tolerable error, combined for the entire audit plan, does not exceed those estimates.
2. Classify the degree of audit assurance desired for the sample.
   a. Substantial — a relatively high level of assurance, generally indicating that little or no reliance is placed on internal accounting control or other related substantive procedures.
   b. Moderate — an average degree of assurance, generally indicating that some reliance is placed on internal accounting control or other related substantive procedures.
   c. Little — the minimal assurance, generally indicating that considerable reliance is placed on internal accounting controls or other related substantive procedures.
3. Assess the expected error in the population from which the sample is selected and choose an appropriate assurance factor.

	Assurance Factors	
Desired Degree of Audit Assurance	*Little or No Error Is Expected*	*Some Error Is Expected*
Substantial	3	6
Moderate	2.3	4
Little	1.5	3

4. Estimate the population's recorded amount after deducting any items that have been determined to be significant and that will be examined 100 percent.
5. Estimate the sample size.

$$\frac{\text{Population's recorded amount}}{\text{Tolerable error}} \times \text{Assurance factor} = \text{Sample size}$$

6. Adjust the sample size estimate to reflect any differences in efficiency between the nonstatistical approach and the statistical approach underlying this model.

If, for example, the auditor is designing a sample of accounts receivable with a recorded amount of $150,000 and desires a moderate degree of audit assurance, he can use this model to estimate an appropriate sample size. First the auditor identifies those items he wishes to examine 100 percent, which in this case are 12 items with a total recorded amount of $70,000. The remaining items, with a total recorded amount of $80,000, would be subject to sampling. If the auditor assesses the tolerable error as $4,000 and expects some error, the sample size can be estimated as follows:

$$\frac{80{,}000}{4{,}000} \times 4 = 80 \text{ sampling units}$$

The calculation of 80 sampling units is based on a highly stratified sampling approach. Because the nonstatistical sample design is planned with only minimal stratification, the auditor might decide to select, for example, a sample of 110 items. In that case a total of 122 items would be examined — 12 individually significant items with a recorded amount of $70,000 and 110 sampling units from the remainder of the population.

Selecting the Sample

The auditor should select the sample in such a way that the sample can be expected to be representative of the population from which it has been selected. Before selecting the sample, the auditor generally identifies individually significant items. The auditor generally stratifies the remaining items subject to sampling and allocates the sample size to the specific groups. For example, the accounts receivable balance may include some large dollar balances and many small dollar balances. In that case the auditor might design the sample to include two groups: one of large dollar balances and one of small dollar balances. The following table shows two such groups:

Groups	*Items*	*Recorded Amount*
Recorded amount from $100 to $1,000	100	$47,000
Recorded amount up to $100	1,000	33,000

The auditor should allocate a portion of the sample to each group. In general, the sample results can provide the auditor with greater assurance if the allocation results in a proportionately larger sample size for the large dollar group than for the small dollar group. For example, after considering the factors in this section, the auditor might determine the appropriate sample size to be 110 customer balances. If the large dollar group and the small dollar group include recorded amounts of $47,000 and $33,000, respectively, the auditor might select 70 sampling units from the large dollar group and the remaining 40 sampling units from the small dollar group. The auditor should select the sampling units from each group by any method that can be expected to result in a representative sample of that group.

Evaluating the Sample Results

Projecting the Error

SAS No. 39 states, "The auditor should project the error results of the sample to the items from which the sample was selected. . . ." The auditor can project the amount of error found in a nonstatistical sample to estimate the amount of error in the population by any one of several methods. This section describes two of the acceptable methods.

One method of projecting the amount of error found in a nonstatistical sample is to divide the amount of error in the sample by the fraction of total dollars from the population included in the sample. For example, an auditor might have selected a sample that includes 10 percent of the recorded amounts of the accounts receivable balance. If the auditor has found $1,000 of error in the sample, his best estimate of error in the population would be calculated to be $10,000 ($1,000 ÷ 10%). This method does not require an estimate of the number of sampling units in the population.

Under another method the auditor projects the average difference between the audited and the recorded amounts of each item included in the sample to all items constituting the population. For example, the auditor might have selected a nonstatistical sample of 100 items. If the auditor found $200 of error in the sample, the average difference between audited and recorded amounts for items in the sample is $2 ($200 ÷ 100). The auditor can then estimate the amount of error in the population by multiplying the total number of items in the population (in this case, 25,000 items) by the average difference of $2 for each sample item. The auditor's estimate of error in the population is $50,000 (25,000 × $2). This approach is the equivalent of the SAS No. 39 illustration of projecting errors from a sample ($200 ÷ [100 ÷ 25,000] = $50,000).

The two methods just described will give identical results if the sample includes the same proportion of items in the population as the proportion of the population's recorded amount included in the sample. If the proportions are different, the average amount of a sample item is generally different from the average amount of an item in the population. If the difference is significant, the auditor chooses between the approaches on the basis of his understanding of the magnitude and distribution of errors in the population. For example, if the auditor expects that the amount of error relates closely to the size of an item, he ordinarily uses the first approach. On the other hand, if the auditor expects the errors to be relatively constant for all items in the population, he ordinarily uses the second approach.

If the auditor designed the sample by separating the items subject to sampling into groups, he should separately project the error results of each group and then calculate his estimate of error in the population by summing the individually projected amounts of error. The auditor should also add to the projected amount of error any error found in the individually significant items that were examined 100 percent.

Considering Sampling Risk

According to SAS No. 39 the total projected error for a sample "should be compared with the tolerable error for the account balance or class of transactions, and appropriate consideration should be given to sampling risk." If the total projected error is less than tolerable error for the account balance or class of transactions, the auditor should consider the risk that such a result might be obtained even though the true monetary error for the population exceeds tolerable error. For example, if the tolerable error in an account balance of $1 million is $50,000 and the total projected error based on an appropriate sample is $10,000, he might be reasonably assured that there is an acceptably low sampling risk that the true monetary error for the population exceeds tolerable error. On the other hand, if the total projected error is close to or exceeds the tolerable error, the auditor may conclude that there is an unacceptably high risk that the true error in the population exceeds tolerable error.

The auditor using nonstatistical sampling uses his experience and professional judgment in making such an evaluation. However, when the projected error is neither very close to tolerable error nor very far from tolerable error, it may require especially careful consideration to determine whether there is an unacceptably high risk that the true error exceeds tolerable error. If the projected error does not exceed the auditor's expectation of errors used in determining an appropriate sample size, the auditor can generally conclude that there is an acceptably low risk that the true error exceeds tolerable error. On the other hand, if the projected error exceeds the auditor's expectation of errors used in determining an appropriate sample size, the auditor would generally conclude that there is an unacceptably high risk that the true error exceeds tolerable error.

Occasionally, the sample results might not support acceptance of the recorded amounts because the sample is not representative of the population even though the sample was selected in a manner that was expected to be representative of the population. When the auditor believes that the sample might not be representative of the population, he might select additional sampling units to try to obtain a sufficiently representative sample or perform alternative procedures as an aid in determining whether the recorded amount of the population is misstated.

If the sample results do not support the recorded amount of the population and the auditor believes the recorded amount might be misstated, the auditor considers the error along with other audit evidence in evaluating whether the financial statements may be materially misstated. The auditor ordinarily suggests that the entity investigate the errors and, if appropriate, adjust the recorded amount.

Considering Qualitative Characteristics

In addition to evaluating the frequency and amounts of monetary misstatements, the auditor should consider the qualitative aspects of the errors. These include (1) the nature and cause of misstatements, such as whether they are (a) differences in principle or in application, (b) errors or irregularities, or (c) due to misunderstanding of instructions or to carelessness and (2) the possible relationship of misstatements to other phases of the audit. The discovery of an irregularity ordinarily requires a broader consideration of possible implications than does the discovery of an error.

Nonstatistical Sampling Case Study

Jones of Jones & Co., CPAs, designed a nonstatistical sample to test the December 31, 19XX accounts receivable balance of Short Circuit, Inc., an electrical supply company that is a new client of Jones & Co. For the year ended December 31, 19XX, Short Circuit had sales of approximately $25 million. As of December 31 there were 1,100 accounts receivable, with debit balances aggregating $4.25 million. These balances ranged from $10 to $140,000. There were also 40 credit balances aggregating $5,000.

Jones made the following decisions:

- The results of his study and evaluation of internal accounting control supported some, but no more than a moderate level of, reliance on internal accounting control in determining the extent of substantive testing.
- A misstatement of $130,000 or more in the accounts receivable balance, when combined with error in other accounts, might result in material misstatement of the financial statements.
- The credit balances in accounts receivable would be tested separately as accounts payable.
- The balance for each selected customer would be confirmed.

Here is some additional information:

- The population contained 5 balances over $50,000, which totaled $500,000. Jones decided to examine these 5 balances 100 percent and exclude them from the population to be sampled. The population also contained 250 other debit balances equal to or greater than $3,000, which totaled $2.5 million.
- Through analytical review procedures and an inventory shortage test, Jones obtained reasonable assurance that all shipments were billed and that no material understatements of receivables existed.

- Jones also performed analytical review procedures on the accounts receivable balance.

Determining the Sample Size

Jones considered the four general factors influencing the appropriate size of a sample.

1. *Variation in the population.* Jones decided to separate the population into two groups based on the recorded amounts of the items constituting the population. The first group consisted of the 250 balances equal to or greater than $3,000 (total recorded amount of $2.5 million), and the second group consisted of the remaining balances that were less than $3,000.
2. *Risk of incorrect acceptance.* Jones wanted a sample size that would provide him with only a moderate risk that the sample results would support the account balance if it were materially misstated. His decision to accept a moderate risk of incorrect acceptance was based on his evaluation of internal accounting control and analytical review procedures related to the same objective.
3. *Tolerable error.* Because Jones had decided that a misstatement of $130,000 or more in the accounts receivable balance, when combined with error in other accounts, might result in material misstatement of the financial statements, the tolerable error for the balance was $130,000.
4. *Expectation of error.* Because Short Circuit, Inc. had only moderately effective internal accounting controls over the processing of accounts receivable transactions, Jones believed that some errors might have existed in the accounts receivable balance. However, Jones did not expect any errors to exist in the items to be examined 100 percent and expected the total error in the population to be no more than $35,000.

Jones considered these factors and, using his experience and professional judgment, decided to use a sample size of 110 customer balances. He also decided to divide the sample between the two groups in a way that was approximately proportional to the recorded amounts of the accounts in the groups. Accordingly, he selected 73 of the 110 customer balances from the first group (balances with recorded amounts equal to or greater than $3,000) and the remaining 37 customer balances from the second group (balances with recorded amounts under $3,000).

Evaluating the Sample Results

Jones mailed confirmation requests to each of the 110 customers whose balances had been selected and to each of the 5 customers selected in the 100-percent examination group. Ninety of the 115 confirmation requests were returned to him. Jones was able to obtain reasonable assurance through alternative procedures that the 25 customer balances that were not confirmed were bona fide receivables and were not misstated. Of the 90 responses, only 3 customers indicated that their balances were overstated. Jones investigated these balances further and concluded that they were, indeed, misstated. Jones determined that the misstatements resulted from ordinary errors in the accounting process. The sample was summarized as follows:

Group	*Recorded Amount*	*Recorded Amount of Sample*	*Audit Amount of Sample*	*Amount of Overstatement*
100% examination	$ 500,000	$500,000	$499,000	$1,000
Over $3,000	2,500,000	739,000	732,700	6,300
Under $3,000	1,250,000	62,500	61,750	750

Jones observed that the sample included 29.56 percent of the dollar amount of the over $3,000 group but only 29.20 percent of the items included in that group. He also observed that the sample included 5 percent of the dollar amount of the under $3,000 group but only 4.38 percent of the items included in that group. On the basis of the above computations, Jones believed that the two methods of projecting sample results described in this section might yield different results. Jones considered the errors found and concluded that the amount of error in the population was more likely to correlate to total dollar amount of items in the population than to the number of items in the population. Therefore, Jones separately projected the amount of error found in each group of the sample by dividing the amount of error in the group by the fraction of total dollars from the population group that was included in the sample. For the over $3,000 group Jones had calculated that the sample included 29.56 percent ($739,000 ÷ $2,500,000) of the group's recorded amount. He projected the sample results for that group to the population by dividing the amount of error in the sample by 29.56 percent. He calculated the projected error to be approximately $21,300 ($6,300 ÷ .2956). Similarly, Jones had calculated that the sample for the under $3,000 group included 5 percent

($62,500 ÷ $1,250,000) of the group's recorded amount and that the projected error was $15,000 ($750 ÷ .05). Because the items examined 100 percent were not subject to sampling, the amount of overstatement identified in those 5 account balances is also the projected error for those items. Therefore, the total projected error was $37,300 ($1,000 + $21,300 + $15,000).

Jones compared the expected error of $35,000 to the $37,300 projected error and concluded that the results were approximately what he had expected. In addition, Jones compared the total projected error of $37,300 with the $130,000 tolerable error and decided that there was an acceptably small risk that he would have obtained the sample results if the recorded amount of the accounts receivable balance was misstated by more than the tolerable error of $130,000. In other words, even the addition of a reasonable allowance for sampling risk to projected error would not be likely to result in a total exceeding tolerable error.

Jones concluded that the sample results supported the recorded amount of the accounts receivable balance. He did, however, include the projected error from the sample results along with other relevant audit evidence when he evaluated whether the financial statements taken as a whole may have been materially misstated.[5]

Section 3: Probability-Proportional-to-Size Sampling

This section discusses a statistical sampling approach called *probability-proportional-to-size (PPS) sampling.* Variations of PPS sampling are known as *dollar-unit sampling (DUS), cumulative monetary amount (CMA) sampling,* and *combined attributes variables (CAV) sampling.*

5. Neither SAS No. 39 nor this guide requires any comparison of sample size for a nonstatistical sample with that from statistical tables. However, some auditors find such comparison useful, in the planning and evaluation phases of a sampling application, to assist them in gaining an understanding of the risk implied by the sample size used. Jones could have done this by calculating the tolerable error as a percentage of the total recorded amount of the population subject to sampling ($130,000 ÷ $3,750,000 = 3.5%) and by assessing the error expectation ($35,000 or approximately 30 percent of the tolerable error). A table (such as the one shown in this section) would suggest that a sample of 110 implies a risk level of approximately 10 percent. Although a higher level of risk might be acceptable in the circumstances, in Jones's judgment the sample size of 110 appropriately reflected the difference between the design of this sample and the sample design underlying the sample sizes presented in the table; that is, the sample in this case was divided into only two groups, but the sample sizes in the table were based on a highly stratified sampling approach.

As discussed in chapter 1, attributes sampling is generally used to reach a conclusion about a population in terms of a rate of occurrence. Variables sampling is generally used to reach conclusions about a population in terms of a dollar amount. PPS sampling is a hybrid method that uses attributes sampling theory to express a conclusion in dollar amounts rather than as a rate of occurrence.[6]

Selecting a Statistical Approach

Both statistical approaches to sampling for substantive testing — classical variables sampling and probability-proportional-to-size sampling — can provide sufficient evidential matter to achieve the auditor's objective. However, in some circumstances PPS sampling may be more practical to use than classical variables sampling.

Advantages

- PPS sampling is generally easier to use than classical variables sampling. Since PPS sampling is based on attributes sampling theory, the auditor can calculate sample sizes and evaluate sample results manually or with the assistance of tables. Sample selection can be performed with the assistance of either a computer program or an adding machine.
- The size of a PPS sample is not based on any measure of the estimated variation of audited amounts. As discussed in section 4 of this chapter, the size of a classical variables sample is based on the variation, or standard deviation, of the characteristic of interest of the items in the population. PPS sampling does not require direct consideration of the standard deviation of dollar amounts to determine the appropriate sample size.
- PPS sampling automatically results in a stratified sample because items are selected in proportion to their dollar amounts. The auditor using classical variables sampling will usually need to stratify the population to reduce the sample size.
- The PPS systematic sample selection described in this guide automatically identifies any item that is individually significant if its amount exceeds the sampling interval.

6. A PPS sample may be evaluated using a classical variables sampling approach. This evaluation approach is not frequently used by auditors and is beyond the scope of this guide. For further information see Roberts, *Statistical Auditing*, pp. 116–19.

- If the auditor expects no errors, a PPS sampling approach will usually result in a smaller sample size than a classical variables sampling approach.
- A PPS sample can be designed more easily and sample selection can begin before the complete population is available.

Some of the circumstances in which PPS sampling may be especially useful include —

- Accounts receivable when unapplied credits are not significant.
- Loans receivable (for example, real estate mortgage, commercial loans, and installment loans).
- Investment securities.
- Inventory price tests where the auditor anticipates relatively few differences.
- Fixed-asset additions.

Disadvantages

- The general approach to PPS sampling includes an assumption that the audited amount of a sampling unit should not be less than zero or greater than the recorded amount. If the auditor anticipates understatements or situations where the audited amount will be less than zero, a PPS sampling approach will require special design considerations.
- If an auditor identifies understatements in a PPS sample, evaluation of the sample will require special considerations.
- Selection of zero balances or negative balances also requires special design considerations. For example, if the population to be sampled is accounts receivable, the auditor might need to segregate credit balances into a separate population. If examination of zero balances is important to the auditor's objectives, he would need to test them separately since zero balances are not subject to PPS selection.
- When errors are found, PPS evaluation might overstate the allowance for sampling risk at a given risk level. As a result, the auditor might be more likely to reject an acceptable recorded amount for the population.
- The auditor usually needs to add through the population for the PPS selection procedure illustrated in this guide. However, adding through the population might not require significant additional audit effort if the related accounting records are on com-

puter files that can be used by the auditor or if the auditor is adding through the population as a part of another audit procedure.

- As the expected amount of error increases, the appropriate PPS sample size increases. In these circumstances the PPS sample size can become larger than the corresponding sample size for classical variables sampling.

Some of the circumstances in which PPS sampling might not be the most cost-effective approach include —

- Accounts receivable where a large number of unapplied credits exist.
- Inventory test counts and price tests where the auditor anticipates a significant number of audit differences or where errors can be both understatements and overstatements.
- Conversion of inventory from FIFO to LIFO.
- Any application where the primary objective is to independently estimate the amount of an account balance or class of transactions.

Using Probability-Proportional-to-Size Sampling

Section 1 of this chapter provided the general considerations in using sampling for substantive tests. This section describes additional factors the auditor should consider when using probability-proportional-to-size sampling.[7] The discussion of these factors includes the following:

1. Defining the sampling unit
2. Selecting the sample
3. Determining the sample size
    a. no errors expected
    b. errors expected
4. Evaluating the sample results
    a. Sample evaluation with 100-percent errors
    b. Sample evaluation with less than 100-percent errors

7. A PPS sampling approach can also be used to obtain evidence of compliance with internal accounting control procedures. A PPS sampling approach would provide evidence in terms of dollar amounts of transactions containing deviations rather than rates of deviation. In that case the feature of interest is compliance deviations rather than substantive errors.

c. Quantitative considerations
d. Qualitative considerations

Defining the Sampling Unit

PPS sampling applies attributes sampling theory to reach dollar-amount conclusions by selecting sampling units proportional to their size. Essentially PPS sampling gives each individual dollar in the population an equal chance of selection. As a practical matter, however, the auditor does not examine an individual dollar within the population. For illustrative purposes some auditors think of each dollar as a hook that snags the entire balance or transaction that contains it. The auditor examines the balance or transaction that includes the selected dollar. The balance or transaction that the auditor examines is called a *logical unit.*

PPS sampling helps the auditor to direct the audit effort toward larger balances or transactions. Because every dollar has an equal chance of being selected, logical units having more dollars (that is, larger recorded amounts) have a greater chance of being selected. The name for this sampling approach, *probability-proportional-to-size sampling,* is derived from the concept that each balance or transaction in the population has a probability of selection proportional to its recorded dollar amount.

Selecting the Sample

This section discusses only one method of selection — systematic selection.[8] This method is easy to apply when selecting a sample from either manually maintained or computerized records. *Systematic selection* involves dividing the population into equal groups of dollars and selecting a logical unit from each group. Each group of dollars is a *sampling interval.*

To use the systematic selection method, the auditor selects a random number between 1 and the sampling interval, inclusive. This number is the *random start.* The auditor then begins adding the recorded amounts of the logical units throughout the population. The first logical unit selected is the one that contains the dollar amount corresponding to the random start. The auditor then selects each logical unit containing every *n*th dollar thereafter (*n* represents the sampling interval). For example, if an auditor uses a sampling

8. For a discussion of other PPS selection methods, see Roberts, *Statistical Auditing*, pp. 21–23.

interval of $5,000, he selects a random number between $1 and $5,000, inclusive, such as the 2,000th dollar, as the random start. Then the 7,000th dollar ($2,000 + $5,000), then the 12,000th dollar ($2,000 + $5,000 + $5,000), and every succeeding *n*th (5,000th) dollar is selected until the entire population has been subject to sampling. The auditor therefore examines the logical units that contain the 2,000th, 7,000th, and 12,000th dollars and so on.

Because every dollar has an equal chance of being selected, logical units having more dollars (that is, a larger recorded amount) have a greater chance of being selected. Conversely, smaller logical units have a smaller chance of being selected. All logical units with dollar amounts equal to or greater than the sampling interval are certain to be selected under the systematic selection method. A logical unit that is one-half the size of the sampling interval has a 50-percent probability of being selected.

If the recorded amount of a logical unit exceeds the sampling interval, the logical unit might be selected more than once. If that happens, the auditor ignores the repeat selection and considers the logical unit only once when evaluating the sample results. Because logical units with recorded amounts greater than the sampling interval might be selected more than once, the actual number of logical units examined might be less than the computed sample size. That consideration is included in the evaluation method described in this section.

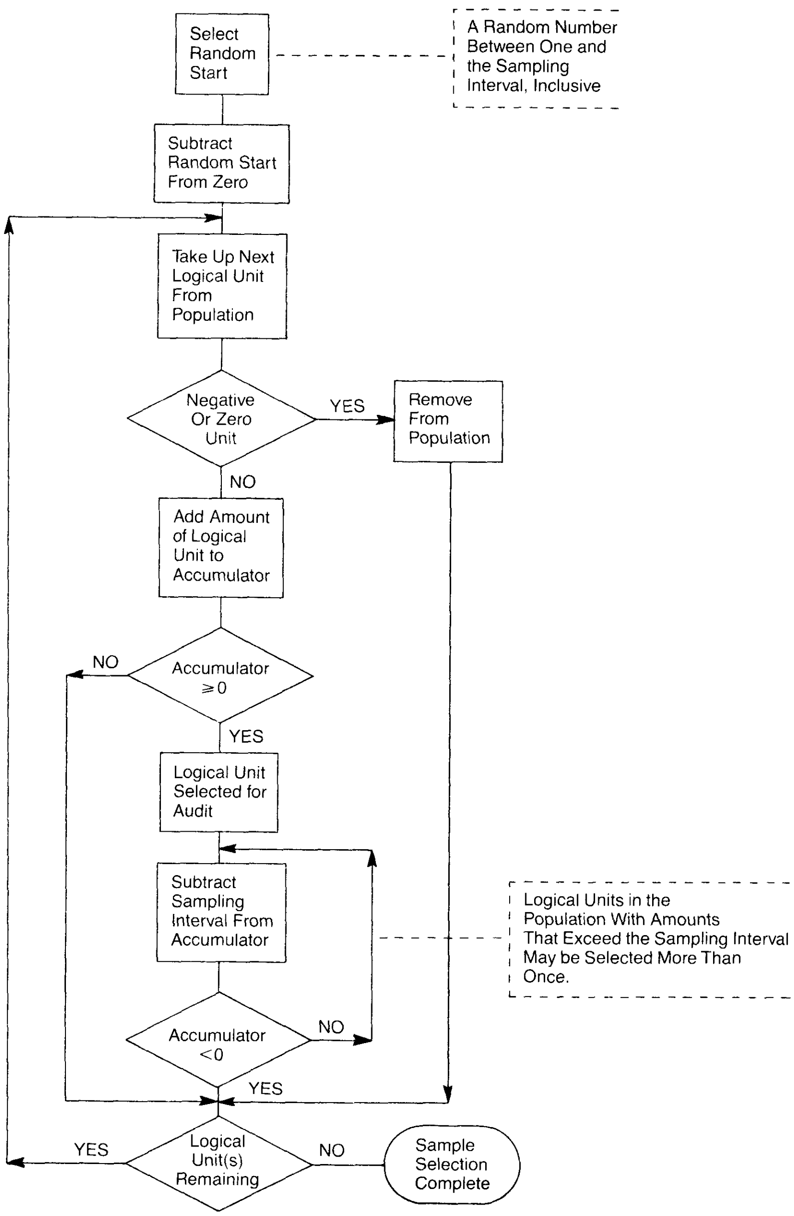
Items in the population with negative balances require special consideration. One way of accomplishing this is to exclude them from the selection process and test them separately.

If the selection is to be done manually, the auditor can use an adding machine in the following manner:

1. Clear the adding machine.
2. Subtract the random start.
3. Begin adding the recorded amounts of logical units in the population, obtaining a subtotal after the addition of each succeeding logical unit. Items with negative balances should be excluded. The first logical unit that makes the subtotal zero or positive is selected as part of the sample. The auditor lists, or segregates, selected logical units from the remaining population.
4. After each selection subtract the sampling interval as many times as necessary to make the subtotal negative again.
5. Continue adding the logical units as before, selecting all items that cause the subtotal to equal zero or become positive.

A summary of the sample selection process is flowcharted in figure 1.

FIGURE 1
Probability-Proportional-to-Size Sample Selection Flowchart



The auditor should reconcile the total recorded amount of logical units accumulated on the adding machine to a control total of the recorded amount of the population. Generally, the auditor adds (1) the balance shown on the adding machine, (2) the random start, and (3) the sampling interval multiplied by the number of times it was subtracted on the adding machine. The total should be the control total for positive amounts.

Determining the Sample Size

As discussed above, the auditor selecting a PPS sample divides the population into uniform groups of dollars, called sampling intervals, and selects a logical unit from each sampling interval. Therefore, the number of selections is equivalent to the recorded amount of the population divided by the sampling interval.[9]

$$\text{Sample size} = \frac{\text{Recorded amount of the population}}{\text{Sampling interval}}$$

Because the recorded amount of a given population is constant, the determination of an appropriate PPS sample size is a function of the sampling interval specified by the auditor.

No Errors Expected

The size of an appropriate sampling interval is related to the auditor's consideration of the risk of incorrect acceptance and the auditor's assessment of tolerable error. Some auditors calculate the appropriate sampling interval by dividing tolerable error by a factor that corresponds to the risk of incorrect acceptance. The factor is known as the *reliability factor*. Some reliability factors are presented in the following table:

Approximate Risk of Incorrect Acceptance	*Reliability Factor*
37%	1
14%	2
5%	3

9. Because logical units with recorded amounts greater than the sampling interval may be selected more than once, the actual number of logical units examined may be less than the calculated sample size. That consideration is included in the evaluation method described in this section of the guide.

For example, if the auditor assesses the tolerable error as \$15,000 and the risk of incorrect acceptance as 5 percent, the sampling interval is calculated to be \$5,000 (\$15,000 ÷ 3). If the recorded amount of the population is \$500,000, the sample size would be 100 (\$500,000 ÷ \$5,000).

Table 1 of Appendix D provides reliability factors for some commonly used risks of incorrect acceptance. The appropriate row to use with the guidance in this subsection, "No Errors Expected," is the row with zero number of overstatement errors.

Errors Expected

When planning a PPS sample, the auditor controls the risk of incorrect rejection by making an allowance for expected errors in the sample. The auditor specifies a desired allowance for sampling risk so that the estimate of projected error plus the allowance for sampling risk will be less than or equal to tolerable error.

If the auditor expects errors, the use of the reliability factor is modified. When errors are expected, the auditor can (1) subtract the effect of expected error from tolerable error and calculate the sampling interval using the method described for sample-size determination where no errors are expected[10] or (2) convert the tolerable error and the expected amount of error into percentages of the population's recorded amount and use a sample size for the equivalent rates shown in the sample-size table based on attributes sampling theory.

As an example of the first method, an auditor using PPS sampling might have assessed tolerable error as \$15,000 and the desired risk of incorrect acceptance as 5 percent. In addition, the auditor may expect approximately \$3,000 of error in the population to be sampled. The expected effect of the errors should be subtracted from the \$15,000 tolerable error. The effect is calculated by multiplying the expected error, in this case \$3,000, by an appropriate expansion factor. Table 2 of Appendix D provides approximate expansion factors for some commonly used risks of incorrect acceptance. It gives an approximate expansion factor of 1.6 for a 5-percent risk of incorrect acceptance; therefore, the effect is \$4,800 (\$3,000 × 1.6). The auditor subtracts the \$4,800 effect from the \$15,000 tolerable error, and the resulting \$10,200 (\$15,000 − \$4,800) is divided by the appropriate reliability factor for applications in which no errors are

10. As the expected error approaches tolerable error, this method tends to overstate sample size.

expected, in this case a reliability factor of 3. The sampling interval in this example is \$3,400 (\$10,200 ÷ 3). Therefore, when the population's recorded amount of \$500,000 from the previous example is used, the sample size increases to 147 (\$500,000 ÷ \$3,400).

Since PPS sampling is based on attributes theory, the second method is to refer directly to the statistical sample-size tables for compliance testing in Appendix A. This results in a more exact calculation of the sample size than does use of the approximate expansion factors in Appendix D. The auditor converts the tolerable error and the expected amount of error into percentages of the population's recorded amount and uses a sample size for the equivalent rates shown in the table. For example, if the auditor is designing a PPS sampling application for a population with a recorded amount of \$500,000, he might have assessed tolerable error as \$15,000 and expected \$2,500 of error in the population. The auditor would calculate tolerable error to be 3 percent (\$15,000 ÷ \$500,000) of the recorded amount and the expected error to be .5 percent (\$2,500 ÷ \$500,000) of the recorded amount. The sample size for a 5-percent risk of overreliance (table 1 of Appendix A) is 157 where the tolerable error is 3 percent and the expected error rate is .5 percent. The auditor then determines the sampling interval to be \$3,184 (\$500,000 ÷ 157). If the auditor were to calculate a percentage of expected error that is not shown on the table, he would generally select the sample size for the next highest percent shown. In the example, if the expected error were \$3,000 (.6 percent of the recorded amount), the appropriate sample size for the next largest percentage in table 1 would be 208. The sampling interval would be \$2,403 (\$500,000 ÷ 208). Similarly, if the auditor were to calculate a percent for tolerable error that is not shown on the table, to be appropriately conservative he would select the sample size for the next smallest percentage shown. The auditor then calculates the sampling interval by dividing the recorded amount by the sample size.

Evaluating the Sample Results

The auditor using PPS sampling should project the error results of the sample to the population from which the sample was selected and calculate an allowance for sampling risk. If no errors are found in the sample, the error projection would be zero dollars and the allowance for sampling risk would be less than or equal to the tolerable error used in designing the sample. As a result, if no errors are found in the sample, the auditor can generally conclude, without making additional calculations, that the recorded amount of the population is not overstated by more than the tolerable error at the specified risk of incorrect acceptance.

If errors are found in the sample, the auditor needs to calculate a projected error and an allowance for sampling risk. This guide illustrates one means of calculating projected error and an allowance for sampling risk that is appropriate for PPS samples selected using the method described in this section. The discussion of this method is limited to overstatements because the PPS approach is primarily designed for overstatements. If understatements are a significant consideration, the auditor should decide whether a separate test designed to detect understatements is appropriate. The consideration of understatement errors discovered in a PPS sample is a subject of current research and is beyond the scope of this guide.[11] An auditor interested in obtaining information on that subject should refer to some of the materials included in Appendix H, "Selected Bibliography."

The auditor's approach to calculating the projected error and an allowance for sampling risk depends on whether the errors are equal to the recorded amount of the logical unit or are less than the recorded amount.

Sample Evaluation With 100-Percent Errors

Projected Error

Since each selected dollar represents a group of dollars, the percentage of error in the logical unit represents the percentage of error (*tainting*) in a sampling interval. For example, if the sampling interval is $5,000 and a selected account receivable with a recorded amount of $100 has an audit amount of zero dollars ($100 error is 100 percent of the recorded amount), then the projected error of that sampling interval is $5,000 (100% × $5,000). If the same account receivable had an audited amount of $30 ($70 error is 70 percent of the recorded amount), then the projected error of that sampling interval would be $3,500 (70% × $5,000). If a logical unit equals or exceeds the sampling interval, the projected error is the actual amount in error for the logical unit. The auditor adds the projected

11. There are several methods for evaluating understatements. For a discussion of one approach used to evaluate sample results with a few understatements, see Roberts, *Statistical Auditing*, p. 124.

errors for all sampling intervals to calculate the total projected error for the population.

Upper Limit on Error

When evaluating a PPS sample, the auditor calculates an *upper limit on error* equal to the projection of error found in the sample plus an allowance for sampling risk. The auditor uses either a computer program or a table of reliability factors as an aid in calculating the upper limit on error. The following reliability factors are from table 1 of Appendix D.

Five-Percent Risk of Incorrect Acceptance

Number of Overstatement Errors	*Reliability Factor*	*Incremental Changes in Factor*
0	3.00	—
1	4.75	1.75
2	6.30	1.55
3	7.76	1.46
4	9.16	1.40
5	10.52	1.36

The first two columns come directly from table 1 in Appendix D. The third column is the difference between the reliability factor and the preceding reliability factor.

If no errors are found in the sample, the upper limit on errors equals the reliability factor for no errors at a given risk of incorrect acceptance multiplied by the sampling interval.

Upper limit on error = Reliability factor × Sampling interval

This upper limit, also referred to as *basic precision*, represents the minimum allowance for sampling risk inherent in the sample. For example, if the auditor specified a 5-percent risk of incorrect acceptance, used a $5,000 sampling interval, and found no errors, the upper limit on errors equals $15,000 (3 × $5,000). Because no errors were found, the projected error is zero, and the allowance for sampling risk equals the upper limit on error.

However, if 2 errors were found in the sample (for example, recorded accounts receivable balances of $10 and $20 were each found to have an audited amount of zero), the auditor would calculate the upper limit on errors by multiplying the reliability factor for the actual number of errors found, at the given risk of incorrect acceptance, by the sampling interval. The upper limit is $31,500 (6.3 × $5,000). The $31,500 represents a projected error of $10,000 (2 errors at 100% × $5,000) and, therefore, an allowance for sampling risk of $21,500 ($31,500 – $10,000).

If the logical units in which the 100-percent errors occurred were equal to or larger than the sampling interval, for example, $15,000 and $20,000 instead of the $10 and $20 errors in the previous example, the upper limit on errors would equal (1) the known errors in the logical units equal to or greater than the sampling interval plus (2) the allowance for sampling risk calculated above. In this example the upper limit would equal $35,000 ($15,000 + $20,000) plus $15,000 (3 × $5,000), or a total of $50,000. The auditor should add this result to the errors discovered in any other items examined 100 percent.

Sample Evaluation With Less Than 100-Percent Errors

In many sampling applications the auditor identifies errors where the logical unit is not completely incorrect. The ratio of the error to the size of the logical unit containing the error is called a *tainting*.

Projected Error When Taintings Occur

To project errors when taintings occur, the auditor determines the percentage of error in the logical unit and multiplies this percentage by the sampling interval. For example, if a receivable balance with a recorded amount of $100 has an audit amount of $50, the auditor would calculate a 50-percent tainting ($50 ÷ $100 = 50%). A tainting percentage is calculated for all logical units except those that have recorded amounts equal to or greater than the sampling interval. The auditor multiplies the tainting percentage by the sampling interval to calculate a projected error. By adding the sum of all projected errors to the actual error found in the logical units equal to or greater than the sampling interval, the auditor calculates the total projected error. For example, 6 errors might have been identified in the sample. The auditor would calculate the total projected error as follows:

A	B	C	D	E
Recorded Amount	*Audit Amount*	*Tainting (A − B) ÷ A*	*Sampling Interval*	*Projected Error C × D*
$ 100	$ 25	75%	$ 5,000	$ 3,750
1,000	950	5%	5,000	250
500	250	50%	5,000	2,500
50	0	100%	5,000	5,000
10	9	10%	5,000	500
10,000	9,000	NA*	NA*	1,000
		Total projected error		$13,000

*The logical unit is greater than the sampling interval; therefore, the projected error equals the actual error.

Upper Limit on Errors When Taintings Occur

The allowance for sampling risk when taintings occur includes both the basic precision and an incremental allowance resulting from the occurrence of errors. To calculate that incremental allowance, the auditor divides the errors into two groups: (1) those occurring in logical units less than the sampling interval and (2) those occurring in logical units equal to or greater than the sampling interval. In the preceding example the first 5 errors are of the first type, and the last error is of the second type.

Errors occurring in logical units equal to or greater than the sampling interval have no allowance for sampling risk associated with them since all logical units of this size have been examined. (Sampling risk exists only where sampling takes place).

One approach to calculating the allowance for sampling risk is to rank the projected errors by percentage tainting and calculate the incremental allowance for sampling risk for each error by (1) multiplying the projected error for each error occurring in a logical unit that is less than the sampling interval by the incremental change in the reliability factor and (2) subtracting the related projected error. In the preceding example the auditor could rank the estimates of errors as shown in the table on p.81. The $19,253 represents $12,000 in projected error and $7,253 in additional allowance for sampling risk.

Projected Error	*Incremental Changes in Reliability Factor*	*Projected Error Plus Incremental Allowance for Sampling Risk*
$ 5,000	1.75	$ 8,750
3,750	1.55	5,813
2,500	1.46	3,650
500	1.40	700
250	1.36	340
$12,000		$19,253

To calculate the upper limit on error, the auditor adds the $19,253 to two components: (1) the basic precision and (2) the error, if any, occurring in logical units equal to or greater than the sampling interval. In the example the basic precision was calculated to be $15,000 (3 × $5,000) and the error occurring in logical units equal to or greater than the sampling interval is $1,000. The upper limit on errors is $35,253 ($19,253 + $15,000 + $1,000).

The sample results can be summarized as follows:

1. The sample contains actual error of $1,426.
2. The total projected error is $13,000.
3. The total allowance for sampling risk is $22,253.
4. Therefore, there is a 5-percent risk that the recorded amount is overstated by more than $35,253.

Quantitative Considerations

In general, if the upper limit on error is less than tolerable error, the sample results will support the conclusion that the population is not misstated by more than tolerable error at the specified risk of incorrect acceptance. If the upper limit on error exceeds tolerable error, the sample results might have been obtained because they do not reflect the auditor's expectation of error. In designing a PPS sampling application, the auditor makes an assumption about the amount of error in the population. If the sample results do not support the auditor's expectation of error because more error exists in the population than was expected, the allowance for sampling risk will not be adequately limited. If the sample results do not support the conclusion that the population is not misstated by more than tolerable error because the allowance for sampling risk has not been adequately limited, the auditor can elect either of these alternatives:

1. Examine an additional representative sample from the population. Because of the mechanics of a PPS sampling application, some auditors use an additional number of sampling units equal to the original sample size.[12]
2. Perform additional substantive tests directed toward the same audit objective. The additional reliance on other tests would allow the auditor to accept a greater risk of incorrect acceptance for the sampling application. Recalculating the allowance for sampling risk with the greater risk of incorrect acceptance will not change the point estimate of the population, but it will move the end of the range closer to that estimate.

The sample results also might not support acceptance of the recorded amount because the sample is not representative of the population. Although the auditor selects a sample in such a way that the sample can be expected to be representative of the population, occasionally the sample might not be representative. For example, if all the related evidential matter contradicts the sample evidence, the auditor might suspect, among other possibilities, that the sample is not representative of the population. When the auditor believes that the sample might not be representative of the population, he examines additional sampling units or performs alternative procedures as an aid in determining whether the recorded amount of the population is misstated.

If the sample results do not support the recorded amount of the population and the auditor believes the recorded amount is misstated, the auditor would consider the error along with other audit

12. To select a sample in this circumstance, the auditor divides the original sampling interval in half and begins selecting the expanded sample by using the same random start. If that random start exceeds the new sampling interval, the auditor subtracts the new sampling interval from the original random start. This results in a sample consisting of the original sample plus additional sampling units. The complexities of alternative methods of expanding the sample are beyond the scope of this guide.

evidence when evaluating whether the financial statements taken as a whole may be materially misstated. The auditor ordinarily suggests that the entity investigate the errors and, if appropriate, adjust the recorded amount. If the upper limit on error after adjustment is less than tolerable error, the sample results would support the conclusion that the population, as adjusted, is not misstated by more than tolerable error at the specified risk of incorrect acceptance.

Qualitative Considerations

In addition to evaluating the frequency and amounts of monetary misstatements, the auditor should consider the qualitative aspects of errors. These considerations are discussed in section 1 of this chapter.

Probability-Proportional-to-Size Sampling Case Study

Andrews of Andrews, Baxter & Co. is the auditor of the EZ Credit Bank. Andrews designed a sampling application to test EZ Credit's commercial loans receivable balance as of September 30, 19XX. The balance of commercial loans receivable was $5 million as of September 30, 19XX. Andrews expected little, if any, error to exist in the commercial loans receivable balance because of the bank's strong internal accounting controls over loan transactions. If any errors did exist, Andrews believed that they would be overstatements. As a result, Andrews decided that probability-proportional-to-size sampling would be an appropriate sampling approach to use.

Andrews decided to confirm all selected commercial loans receivable with the bank's customers. He decided that a misstatement of $55,000 or more in the commercial loans receivable balance, when combined with errors in other accounts, might result in the financial statements being materially misstated. As a result, tolerable error for the sampling application was $55,000. In addition, because Andrews decided to place only minimal reliance on related internal accounting control and because the sampling application was the primary test of the commercial loans receivable, Andrews decided that a 10-percent risk of incorrect acceptance was appropriate.

Because Andrews had only a very limited period of time to complete his examination, he decided to expect some misstatement in the account balance when he determined the appropriate sample size. Therefore, based on his professional judgment, he decided to use an expected error of $10,000 in designing his sampling application. Although this would result in a somewhat larger sample size, expecting some misstatement when determining the sample size would reduce the possibility that he would have to extend the sampling application.

Selecting the Sample

Andrews calculated the appropriate sampling interval as follows:

Tolerable error		$55,000
Expected error	$10,000	
(Multiplied by) Expansion factor for a 10% risk of incorrect acceptance (Appendix D)	× 1.5	
(Less) Expected effect of errors		$15,000
Tolerable error adjusted for expected errors		$40,000
(Divided by) Reliability factor for no expected errors for a 10% risk of incorrect acceptance (Appendix D)		÷ 2.31
Sampling interval		$17,316

Andrews then calculated the approximate sample size by dividing the recorded amount of the commercial loans receivable by the sampling interval. The calculated sample size was 289 ($5,000,000 ÷ $17,316). Andrews did not need to identify the commercial loans that individually exceeded the tolerable error of $55,000 because the systematic selection method used would be certain to select all logical units with recorded amounts greater than or equal to the $17,316 sampling interval. Andrews manually selected his sample on an adding machine as follows:

1. He cleared the adding machine.
2. He subtracted a random start between 1 and 17,316, inclusive.
3. He began adding the recorded amounts of logical units in the population, obtaining a subtotal after the addition of each succeeding logical unit. The first logical unit that made the subtotal zero or positive was selected as part of the sample.

4. After each selection he subtracted the sampling interval of $17,316 as many times as necessary to make the subtotal negative again.
5. He continued adding the logical units as before, selecting all items that caused the subtotal to become positive.

The selected sample included 281 customer balances rather than the 289 originally calculated because 3 accounts were larger than $17,316 and were included in the items examined 100 percent.

Evaluating the Sample Results

Andrews mailed confirmation requests to each of the 281 customers whose commercial loan balances had been selected. Two hundred of the 281 confirmation requests were returned to him. Andrews was able to obtain reasonable assurance through alternative procedures that the remaining 81 balances were bona fide receivables and were not misstated. Of the 200 responses, only 2 indicated that the recorded balances were overstated.

Andrews calculated the projected error for the sample as follows:

	A	B	C	D	E
Error Number	*Recorded Amount*	*Audit Amount*	*Tainting (A − B) ÷ A*	*Sampling Interval*	*Projected Error C × D*
1	$9,000	$8,100	10%	$17,316	$1,732
2	500	480	4%	17,316	693
			Total projected error		$2,425

Andrews then calculated an allowance for sampling risk. The allowance consisted of two parts: the basic precision and the incremental allowance.

Sampling interval	$17,316
(Multiplied by) Reliability factor for a 10% risk of incorrect acceptance	× 2.31
Basic precision	$40,000

Error Number	Projected Error	Incremental Factor	Projected Error × Incremental Factor
1	$1,732	1.58	$2,737
2	693	1.44	998
	$2,425		$3,735
(Less) Projected error			2,425
Incremental allowance			$1,310

Andrews compared the total projected error plus an allowance for sampling risk, $43,735 ($2,425 + $40,000 + $1,310), with the tolerable error of $55,000. Because the total projected error plus the allowance for sampling risk was less than tolerable error, Andrews concluded that the sample results supported the recorded amount of the commercial loans receivable. Andrews also concluded that the overstatements were due to ordinary errors in the accounting process and that they did not require him to modify his reliance on related internal accounting controls or other planned substantive procedures. He did, however, include the projected error from the sample results along with other relevant audit evidence when he evaluated whether the financial statements taken as a whole were materially misstated.

Section 4: Classical Variables Sampling

Classical variables sampling techniques use normal distribution theory to evaluate selected characteristics of a population on the basis of a sample of the items constituting the population. This section will describe several classical variables techniques and some of the special factors to be considered by an auditor applying these techniques.

The design of a classical variables sampling approach involves mathematical calculations that tend to be complex and difficult to apply manually. Because auditors generally use computer programs to assist them in determining sample sizes and evaluating sample results for classical variables sampling applications, it is not essential for auditors to know mathematical formulas to use these methods. Consequently, such formulas are not provided in this guide.[13]

13. Formulas related to the use of classical variables sampling may be found in Roberts, Appendix 2, *Statistical Auditing*.

Selecting a Statistical Approach

Both statistical approaches to sampling for substantive testing (classical variables sampling and probability-proportional-to-size sampling) can provide sufficient evidential matter to achieve the auditor's objective. However, in some circumstances classical variables sampling might be more practical to use than PPS sampling. Some of the advantages of classical variables sampling follow.

- If there are many differences between recorded and audited amounts, classical variables sampling might meet the auditor's objectives with a smaller sample size.
- Classical variables samples may be easier to expand if that becomes necessary.
- Selection of zero balances generally does not require special sample design considerations. If examining zero balances is important to the auditor's objectives, the auditor using PPS sampling would need to design a separate test of zero balances because the PPS method of sample selection described in this guide does not allow for selection of zero balances.
- Inclusion of negative balances in the evaluation of a classical variables sample generally does not require special considerations.[14] A PPS sample might need to be designed with special considerations to be able to include negative balances in the sample evaluation.

There are also several disadvantages of a classical variables sampling approach.

- Classical variables sampling is more complex than PPS sampling; generally, an auditor needs the assistance of computer programs to design an efficient classical variables sample and to evaluate sample results.
- To determine a sample size for a classical variables sample, the auditor must have an estimate of the standard deviation of the characteristic of interest in the population. Because the auditor generally does not know this information when designing a sample, the auditor determines the appropriate sample size on the basis of an estimate of this standard deviation. This estimate might be difficult or time-consuming to make. In some applica-

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14. For further information concerning the special design considerations for negative balances in accounts tested by ratio estimation, see Roberts, *Statistical Auditing*, p. 79.

tions, if the population is maintained on a computer file and the auditor is able to analyze the file using computer-assisted audit techniques, he may be able to measure the standard deviation of the recorded amounts as a reasonable estimate of the standard deviation of the audited amounts. This estimate may also be based on the standard deviation of a pilot sample or the auditor's prior knowledge of the population.

- When (1) there are either very large items or very large differences between recorded and audited amounts in the population and (2) the sample size is not large, the normal distribution theory might not be appropriate. As a result, the auditor might accept an unacceptable recorded amount of the population more often than the desired risk of incorrect acceptance.

The auditor considers the advantages and disadvantages of classical variables sampling in deciding which approach to use. Some circumstances in which a classical variables approach may be especially useful include—

- Accounts receivable when a large number of unapplied credits exist.
- Inventory test counts and price tests where the auditor anticipates a significant number of audit differences.
- Conversion of inventory from FIFO to LIFO.
- Applications for which the objective is to estimate independently the amount of a class of transactions or account balance.

Types of Classical Variables Sampling Techniques

There are three classical variables sampling methods discussed in this section: the mean-per-unit, difference, and ratio methods.[15]

Mean-per-unit approach. When using this approach, the auditor estimates a total population amount by calculating an average audited amount for all items in the sample and multiplying that average amount by the number of items constituting the population. For example, an auditor has selected 200 items from a population of

15. Another approach, the *regression approach*, is similar to the difference and ratio approaches. This approach has the effect of using both the average ratio and the average difference in calculating an estimate of the total amount for the population. Although the regression approach might be more efficient than the other approaches discussed in this section, the approach is very complex and is not discussed in detail in this section.

1,000 inventory items. After determining the correct purchase price and recalculating price-quantity extensions, the auditor determines the average audited amount for items in the sample to be $980 by totaling the audited amounts of the 200 sampling units and dividing by 200. The estimated inventory balance is then calculated as $980,000 ($980 × 1,000). Using normal distribution theory based on the variability of the audited amounts in the sample, the auditor also calculates an allowance for sampling risk.

Difference approach. When using this approach, the auditor calculates the average difference between audited and recorded amounts of the sample items and projects that average difference to the population. For example, an auditor has examined 200 items from a population of 1,000 inventory items. The total recorded amount for the population is $1,040,000. The auditor compares the audited amount with the recorded amount for each of the 200 sampling units and accumulates the difference between the recorded amounts ($208,000) and the audited amounts ($196,000)—in this case $12,000. The difference of $12,000 is divided by the number of sample items (200) to yield an average difference of $60. The auditor then multiplies the average difference by the number of items in the population to calculate a total difference of $60,000 ($60 × 1,000) between the recorded amount and audited amount. Because the total recorded amount of the sampling units is greater than the total audited amount, the difference is subtracted from the total recorded amount to obtain an estimated inventory balance of $980,000. The auditor also calculates an allowance for sampling risk using normal distribution theory based on the variability of the differences between the recorded amount and the audited amount of the sampling units.

Ratio approach. When using this approach, the auditor calculates the ratio between the sum of the audited amounts and the sum of the recorded amounts of the sample items and projects this ratio to the population. The auditor estimates the total population amount by multiplying the total recorded amount for the population by the aforementioned ratio. If the auditor had used the ratio approach in the previous example, the ratio of the sum of the sample's audited amounts to the sum of the sample's recorded amounts would have been .94 ($196,000 ÷ $208,000). The auditor would multiply the total recorded amount for the population by this ratio to obtain an estimate of the inventory balance of $978,000 ($1,040,000 × .94). The auditor would also calculate an allowance for sampling risk using normal distribution theory based on the extent and magnitude of the differences.[16]

Special Considerations

Section 1 of this chapter provided the general considerations in using audit sampling for substantive tests. This section will describe additional factors the auditor should consider when using classical variables sampling for a substantive test. In general, these factors relate to the following considerations discussed in section 1:

1. Selecting a classical variables approach
2. Determining the sample size
   a. Considering variation within the population
   b. Calculating the sample size
3. Evaluating the sample results

Selecting a Classical Variables Approach

The auditor should consider the constraints of each of the classical variables approaches, explained below, when selecting an approach for a substantive test.

The ability to design a stratified sample. As discussed in section 1 of this chapter, the auditor can reduce sample size by effectively stratifying a population. The mean-per-unit approach requires sample sizes for an unstratified population that may be too large to be cost-effective for ordinary audit applications. There are circumstances, however, when the auditor might efficiently use an unstratified sampling approach. For example, stratification might not significantly reduce sample size for the ratio or the difference approach.

The expected number of differences between the audited and recorded amounts. Both the ratio and the difference approaches require that differences between the audited and recorded amounts exist in the sample. If no differences exist between the audited and recorded amounts of the sample items, the mechanics of the formula underlying each of these methods would lead to the erroneous conclusion that the allowance for sampling risk is zero—that is, there is no sampling risk. Such a conclusion is erroneous because sampling risk always exists unless the auditor examines all items

16. For further information, see Roberts, *Statistical Auditing*, p. 81.

constituting the population. There is some disagreement about how many differences are necessary to accurately estimate the allowance for sampling risk for a sample using either the ratio or difference approach. A minimum of 20 to 50 differences has been suggested.[17] If the auditor desires to use a statistical approach and expects to find only a few differences, he should consider such alternative approaches as mean-per-unit sampling or probability-proportional-to-size sampling.

The available information. In addition to sample size, all the classical variables approaches require different information for the population or for each stratum if stratified sampling is used. To use the mean-per-unit approach, the auditor needs to know the total number of items in each stratum and an audited amount for each sampling unit. Both the ratio and the difference approaches require an audited amount and recorded amount for each sampling unit. The recorded amount may be developed from the entity's normal record-keeping system (for example, the inventory shown by the perpetual records), or it may be any amount developed by the entity for each item in the population (for example, the entity's priced inventory). In both approaches the auditor needs to know the recorded amount for the total population and the total number of items in the population. In both the ratio and the difference methods, the auditor needs to obtain reasonable assurance that the entity has properly accumulated the recorded amounts of the items in the population. In the mean-per-unit method, estimation of the total population amount will correct for accumulation errors, but it will not in the other two methods. Therefore, in the ratio and the difference methods, the auditor usually performs a test independent of the sampling application. For example, the auditor can use a computer-assisted audit test to foot the recorded amounts of the items in the population. However, accumulation is a concept broader than footing; tests of accumulation also should include tests for duplication of sampling units, omission of sampling units, and other errors that may cause the actual total of all the sampling units to be different from the entity's total.

In some circumstances all of these constraints may be overcome by any of the classical variables approaches. In such cases many auditors prefer to use either a difference or a ratio approach because

17. For further information on this consideration, see Roberts, *Statistical Auditing*, pp. 84–85.

they are generally more efficient than the mean-per-unit approach; that is, the difference and the ratio approaches generally require a smaller sample size to achieve the same results at the risk of incorrect acceptance and tolerable error specified by the auditor. The increased efficiency is a result of the auditor's ability to utilize more information about the population and the sampling units in making his evaluation.

Determining the Sample Size

The mathematical calculations necessary to design a classical variables sampling approach, including the calculation of an appropriate sample size, tend to be complex and difficult to apply manually. Because auditors usually use computer programs to assist them in determining appropriate sample sizes for classical variables sampling applications, they generally do not need to know mathematical formulas to use these methods.

Considering Variation Within the Population

Section 1 of this chapter discussed the effect variation in the population had on sample size. The sample size required for a classical variables sampling application increases as the variation becomes greater. In general, any change in the variation in the population affects the sample size by the square of the relative change. For example, the sample size (unstratified) for a given risk of incorrect acceptance, population size, tolerable error, and amount of variation in the population has been determined to be 100. If the amount of variation were twice the original amount, the sample size necessary to meet the auditor's objectives would be four times the original sample size (in this case, a sample size of 400).

If an auditor designs an unstratified mean-per-unit sampling application, the appropriate sample size might be too large to be cost-effective for most audit applications. The auditor can reduce the effect of this variation by stratifying the population.

The optimal number of strata depends on the circumstances. After a certain point, division of the population into additional strata has a diminishing effect on the variation within strata. The auditor should consider the additional costs of dividing the population into more strata in relation to the resulting reduction of the overall sample size.

Stratification can be performed on computerized records with the assistance of programs designed for such audit applications. Stratification can be more time-consuming where the auditor must select the sample from manual records. In some circumstances auditors subjectively determine strata boundaries based on their knowledge of the population's composition. Some auditors believe it is generally not cost-effective to manually divide a population into more than two or three strata. The auditor then estimates the variation for each stratum, uses the tolerable error and risk of incorrect acceptance for the population to calculate the sample size, and allocates a portion of the sample size to each stratum.

Calculating the Sample Size

Auditors consider tolerable error and the risk of incorrect acceptance when determining sample size. In addition, they may also find it practical to explicitly consider the risk of incorrect rejection. Some computer programs for classical variables sampling applications allow the auditor to specify these factors directly when calculating a sample size. Other computer programs do not allow the auditor to directly specify the tolerable error, the risk of incorrect acceptance, and the risk of incorrect rejection. Instead they ask the auditor to specify a confidence level and a desired precision (this may be referred to as *desired allowance for sampling risk*).

For the latter computer programs, the confidence level is the complement of the risk of incorrect rejection and not the risk of incorrect acceptance. For example, if the auditor wishes to specify a 20-percent risk of incorrect rejection, he enters an 80-percent confidence level.[18] The auditor determines a desired allowance for sampling risk by relating the tolerable error and the risk of incorrect acceptance to a given level of the risk of incorrect rejection. The Appendix C table illustrates the relationship of these factors in order to determine the appropriate desired allowance for sampling risk.

In planning a classical variables sampling application, for example, the auditor might wish to specify a tolerable error of $10,000, a 5-percent risk of incorrect acceptance, and a 10-percent risk of incorrect rejection. If the computer program he is using asks him to specify a confidence level and a desired allowance for sampling risk, the auditor would specify a 90-percent confidence level (the complement of the 10-percent risk of incorrect rejection), and he would determine the appropriate desired allowance for sampling risk using

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18. The risk of incorrect rejection is usually measured for a particular hypothesis, for example, that the correct amount is equal to the recorded amount. Further discussion of this concept can be found in Roberts, *Statistical Auditing*, pp. 41–43.

the Appendix C table. The ratio of the desired allowance for sampling risk to tolerable error for a 5-percent risk of incorrect acceptance and a 10-percent risk of incorrect rejection is .50. The auditor calculates the desired allowance for sampling risk by multiplying this ratio by the tolerable error. In this case the desired allowance for sampling risk is $5,000 ($10,000 × .50).

The size of the sample required to achieve the auditor's objective will be affected by changes in the auditor's desired allowance for sampling risk. The sample size required to achieve the auditor's objective at a given risk of incorrect rejection for a given population increases as the auditor specifies a smaller desired allowance for sampling risk. In general, any change in the desired allowance for sampling risk affects the sample size by the square of the relative change. For example, the sample size for a given desired allowance for sampling risk may be 100. If the desired allowance for sampling risk is reduced by one-half, the sample size would be four times the original sample size.

To protect against the possibility that the normal distribution theory might not be appropriate, some auditors use rules of thumb concerning sample sizes for classical variables samples. One rule of thumb is to set the minimum sample size (by stratum and in total) equal to what would have been selected using the probability-proportional-to-size approach described in chapter 3, section 3, assuming no errors are expected. Another example of a rule of thumb is to establish minimum sample sizes, for example, 50 to 100 sampling units per application.

Evaluating the Sample Results

Each of the classical variables approaches to sampling provides the auditor with an estimated amount of the account balance or class of transactions being examined. The difference between this estimated amount and the entity's recorded amount is the projected error. Each approach also provides the auditor with an allowance for sampling risk, often referred to as *achieved precision*.[19] Because of the complexities involved, many auditors use computer programs to calculate the estimated amount of the population and the allowance

19. Some computer programs for evaluating classical variables sampling applications provide the auditor with such measures of sampling risk as *sampling error* and *precision*. See Roberts, *Statistical Auditing*, pp. 70 and 103, for a discussion of how these measures relate to an allowance for sampling risk.

for sampling risk when evaluating a classical variables sample.

According to SAS No. 39 the auditor should compare total projected error with tolerable error for the population and should give appropriate consideration to sampling risk. The comparison of projected error with tolerable error and the consideration of sampling risk are generally considered together in a decision rule when the auditor evaluates the results of a classical variables sample.

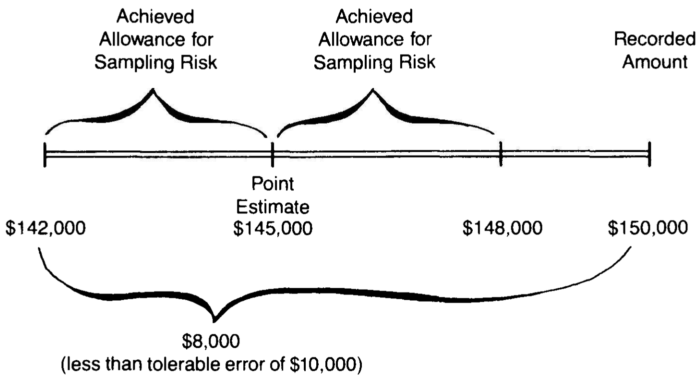
For those computer programs that give an allowance for sampling risk related to the risk of incorrect acceptance, the auditor will accept the population's recorded amount when the absolute value of the projected error is less than or equal to the tolerable error minus the achieved allowance for sampling risk.

For those computer programs that give an allowance for sampling risk related to the risk of incorrect rejection the decision process is more complex. One decision rule that would accomplish controlling the achieved risk of incorrect acceptance would be to accept the recorded amount of the population if it is within the range of the audit estimate of the population plus or minus an achieved allowance for sampling risk related to the risk of incorrect rejection that is no greater than the allowance specified in planning the sample. This approach to measuring allowance for sampling risk is consistent with the guidance associated with Appendix C.

However, in some circumstances the recorded amount might be outside that range, but the auditor might still find the sample results to be acceptable based on consideration of the risk of incorrect acceptance associated with the achieved results. If the acceptable level for the risk of incorrect rejection is *not* larger than twice the risk of incorrect acceptance and if the difference between the recorded amount and the far end of the range (based on the achieved allowance related to incorrect rejection) is *less* than tolerable error, the sample results *would* support the recorded amount of the population. If the acceptable level for the risk of incorrect rejection *is* larger than twice the risk of incorrect acceptance or if the difference between the recorded amount and the far end of the range is *greater* than tolerable error, the sample results might *not* support the recorded amount of the population. This might require recomputation of the results.[20]

20. For discussion of how this recomputation is done, see Roberts, *Statistical Auditing*, pp. 43–44.

The sample results, for example, might have yielded an allowance for sampling risk that was related to the risk of incorrect rejection and smaller than the desired allowance for sampling risk specified by the auditor when the sample size was calculated. To illustrate: An auditor has calculated a sample size based on a 5-percent risk of incorrect acceptance and a 10-percent risk of incorrect rejection. The auditor has assessed tolerable error to be $10,000 for a population with a recorded amount of $150,000 and has specified a desired allowance for sampling risk of $5,000. In evaluating the sample results the auditor might determine that the audit estimate of the population on the basis of a classical variables sample is $145,000



with a $3,000 achieved allowance related to the risk of incorrect rejection (that is, the audit estimate is $145,000 plus or minus $3,000). Although the recorded amount of $150,000 is outside the range of the audit estimate, the auditor will still find that the sample results support the recorded amount because the risk of incorrect rejection is not larger than twice the risk of incorrect acceptance, and the difference between the recorded amount and the far end of the range is less than tolerable error.

The same type of analysis can be used for the first rule of thumb if the achieved allowance for sampling risk relates to the risk of incorrect acceptance. When using this approach, the auditor would recompute the allowance for sampling risk. Because of the facts in this specific example, the allowance for sampling risk related to the risk of incorrect acceptance is also $3,000. Therefore, the results would be acceptable because the absolute value of the projected error ($5,000) is less than tolerable error minus the achieved allowance for sampling risk ($10,000 − $3,000 = $7,000).

If the difference between the recorded amount and the far end of the range is greater than tolerable error, the sample results might have been obtained because of one of the following:

- The sample results yield an allowance for sampling risk larger than specified by the auditor because the sample size was too small.
- The sample is not representative of the population.
- The recorded amount is misstated by an amount greater than tolerable error.

In designing a classical variables sampling application, the auditor determined a sample size that he believed would allow him to expect that, when evaluating the sample results, the allowance for sampling risk, when combined with expected error, would be adequately limited. However, the sample results might not adequately limit the allowance for sampling risk if the variation of the characteristic of interest exceeded the estimate of the variation used by the auditor when he determined the sample size. The auditor using a computer program to perform a classical variables application can generally ascertain if this has occurred by comparing the standard deviation used to determine sample size with the standard deviation calculated as part of the evaluation of the sample results. If the standard deviation calculated when evaluating the sample results is greater than the standard deviation used to determine sample size, the allowance for sampling risk might not be adequately controlled. In the above example, the audit estimate of the population, based on a classical variables sample, might be $145,000, with an allowance for sampling risk of $10,000 (that is, $145,000 plus or minus $10,000). Because the difference between the recorded amount ($150,000) and the far end of the range ($135,000) is greater than the tolerable error of $10,000, the sample results do not support acceptance of the recorded amount.

If the allowance for sampling risk has not been adequately limited, the auditor can choose either of these options:

1. Examine additional randomly selected sampling units. The auditor should calculate the additional sample size using a revised estimate of the variation in the population; the total number of sampling units in the additional sample combined with the original sample can be expected to adequately limit the allowance for sampling risk.
2. Perform additional substantive tests directed toward the same audit objective. The additional reliance on other tests would allow the auditor to accept a greater risk of incorrect acceptance for the sampling application. Recalculating the allowance for sampling risk with the greater risk of incorrect acceptance will not change the point estimate of the population, but it will move the ends of the range closer to that estimate.

The sample results also might not support acceptance of the recorded amounts because the sample is not representative of the population. Although the auditor selects a sample in such a way that the sample can be expected to be representative of the population, occasionally the sample might not be representative of the population. In some circumstances the auditor might have reason to believe that the sample is not representative of the population. For example, (1) if the results of a mean-per-unit sample do not support the recorded amount of the population even though no errors were found in the sample or (2) if all the other related evidential matter contradicts the sample evidence, the auditor might suspect, among other possibilities, that the sample consists of items with unrepresentatively small or large amounts. In such situations the auditor might examine additional sampling units or perform alternative procedures as an aid in determining whether the recorded amount of the population is misstated.

If the sample results do not support the recorded amount of the population and the auditor believes that the recorded amount may be misstated, the auditor considers the error along with other audit evidence when evaluating whether the financial statements are materially misstated. The auditor ordinarily suggests that the entity investigate the errors and, if appropriate, adjust the recorded amount. If the difference between the adjusted recorded amount and the far end of the range is less than tolerable error, the sample results would support the conclusion that the population, as adjusted, is not misstated by more than tolerable error.

In addition to evaluating the frequency and amounts of monetary misstatements, the auditor should consider the qualitative aspects of errors. These considerations are discussed in section 1 of this chapter.

Classical Variables Sampling Case Study

ABC Co., a distributor of household products, is audited by Smith, Stein & Co., CPAs. Stein of Smith, Stein & Co. decided to design a classical variables statistical sample to test the pricing of ABC Co.'s inventory as part of the examination of ABC Co.'s June 30, 19XX financial statements. For the year ended June 30, 19XX, ABC Co.'s inventory had a recorded amount of $3,207,892.50 and consisted of approximately 2,700 different items.

Stein decided that the results of her study and evaluation of ABC Co.'s internal accounting control procedures supported a moderate degree of reliance on the control procedures in determining the scope of substantive tests of the inventory balance. She also decided that a misstatement of $45,000 or more in the inventory balance, when combined with error in other accounts, would result in the financial statements being materially misstated.

Stein chose a classical variables sampling approach because (1) on the basis of the prior year's audit, she expected the account to contain both overstatements and understatements and (2) the accounting records had been maintained on computer file; she had computer software available for analyzing the accounting records and assisting her in designing and evaluating the sample.

Stein obtained reasonable assurance that inventory quantities were recorded properly through observation of ABC Co.'s physical inventory as of June 30, 19XX and application of cutoff procedures. Stein also planned to perform some analytical review procedures on the inventory account to obtain further assurance that both the quantities and pricing were reasonable. Although Stein expected to find some errors, she did not expect to find enough errors to use either a ratio or a difference estimation approach. Stein decided to design a mean-per-unit statistical sample.

The approximately 2,700 items of ABC Co.'s inventory balance had a wide range of recorded amounts, from approximately $20 to $7,500. Stein decided to stratify the items constituting the balance to reduce the effect that variation in recorded amounts had on the determination of sample size. Stein first identified 9 items whose recorded amounts each exceeded $4,500. Those items were to be examined 100 percent and would not be included in the items subject to sampling.

Using professional judgment, Stein decided that a 30-percent risk of incorrect acceptance was appropriate for this test because of the moderately effective internal accounting controls related to inventory transactions and the moderate reliance she intended to place on other planned substantive tests related to the inventory account. In calculating the sample size, Stein also decided to specify a 5-percent risk of incorrect rejection to provide a sample size that would be large enough to allow for some error.

Because ABC Co.'s inventory records were maintained on a computer file, Stein was able to use a computer program to assist her in stratifying the June 30, 19XX inventory and in selecting an appropriate sample. The computer program, MPUSTRAT, divided the items subject to sampling into 10 strata and calculated an appropriate sample size for each stratum (see figure 2). The overall sample size calculated by the program, based on the risk levels and tolerable error specified by Stein, was 209 (see figure 2). The total sample size of 209 was comprised of 200 items selected from the population subject to sampling and 9 items examined 100 percent. Stein tested the pricing of the 209 inventory items and identified 6 errors: 5 errors in the sample of 200 and 1 overstatement error in the items examined 100 percent.

Stein used another computer program to assist her in calculating a projected error and an allowance for sampling risk for the sample. That program, MPUEVAL, calculated a projected error for each stratum and a total projected error and allowance for sampling risk for the entire sample at the 30-percent risk of incorrect acceptance specified by Stein (see figure 3). The total projected error was $16,394.48 ($3,207,892.50 − $3,191,498.02).

Because the total projected error of $16,394.48 in the inventory balance ($14,394.48 projected from the population subject to sampling plus $2,000 of error identified in the items examined 100 percent) plus a $21,222.11 allowance for sampling risk (see figure 3) was less than the $45,000 tolerable error for the inventory balance, Stein concluded that the sample results supported ABC Co.'s recorded amount of inventory. However, Stein included the projected error from the sample results along with other relevant audit evidence when she evaluated whether the financial statements taken as a whole were materially misstated.

FIGURE 2

ABC CO. | INVENTORY | JUNE 30, 19XX

SAMPLE-SIZE REPORT

STRATUM NUMBER	STRATUM LOW RANGE	STRATUM HIGH RANGE	TOTAL ITEMS IN STRATUM	STANDARD DEVIATION	SAMPLE SIZE
1	0	236	409	65.06	21
2	237	450	420	62.38	21
3	451	663	390	62.23	19
4	664	911	356	68.65	19
5	912	1,260	308	101.21	24
6	1,261	1,698	187	123.70	18
7	1,699	2,441	127	212.92	21
8	2,442	3,116	144	181.52	21
9	3,117	3,555	205	113.52	19
10	3,556	4,500	148	145.71	17
100%	4,500	–	9	–	9

RECORDED AMOUNT OF POPULATION	3,207,892.50
TOTAL SAMPLING UNITS IN POPULATION	2,695
TOTAL SAMPLE SIZE	209

THE SAMPLE WAS CALCULATED BASED ON THE FOLLOWING SPECIFICATIONS:

TOLERABLE ERROR	45,000
RISK OF INCORRECT ACCEPTANCE	.30
RISK OF INCORRECT REJECTION	.05
LOWER 100% CUTOFF	0
UPPER 100% CUTOFF	4,500

FIGURE 3

ABC CO.	INVENTORY	JUNE 30, 19XX
	SAMPLE EVALUATION REPORT	

ERRORS LOCATED IN AUDIT

	RECORDED AMOUNT	AUDIT AMOUNT
1	$ 1,250.00	$ 350.00
2	200.00	360.00
3	600.00	240.00
4	510.00	650.00
5	320.00	319.00
6	7,550.00	5,550.00
TOTAL	$10,430.00	$7,469.00

VARIABLES TEST EVALUATION

RECORDED AMOUNT OF 3,207,892.50 CAN BE ACCEPTED AS CORRECT
GIVEN THE TOLERABLE ERROR ORIGINALLY SPECIFIED
IF THE RISK OF INCORRECT ACCEPTANCE OF .30 FOR THIS
TEST REMAINS APPROPRIATE AFTER CONSIDERING THE RESULTS
OF OTHER AUDITING PROCEDURES.

ESTIMATED TOTAL AMOUNT	3,191,498.02
ALLOWANCE FOR SAMPLING RISK	21,222.11
SAMPLING UNITS IN POPULATION	2,695
SAMPLE SIZE	209
TOLERABLE ERROR	45,000.00
RISK OF INCORRECT ACCEPTANCE	.30
RISK OF INCORRECT REJECTION	.05

Appendix A

Statistical Sampling Tables for Compliance Tests

This appendix includes four tables to assist the auditor in planning and evaluating a statistical sample of a fixed size for a compliance test.* They are as follows:
Table 1 — Sample size with a 5-percent risk of overreliance
Table 2 — Sample size with a 10-percent risk of overreliance
Table 3 — Sample evaluation for a 5-percent risk of overreliance
Table 4 — Sample evaluation for a 10-percent risk of overreliance

Using the Tables

Chapter 2 discusses the factors that the auditor needs to consider when planning an audit sampling application for a compliance test. For statistical sampling the auditor needs to explicitly specify (1) an acceptable level of the risk of overreliance on internal accounting control, (2) the tolerable rate, and (3) the expected population deviation rate. This appendix includes tables for 5-percent and 10-percent levels of risk of overreliance. If the auditor desires another level of risk of overreliance, use of either a table in another reference on statistical sampling or a computer program will be necessary.

The auditor selects the table for the acceptable level of risk of overreliance and then reads down the expected population deviation rate column to find the appropriate rate. Next the auditor locates the column corresponding to the tolerable rate. The appropriate sample size is shown where the two factors meet.

In some circumstances tables 1 and 2 can be used to evaluate the sample results. The parenthetical number shown next to each sample size is the expected number of deviations to be found in the sample. The expected

* Auditors using a sequential sampling plan should not use these tables for designing or evaluating the sampling application. See the discussion of sequential sampling in Appendix B.

number of deviations is the expected population deviation rate multiplied by the sample size. If the auditor finds that number of deviations or fewer in the sample, he can conclude that at the desired risk of overreliance, the projected deviation rate for the population plus an allowance for sampling risk is not more than the tolerable rate. In these circumstances the auditor need not use tables 3 or 4 to evaluate the sample results.

If more than the expected number of deviations are found in the sample, the auditor cannot conclude that the population deviation rate is less than the tolerable rate. Accordingly, the test would not support his planned reliance on internal accounting control. However, the sample might support some lesser level of reliance.

If the number of deviations found in the sample is not the expected number of deviations shown in parentheses in tables 1 or 2 and the auditor wishes to calculate the maximum deviation rate in the population, he can evaluate the sample results using either table 3 for a 5-percent acceptable risk of overreliance or table 4 for a 10-percent acceptable risk of overreliance. Space limitations do not allow tables 3 and 4 to include evaluations for all possible sample sizes and number of deviations. If the auditor is evaluating sample results for a sample size or number of deviations not shown in these tables, he can use either a table in another reference on statistical sampling or a computer program. Alternatively, the auditor might interpolate between sample sizes shown in these tables. Any error due to interpolation should not be significant to the auditor's evaluation. If the auditor wishes to be conservative, he can use the next smaller sample size shown in the table to evaluate the number of deviations found in the sample.

The auditor selects the table applicable to the acceptable level of risk of overreliance and then reads down the sample-size column to find the appropriate sample size. Next the auditor locates the column corresponding to the number of deviations found in the sample. The projection of the sample results to the population plus an allowance for sampling risk (that is, the maximum population deviation rate) is shown where the two factors meet. If this maximum population deviation rate is less than the tolerable rate, the test supports the planned reliance on internal accounting control.

How the Tables Might Be Useful in Applying Nonstatistical Sampling

The auditor using nonstatistical sampling for compliance testing uses his professional judgment to consider the factors described in chapter 2 in determining sample sizes. The relative effect of each factor on the appropriate nonstatistical sample size is illustrated in chapter 2 and is summarized below.

Factor	*General Effect on Sample Size*
Tolerable rate increase (decrease)	Smaller (larger)
Risk of overreliance on internal accounting controls increase (decrease)	Smaller (larger)
Expected population deviation rate increase (decrease)	Larger (smaller)
Population size	Virtually no effect

Neither SAS No. 39 nor this guide requires the auditor to compare the sample size for a nonstatistical sampling application with a corresponding sample size calculated using statistical theory. However, in applying professional judgment to determine an appropriate nonstatistical sample size for a compliance test, an auditor might find it helpful to be familiar with the tables in this appendix. The auditor using these tables as an aid in understanding relative sample sizes for compliance tests will need to apply professional judgment in reviewing the risk levels and expected population deviation rates in relation to sample sizes. For example, an auditor designing a nonstatistical sampling application to test compliance with a prescribed control procedure might have assessed the tolerable rate as 8 percent. If the auditor were to consider selecting a sample size of 60, these tables would imply that at approximately a 5-percent risk level the auditor expected no more than approximately 1.5 percent of the items in the population to be deviations from the prescribed control procedure. These tables also would imply that at approximately a 10-percent risk level the auditor expected no more than approximately 3 percent of the items in the population to be deviations.

TABLE 1

Statistical Sample Sizes for Compliance Testing
Five-Percent Risk of Overreliance
(with number of expected errors in parentheses)

Expected Population Deviation Rate	*Tolerable Rate* 2%	3%	4%	5%	6%	7%	8%	9%	10%	15%	20%
0.00%	149(0)	99(0)	74(0)	59(0)	49(0)	42(0)	36(0)	32(0)	29(0)	19(0)	14(0)
.25	236(1)	157(1)	117(1)	93(1)	78(1)	66(1)	58(1)	51(1)	46(1)	30(1)	22(1)
.50	*	157(1)	117(1)	93(1)	78(1)	66(1)	58(1)	51(1)	46(1)	30(1)	22(1)
.75	*	208(2)	117(1)	93(1)	78(1)	66(1)	58(1)	51(1)	46(1)	30(1)	22(1)
1.00	*	*	156(2)	93(1)	78(1)	66(1)	58(1)	51(1)	46(1)	30(1)	22(1)
1.25	*	*	156(2)	124(2)	78(1)	66(1)	58(1)	51(1)	46(1)	30(1)	22(1)
1.50	*	*	192(3)	124(2)	103(2)	66(1)	58(1)	51(1)	46(1)	30(1)	22(1)
1.75	*	*	227(4)	153(3)	103(2)	88(2)	77(2)	51(1)	46(1)	30(1)	22(1)
2.00	*	*	*	181(4)	127(3)	88(2)	77(2)	68(2)	46(1)	30(1)	22(1)
2.25	*	*	*	208(5)	127(3)	88(2)	77(2)	68(2)	61(2)	30(1)	22(1)
2.50	*	*	*	*	150(4)	109(3)	77(2)	68(2)	61(2)	30(1)	22(1)
2.75	*	*	*	*	173(5)	109(3)	95(3)	68(2)	61(2)	30(1)	22(1)
3.00	*	*	*	*	195(6)	129(4)	95(3)	84(3)	61(2)	30(1)	22(1)
3.25	*	*	*	*	*	148(5)	112(4)	84(3)	61(2)	30(1)	22(1)
3.50	*	*	*	*	*	167(6)	112(4)	84(3)	76(3)	40(2)	22(1)
3.75	*	*	*	*	*	185(7)	129(5)	100(4)	76(3)	40(2)	22(1)
4.00	*	*	*	*	*	*	146(6)	100(4)	89(4)	40(2)	22(1)
5.00	*	*	*	*	*	*	*	158(8)	116(6)	40(2)	30(2)
6.00	*	*	*	*	*	*	*	*	179(11)	50(3)	30(2)
7.00	*	*	*	*	*	*	*	*	*	68(5)	37(3)

*Sample size is too large to be cost-effective for most audit applications.

NOTE: This table assumes a large population. For a discussion of the effect of population size on sample size, see chapter 2.

TABLE 2

Statistical Sample Sizes for Compliance Testing Ten-Percent Risk of Overreliance (with number of expected errors in parentheses)

Expected Population Deviation Rate	*Tolerable Rate* 2%	3%	4%	5%	6%	7%	8%	9%	10%	15%	20%
0.00%	114(0)	76(0)	57(0)	45(0)	38(0)	32(0)	28(0)	25(0)	22(0)	15(0)	11(0)
.25	194(1)	129(1)	96(1)	77(1)	64(1)	55(1)	48(1)	42(1)	38(1)	25(1)	18(1)
.50	194(1)	129(1)	96(1)	77(1)	64(1)	55(1)	48(1)	42(1)	38(1)	25(1)	18(1)
.75	265(2)	129(1)	96(1)	77(1)	64(1)	55(1)	48(1)	42(1)	38(1)	25(1)	18(1)
1.00	*	176(2)	96(1)	77(1)	64(1)	55(1)	48(1)	42(1)	38(1)	25(1)	18(1)
1.25	*	221(3)	132(2)	77(1)	64(1)	55(1)	48(1)	42(1)	38(1)	25(1)	18(1)
1.50	*	*	132(2)	105(2)	64(1)	55(1)	48(1)	42(1)	38(1)	25(1)	18(1)
1.75	*	*	166(3)	105(2)	88(2)	55(1)	48(1)	42(1)	38(1)	25(1)	18(1)
2.00	*	*	198(4)	132(3)	88(2)	75(2)	48(1)	42(1)	38(1)	25(1)	18(1)
2.25	*	*	*	132(3)	88(2)	75(2)	65(2)	42(1)	38(1)	25(1)	18(1)
2.50	*	*	*	158(4)	110(3)	75(2)	65(2)	58(2)	38(1)	25(1)	18(1)
2.75	*	*	*	209(6)	132(4)	94(3)	65(2)	58(2)	52(2)	25(1)	18(1)
3.00	*	*	*	*	132(4)	94(3)	65(2)	58(2)	52(2)	25(1)	18(1)
3.25	*	*	*	*	153(5)	113(4)	82(3)	58(2)	52(2)	25(1)	18(1)
3.50	*	*	*	*	194(7)	113(4)	82(3)	73(3)	52(2)	25(1)	18(1)
3.75	*	*	*	*	*	131(5)	98(4)	73(3)	52(2)	25(1)	18(1)
4.00	*	*	*	*	*	149(6)	98(4)	73(3)	65(3)	25(1)	18(1)
5.00	*	*	*	*	*	*	160(8)	115(6)	78(4)	34(2)	18(1)
6.00	*	*	*	*	*	*	*	182(11)	116(7)	43(3)	25(2)
7.00	*	*	*	*	*	*	*	*	199(14)	52(4)	25(2)

*Sample size is too large to be cost-effective for most audit applications.

NOTE: This table assumes a large population. For a discussion of the effect of population on sample size, see chapter 2.

TABLE 3

Statistical Sample Results Evaluation Table for Compliance Tests Upper Limits at Five-Percent Risk of Overreliance

	Actual Number Of Deviations Found										
Sample Size	*0*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
25	11.3	17.6	*	*	*	*	*	*	*	*	*
30	9.5	14.9	19.6	*	*	*	*	*	*	*	*
35	8.3	12.9	17.0	*	*	*	*	*	*	*	*
40	7.3	11.4	15.0	18.3	*	*	*	*	*	*	*
45	6.5	10.2	13.4	16.4	19.2	*	*	*	*	*	*
50	5.9	9.2	12.1	14.8	17.4	19.9	*	*	*	*	*
55	5.4	8.4	11.1	13.5	15.9	18.2	*	*	*	*	*
60	4.9	7.7	10.2	12.5	14.7	16.8	18.8	*	*	*	*
65	4.6	7.1	9.4	11.5	13.6	15.5	17.4	19.3	*	*	*
70	4.2	6.6	8.8	10.8	12.6	14.5	16.3	18.0	19.7	*	*
75	4.0	6.2	8.2	10.1	11.8	13.6	15.2	16.9	18.5	20.0	*
80	3.7	5.8	7.7	9.5	11.1	12.7	14.3	15.9	17.4	18.9	*
90	3.3	5.2	6.9	8.4	9.9	11.4	12.8	14.2	15.5	16.8	18.2
100	3.0	4.7	6.2	7.6	9.0	10.3	11.5	12.8	14.0	15.2	16.4
125	2.4	3.8	5.0	6.1	7.2	8.3	9.3	10.3	11.3	12.3	13.2
150	2.0	3.2	4.2	5.1	6.0	6.9	7.8	8.6	9.5	10.3	11.1
200	1.5	2.4	3.2	3.9	4.6	5.2	5.9	6.5	7.2	7.8	8.4

*Over 20 percent

NOTE: This table presents upper limits as percentages. This table assumes a large population.

TABLE 4

Statistical Sampling Results Evaluation Table for Compliance Tests Upper Limits at Ten-Percent Risk of Overreliance

	Actual Number Of Deviations Found										
Sample Size	*0*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
20	10.9	18.1	*	*	*	*	*	*	*	*	*
25	8.8	14.7	19.9	*	*	*	*	*	*	*	*
30	7.4	12.4	16.8	*	*	*	*	*	*	*	*
35	6.4	10.7	14.5	18.1	*	*	*	*	*	*	*
40	5.6	9.4	12.8	16.0	19.0	*	*	*	*	*	*
45	5.0	8.4	11.4	14.3	17.0	19.7	*	*	*	*	*
50	4.6	7.6	10.3	12.9	15.4	17.8	*	*	*	*	*
55	4.1	6.9	9.4	11.8	14.1	16.3	18.4	*	*	*	*
60	3.8	6.4	8.7	10.8	12.9	15.0	16.9	18.9	*	*	*
70	3.3	5.5	7.5	9.3	11.1	12.9	14.6	16.3	17.9	19.6	*
80	2.9	4.8	6.6	8.2	9.8	11.3	12.8	14.3	15.8	17.2	18.6
90	2.6	4.3	5.9	7.3	8.7	10.1	11.5	12.8	14.1	15.4	16.6
100	2.3	3.9	5.3	6.6	7.9	9.1	10.3	11.5	12.7	13.9	15.0
120	2.0	3.3	4.4	5.5	6.6	7.6	8.7	9.7	10.7	11.6	12.6
160	1.5	2.5	3.3	4.2	5.0	5.8	6.5	7.3	8.0	8.8	9.5
200	1.2	2.0	2.7	3.4	4.0	4.6	5.3	5.9	6.5	7.1	7.6

*Over 20 percent

NOTE. This table presents upper limits as percentages. This table assumes a large population.

Appendix B

Sequential Sampling for Compliance Tests

The auditor designs samples for compliance tests using either a fixed sampling plan or a sequential sampling plan.* Under a fixed sampling plan the auditor examines a single sample of a specified size; under a sequential sampling plan the sample is selected in several steps, with each step conditional on the results of the previous steps. The decision to use a fixed or a sequential sampling plan depends on which plan the auditor believes will be most efficient in the circumstances.

In planning a fixed sampling application, the auditor should consider that if the deviation rate in the sample exceeds the specified expected population deviation rate, the sample results would suggest that the estimated population deviation rate plus an allowance for sampling risk exceeds the tolerable rate. In that case the sample results would not support the auditor's planned reliance on the internal accounting control. These results might be obtained even though the actual population deviation rate would support the auditor's planned reliance because the sample size is too small to adequately limit the allowance for sampling risk.

The auditor can use a sequential sampling plan to help overcome this limitation of a fixed sampling plan. A sequential sample generally consists of two to four groups of sampling units. The auditor determines the sizes of the individual groups of sampling units based on the specified risk of overreliance on internal accounting control, the tolerable rate, and the expected population deviation rate. The auditor generally uses a computer program or tables for sequential sampling plans to assist in determining the appropriate size for each group of sampling units. The auditor examines the first group of sampling units and, on the basis of the results, decides whether (1) to rely on the internal accounting control, as planned, without examining additional sampling units, (2) to reduce the planned reliance on the internal accounting control without examining additional sampling

* A more thorough discussion of designing a sequential sample can be found in Donald Roberts, *Statistical Auditing* (New York: AICPA, 1978), pp. 57–60.

units, or (3) to examine additional sampling units because sufficient information to determine whether planned reliance is warranted has not been obtained.

An Example of a Four-Step Sequential Sampling Plan

The following table illustrates the number of sampling units for each group in a four-step sequential sampling plan, assuming a 5-percent tolerable rate, a 10-percent risk of overreliance on internal accounting control, and a .5-percent expected population deviation rate.

			Accumulated Deviations		
Group	*No. of Sampling Units*	*Accumulated Sample Size*	*Accept Planned Reliance*	*Sample More*	*Reduce Planned Reliance*
1	50	50	0	1–3	4
2	51	101	1	2–3	4
3	51	152	2	3	4
4	51	203	3	NA	4

If the auditor finds 4 deviations in this example, the examination of sampling units stops and planned reliance on the internal accounting control is reduced. If no deviations are found in the first group of 50 sampling units, the auditor evaluates the sample as supporting the planned reliance without examining more sampling units. If 1, 2, or 3 deviations exist in the first group of sampling units, the auditor examines additional sampling units in the next group(s). The auditor continues to examine sampling units in succeeding groups until the sample results either support or do not support the planned reliance. For example, if 3 deviations exist in the first group, the next three groups of sampling units must be examined without finding additional deviations in order to support the planned reliance on the internal accounting control.

Comparison of Sequential Sample Sizes With Fixed Sample Sizes

Sample sizes under fixed sampling plans are larger, on the average, than those under sequential sampling plans if the auditor overstates the expected population deviation rate. For example, if the actual population deviation rate is .5 percent, the four-step sequential sampling plan just illustrated would generally require the auditor to examine fewer sampling units to support the planned reliance than a fixed sampling plan would require. Under a fixed sampling plan a sample size of 77 is sufficient to support the planned reliance when the population deviation rate is .5 percent (see table 2 in Appendix A). Under the sequential sampling plan the auditor examines 50, 101, 152, or 203 items. However, the auditor considers the long-run average sample size when deciding whether to use a fixed or a sequential sampling approach. If the true population deviation rate is .5 percent, the auditor may need to examine an average of 65 sampling units under the four-step sequential sampling plan as compared with 77 sampling units under the fixed sampling plan.

A sequential sampling plan provides an opportunity to design a sample with a minimum size in anticipation of a low population deviation rate. However, an auditor might find that the audit effort of examining the total number of sampling units for all four steps of a sequential sampling plan would exceed the reduction of substantive testing that could be achieved by reliance on internal accounting control. Therefore, some auditors decide to stop a four-step sequential sampling plan before completing all four steps. For example, an auditor using the four-step plan just illustrated might decide to stop examining sampling units if 2 or 3 deviations are found in the second group. In that case the auditor might have decided that the resulting reduction in substantive testing may not justify the additional audit effort of examining up to 102 additional sampling units.

If the auditor believes it would not be practical to examine the total number of sampling units for all steps of a four-step sequential sampling plan, a sequential sampling plan with fewer than four steps could be designed. For example, some auditors find it practical to design two-step sequential sampling plans.

Sequential sampling plans are generally designed for statistical sampling applications. However, by using the same tables or computer programs to determine the sample size, it might be possible to design a nonstatistical sequential sampling plan.

Appendix C

Ratio of Desired Allowance For Sampling Risk to Tolerable Error

Risk of Incorrect Acceptance	*Risk of Incorrect Rejection*			
	.20	*.10*	*.05*	*.01*
.01	.355	.413	.457	.525
.025	.395	.456	.500	.568
.05	.437	.500	.543	.609
.075	.471	.532	.576	.641
.10	.500	.561	.605	.668
.15	.511	.612	.653	.712
.20	.603	.661	.700	.753
.25	.653	.708	.742	.791
.30	.707	.756	.787	.829
.35	.766	.808	.834	.868
.40	.831	.863	.883	.908
.45	.907	.926	.937	.952
.50	1.000	1.000	1.000	1.000

This table is derived from *Statistical Auditing* by Donald Roberts (New York: AICPA, 1978) and is used in connection with the classical variables sampling guidance in "Calculating the Sample Size," found in chapter 3, section 4. For further information on the hypotheses underlying this measure of the risk of incorrect rejection, see pages 41 to 43 in *Statistical Auditing*.

Appendix D

Probability-Proportional-to-Size Sampling Tables

TABLE 1

Reliability Factors for Errors of Overstatement

Number of Over-statement Errors	*Risk of Incorrect Acceptance*								
	1%	*5%*	*10%*	*15%*	*20%*	*25%*	*30%*	*37%*	*50%*
0	4.61	3.00	2.31	1.90	1.61	1.39	1.21	1.00	.70
1	6.64	4.75	3.89	3.38	3.00	2.70	2.44	2.14	1.68
2	8.41	6.30	5.33	4.72	4.28	3.93	3.62	3.25	2.68
3	10.05	7.76	6.69	6.02	5.52	5.11	4.77	4.34	3.68
4	11.61	9.16	8.00	7.27	6.73	6.28	5.90	5.43	4.68
5	13.11	10.52	9.28	8.50	7.91	7.43	7.01	6.49	5.68
6	14.57	11.85	10.54	9.71	9.08	8.56	8.12	7.56	6.67
7	16.00	13.15	11.78	10.90	10.24	9.69	9.21	8.63	7.67
8	17.41	14.44	13.00	12.08	11.38	10.81	10.31	9.68	8.67
9	18.79	15.71	14.21	13.25	12.52	11.92	11.39	10.74	9.67
10	20.15	16.97	15.41	14.42	13.66	13.02	12.47	11.79	10.67
11	21.49	18.21	16.60	15.57	14.78	14.13	13.55	12.84	11.67
12	22.83	19.45	17.79	16.72	15.90	15.22	14.63	13.89	12.67
13	24.14	20.67	18.96	17.86	17.02	16.32	15.70	14.93	13.67
14	25.45	21.89	20.13	19.00	18.13	17.40	16.77	15.97	14.67
15	26.75	23.10	21.30	20.13	19.24	18.49	17.84	17.02	15.67
16	28.03	24.31	22.46	21.26	20.34	19.58	18.90	18.06	16.67
17	29.31	25.50	23.61	22.39	21.44	20.66	19.97	19.10	17.67
18	30.59	26.70	24.76	23.51	22.54	21.74	21.03	20.14	18.67
19	31.85	27.88	25.91	24.63	23.64	22.81	22.09	21.18	19.67
20	33.11	29.07	27.05	25.74	24.73	23.89	23.15	22.22	20.67

TABLE 2

Expansion Factors for Expected Errors

	Risk of Incorrect Acceptance								
	1%	*5%*	*10%*	*15%*	*20%*	*25%*	*30%*	*37%*	*50%*
Factor	1.9	1.6	1.5	1.4	1.3	1.25	1.2	1.15	1.0

Appendix E

Computerized Methods for Statistical Sampling

Many tools have been developed to assist the auditor in performing sampling applications without the use of complex formulas. For example, tables to determine sample sizes and to evaluate sample results are found in Appendix A as well as in many books on auditing applications of statistical sampling. While tables might be convenient reference tools, they have several limitations. In general, tables are difficult to use for certain variables sampling applications. For example, classical variables sampling by strata requires the calculation of a standard deviation by strata. Tables are also generally limited to a small number of factors, such as risk levels and sample sizes.

Computer programs have been developed to assist the auditor in planning and evaluating sampling procedures. These programs overcome the limitations of tables and perform calculations, such as a standard deviation computation, that are difficult and time-consuming to perform manually. Computer programs are flexible. For example, they can calculate sample sizes for different sampling techniques. They can help the auditor select a random sample. They can evaluate samples covering single or multiple locations and can offer many more options for the auditor's planning considerations. These programs generally have built-in controls over human errors. For example, programs can be designed to include controls that identify unreasonable input.

A computer's printed output is generally written in nontechnical language that can be easily understood by an auditor. It can also be included in the auditor's working papers as part of the documentation of the sampling procedure.

Time-Sharing Programs

Individual time-sharing applications for a statistical sampling procedure are relatively inexpensive. An auditor who decides to use computer time-sharing in performing statistical sampling might need to pay a small minimum monthly fee to receive a confidential user code and a password to access a vendor's library of statistical sampling programs.

Time-sharing programs are available from a variety of sources, including vendors who make their programs available to all auditors. In selecting a time-sharing program, the auditor should obtain reasonable assurance that the program is suitable for his needs. The following considerations might assist the auditor in making such a determination.

Consideration: Are the assumptions used in developing the program appropriate, and has the program been properly tested under a variety of circumstances?

Comment: Programs offered by time-sharing vendors generally are developed by the vendors, by third parties for the vendors, or by CPA firms. In most circumstances more than one statistical theory might be acceptable for use in developing programs. The auditor might inquire about which theory was used in order to determine whether that theory is appropriate for his specific purpose.

The extent of a vendor's testing of its programs varies significantly. It is important for the auditor to determine the extent of such tests before using the programs. For example, the auditor should ask whether the programs were tested with data that an auditor may encounter both in usual and in rare, but possible, circumstances.

The auditor should also consider making inquiries about the business reputation of the vendor and the qualifications of the program developer. Vendors have significant differences in their philosophies about responsibility to the users of their programs. The extent to which vendors are willing to assume responsibility for their programs might indicate the degree to which they believe the programs are suitable for an auditor's purpose.

Consideration: What controls are included in the program?

Comment: Statistical sampling software should contain basic control features that, for example, reject negative numbers where inapplicable or alert the auditor to inappropriately high risk levels or tolerable rates. The auditor should establish whether documentation of the controls is available for review. The software should also contain prompts to lead an auditor who is new to statistical sampling through the various input requirements and alternatives.

Consideration: What services does the vendor provide?

Comment: A clear and comprehensive user manual should accompany each program. The auditor also should consider if the availability of programs will meet current needs based on work hours and office locations. For example, some vendors make their programs available twenty-four hours a day. The auditor should consider the amount of technical support available from the vendor when programs are used.

Consideration: Can the program be easily understood and used by the auditor?

Comment: Many time-sharing vendors provide simple operating instructions designed to meet the needs of the auditor. The program instructions should indicate the program's capabilities. The amount of required input should be minimal and free of complex, special codes. The printout reports should be concise and readily understandable to the auditor.

Batch Programs

Batch programs are especially useful where the company's records are in computer-readable form and the auditor wishes to perform other procedures along with the statistical procedures. For example, the auditor might wish to print confirmation requests at the same time he selects a sample of items to be confirmed using a random selection technique. Many batch processing computer-assisted auditing packages contain routines for statistical sampling that allow for this flexibility.

Batch programs can be purchased, leased, or internally developed and are usually stored on computer cards or magnetic tape. Instruction manuals that describe the program, its use, and the output to be produced generally accompany purchased or leased programs.

Auditors often find it practical to use batch programs on the company's computer system. In circumstances in which the auditor does not believe this is practical, he might decide to use his own computer or a service bureau computer system to process the batch programs.

The use of batch programs generally requires preparing a description of the input data file and parameter cards. The file description is needed to instruct the program about where data are located. The parameter cards are used to relay instructions to the program and instruct the program on how to process data or what statistical routine to execute. To execute the program, the user needs only to combine the file description and parameters with the program and to process them with the appropriate data file.

Many of the criteria used in selection of a time-sharing program described above apply to selection of a batch program.

Appendix F

A Model for Relating the Risk Components of an Audit

The appendix of SAS No. 39 provides a planning model expressing the general relationship of ultimate risk to the extent of reliance the auditor places on a substantive test of details, internal accounting controls, and other substantive tests, such as analytical review procedures, directed toward the same specific audit objective. The model is not intended to be a mathematical formula including all factors that might influence the determination of individual risk components. However, some auditors find such a model useful when planning an audit.

The model is $UR = IC \times AR \times TD$.* The form of the model can be restated to assist the auditor in planning an acceptable level of risk of incorrect acceptance (TD) after the determination of the acceptable levels of (1) ultimate risk (UR), (2) the risk of undetected error due to internal accounting control failure (IC), and (3) the risk of failing to detect errors by other substantive tests directed toward the same specific audit objective (AR). The revised form of the model is $TD = UR \div (IC \times AR)$. To use this model, the auditor exercises professional judgment in specifying an acceptable ultimate risk (UR) and subjectively quantifies his judgment of the risks IC and AR.

UR is the allowable ultimate risk that any existing monetary errors greater than tolerable error might remain undetected in the account balance or class of transactions after the auditor has completed all audit

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* This model has also been expressed as follows: Audit risk is equal to the product of inherent risk, control risk, and detection risk. This approach combines the test of details risk and analytical review risk while separating inherent risk from control risk. *Inherent risk* is the auditor's assessment of the susceptibility of an account balance or class of transactions to errors exceeding tolerable error before considering the operation of related internal accounting controls; *control risk* is the auditor's assessment of the risk that error exceeding tolerable error that may occur will not be prevented or detected on a timely basis by the system of internal accounting control; *detection risk* is the auditor's assessment of the risk that his procedures will lead him to conclude that error exceeding tolerable error does not exist when in fact it does exist.

procedures deemed necessary. For the purpose of this model, the nonsampling risk aspect of ultimate risk is assumed to be negligible. This is usually a reasonable assumption in light of the typical level of supervision on an audit and the quality control policies and procedures applicable to audit practice.

IC is the auditor's assessment of the risk that, given that errors greater than tolerable error have occurred, the system of internal accounting control would fail to detect them. By evaluating the system and testing compliance with the control procedures, the auditor would assign this risk for control procedures on which he intends to rely in establishing the scope of the substantive test of details.

The quantification of internal accounting control effectiveness requires professional judgment. This same judgment is used when the auditor implicitly evaluates the effectiveness of internal accounting controls on which he plans to rely in reducing the extent of a substantive test, whether sampling is used or not. For the purpose of this model, some auditors find a guide, such as the one that follows, useful in making an explicit judgment about the effectiveness of internal accounting controls related to a specific account balance or class of transactions.

Subjective Evaluation	*Risk of Undetected Error Due to Internal Accounting Control Failure (IC)*
Substantial reliance is warranted	10%–30%
Moderate reliance is warranted	20%–70%
Limited or no reliance is warranted	60%–100%

The quantification of the effectiveness of internal accounting control for the purpose of this model should not be confused with any levels of risk of overreliance on internal accounting control that the auditor accepted for compliance testing. The acceptable level of risk was an indication of the auditor's confidence that an individual sample provided correct information about the population. However, the quantification for this model relates to the auditor's evaluation of the overall effectiveness of one or more related internal accounting controls. For example, an auditor might have accepted a 10-percent risk of overreliance on internal accounting control in performing audit sampling applications for each compliance test of three internal accounting controls related to a particular account balance. The overall evaluation of the three tests might lead the auditor to conclude that moderate reliance can be placed on internal accounting control in performing substantive tests of that account balance. The auditor might therefore subjectively decide to quantify the risk of undetected error due to internal accounting control failure as 40 percent.

AR is the auditor's assessment of the risk that analytical review procedures and other relevant auditing procedures would fail to detect errors greater than tolerable error, given that such errors have occurred and were not detected by the system of internal accounting control. For the purpose of this model, some auditors find a guide, such as the one that follows, useful in making an explicit judgment about the effectiveness of analytical review procedures and other substantive tests of details directed toward the same account balance or class of transactions.

Subjective Evaluation	*Risk of Undetected Error Due to Analytical Review Procedures Failure (AR)*
Very effective	10%–40%
Moderately effective	30%–60%
Marginally effective or ineffective	50%–100%

Illustration of the use of the model. Although this model is not intended to be used as a mathematical formula, the auditor might find it helpful when relating subjective evaluations of the factors in the model. For example, if the auditor is planning a sampling application to test an entity's accounts receivable balance, the risk of undetected error due to internal accounting control failure might be subjectively quantified as 30 percent, and the risk of undetected error due to analytical review failure, as 80 percent. The auditor might also have decided that a 5-percent level of ultimate risk is acceptable. The model might then be used to gain some understanding of what level of risk of incorrect acceptance might be appropriate for the sampling application being designed.

$$TD = UR \div (IC \times AR)$$
$$TD = .05 \div (.30 \times .80) = .21$$

The auditor using this simplified model must be cautioned that the resulting quantification of the risk of incorrect acceptance is only a general indication of an appropriate acceptable level relative to other alternative planning considerations. For example, the auditor might compare the above results with an alternative approach that would include an additional analytical review procedure and then decide that, in this case, the combination of analytical review procedures and other related substantive tests should result in a 60-percent risk of undetected error due to analytical review failure. Use of the model would suggest that the acceptable level of risk of incorrect acceptance under the alternative planning considerations would be approximately 27 percent. The auditor would then decide if the additional analytical review procedure is warranted by the resulting reduction in sample size for the planned substantive test of details.

The following table illustrates some allowable risks of incorrect acceptance (TD) for various assessments of IC and AR when UR = .05.

Allowable Risk of Incorrect Acceptance (TD) for Various Assessments of IC and AR for UR = .05

Auditor's subjective assessment of risk that internal accounting control might fail to detect aggregate errors greater than tolerable error	*Auditor's subjective assessment of risk that analytical review procedures and other relevant substantive tests might fail to detect aggregate errors greater than tolerable error*			
IC	*AR*			
	10%	*30%*	*50%*	*100%*
	TD			
10%	*	*	*	50%
30%	*	55%	33%	16%
50%	*	33%	20%	10%
100%	50%	16%	10%	5%

* The allowable level of UR of 5 percent equals or exceeds the product of IC and AR, and thus, the planned substantive test of details may not be necessary.

NOTE: Table entries for TD are computed from the illustrative model; TD = UR ÷ (IC × AR). For example, for IC = .50 and AR = .30, TD = .05 ÷ (.50 × .30) or .33 (equals 33 percent).

Appendix G

Glossary

This glossary summarizes definitions of the terms related to audit sampling used in this guide. It does not contain definitions of common audit terms or statistical terms not necessary for an understanding of the guide. Related terms are shown in parentheses.

allowance for sampling risk (precision, sampling error) A measure of the difference between a sample estimate and the corresponding population characteristic at a specified sampling risk.

alpha risk *See* risk of incorrect rejection and risk of underreliance on internal accounting control.

attribute Any characteristic that is either present or absent. In compliance testing the presence or absence of evidence of the application of a specified internal accounting control procedure is sometimes referred to as an attribute.

attributes sampling Statistical sampling that reaches a conclusion about a population in terms of a rate of occurrence.

audit risk *See* ultimate risk.

audit sampling The application of an audit procedure to less than 100 percent of the items within an account balance or class of transactions for the purpose of evaluating some characteristic of the balance or class.

beta risk *See* risk of incorrect acceptance and risk of overreliance on internal accounting control.

block sample (cluster sample) A sample consisting of contiguous transactions.

classical variables sampling A sampling approach that measures sampling risk using the variation of the underlying characteristic of interest. This approach includes methods such as mean-per-unit, ratio estimation, and difference estimation.

CMA sampling *See* probability-proportional-to-size sampling.

confidence level (reliability level) The complement of the applicable sampling risk (*see* risk of incorrect acceptance, risk of overreliance on internal accounting control, risk of incorrect rejection, risk of underreliance on internal accounting control).

control risk The auditor's assessment of the risk that error exceeding tolerable error that may occur will not be prevented or detected on a timely basis by the system of internal accounting control.

detection risk The auditor's assessment of the risk that his procedures will lead him to conclude that error exceeding tolerable error does not exist when in fact it does exist.

difference estimation A classical variables sampling technique that uses the average difference between audited amounts and individual recorded amounts to estimate the total audited amount of a population and an allowance for sampling risk.

discovery sampling A procedure for determining the sample size required to have a stipulated probability of observing at least one occurrence when the expected population occurrence rate is at a designated level.

dollar-unit sampling *See* probability-proportional-to-size sampling.

dollar-value estimation A decision model to estimate the dollar amount of the population.

expansion factor A factor used in the calculation of sample size in a probability-proportional-to-size sampling application if errors are expected.

expected population deviation rate An anticipation of the deviation rate in the entire population. It is used in determining an appropriate sample size for an attributes sample.

field *See* population.

haphazard sample A sample consisting of sampling units selected without any conscious bias, that is, without any special reason for including or omitting items from the sample. It does not consist of sampling units selected in a careless manner, and is selected in a manner that can be expected to be representative of the population.

hypothesis testing A decision model to test the reasonableness of an amount.

inherent risk The auditor's assessment of the susceptibility of an account balance or class of transactions to errors exceeding tolerable error before considering the operation of related internal accounting controls.

logical unit The balance or transaction that includes the selected dollar in a probability-proportional-to-size sample.

mean-per-unit approach A classical variables sampling technique that projects the sample average to the total population by multiplying the sample average by the total number of items in the population.

nonsampling risk All aspects of ultimate risk not due to sampling.

nonstatistical sampling A sampling technique for which the auditor considers sampling risk in evaluating an audit sample without using statistical theory to measure that risk.

population (field, universe) The items constituting the account balance or class of transactions of interest. The population excludes individually significant items that the auditor has decided to examine 100 percent or other items that will be tested separately.

precision *See* allowance for sampling risk.

probability-proportional-to-size (PPS) sampling (dollar-unit sampling, CMA sampling) A variables sampling procedure that uses attributes theory to express a conclusion in dollar amounts.

random sample A sample selected so that every combination of the same number of items in the population has an equal probability of selection.

ratio estimation A classical variables sampling technique that uses the ratio of audited amounts to recorded amounts in the sample to estimate the total dollar amount of the population and an allowance for sampling risk.

reliability level *See* confidence level.

risk of incorrect acceptance (beta risk, Type II error) The risk that the sample supports the conclusion that the recorded account balance is not materially misstated when it is materially misstated.

risk of incorrect rejection (alpha risk, Type I error) The risk that the sample supports the conclusion that the recorded account balance is materially misstated when it is not.

risk of overreliance on internal accounting control (beta risk, Type II error) The risk that the sample supports the auditor's planned degree of reliance on the control when the true compliance rate does not justify such reliance.

risk of underreliance on internal accounting control (alpha risk, Type I error) The risk that the sample does not support the auditor's planned degree of reliance on the control when the true compliance rate supports the reliance.

sample Items selected from a population to reach a conclusion about the population.

sampling error *See* allowance for sampling risk.

sampling risk The risk that the auditor's conclusion based on a sample might be different from the conclusion he would reach if the test were applied in the same way to the entire population. For compliance testing, sampling risk is the risk of overreliance on internal accounting control or the risk of underreliance on internal accounting control. For substantive testing, sampling risk is the risk of incorrect acceptance or the risk of incorrect rejection.

sampling unit Any of the individual elements, as defined by the auditor, that constitute the population.

sequential sampling (stop-or-go sampling) A sampling plan for which the sample is selected in several steps, with each step conditional on the results of the previous steps.

standard deviation A measure of the dispersion among the respective amounts of a particular characteristic as measured for all items in the population for which a sample estimate is developed.

statistical sampling Audit sampling that uses the laws of probability for selecting and evaluating a sample from a population for the purpose of reaching a conclusion about the population.

stop-or-go sampling *See* sequential sampling.

stratification Division of the population into relatively homogeneous groups.

systematic sampling A method of selecting a sample in which every *n*th item is selected.

tainting In a probability-proportional-to-size sample, the proportion of error present in a logical unit. It is usually expressed as the ratio of the amount of error in the item to the item's recorded amount.

tolerable error An estimate of the maximum monetary error that may exist in an account balance or class of transactions, when combined with error in other accounts, without causing the financial statements to be materially misstated.

tolerable rate The maximum population rate of deviations from a prescribed control procedure that the auditor will tolerate without modifying the planned reliance on internal accounting control.

Type I error *See* risk of incorrect rejection and risk of underreliance on internal accounting control.

Type II error *See* risk of incorrect acceptance and risk of overreliance on internal accounting control.

ultimate risk (audit risk) A combination of the risk that material errors will occur in the accounting process used to develop the financial statements and the risk that any material errors that occur will not be detected by the auditor.

universe *See* population.

variables sampling Statistical sampling that reaches a conclusion on the monetary amounts of a population.

Appendix H

Selected Bibliography

The following bibliography includes articles and books on audit sampling. The articles and books in this bibliography are generally available to auditors and should help them obtain background information or solve sampling problems. The listing for each article or book includes a brief description of the subject and a general designation of the area of the subject matter. The articles and books are grouped by the degree of expertise that an auditor should have to adequately understand the article or book.

Articles Requiring Basic Expertise

These articles require little or no knowledge of statistical sampling. The reader is not expected to have performed more than a few statistical sampling applications. However, the articles assume a basic knowledge of auditing procedures and standards.

AKRESH, ABRAHAM D. "Some Common Problems in Statistical Sampling Applications." *The Internal Auditor* 36 (December 1979): 45–49. Summarizes some problems encountered during the author's experiences with planning, executing, and evaluating statistical sampling applications. Useful for attribute sampling and variables sampling.

———. "Statistical Sampling in Public Accounting." *The CPA Journal* 50 (July 1980): 20–26. Summarizes an AICPA statistical sampling subcommittee survey of the use of statistical sampling in public accounting practice. Useful for attributes sampling and variables sampling.

AKRESH, ABRAHAM D., and GEORGE R. ZUBER. "Exploring Statistical Sampling." *Journal of Accountancy* 151 (February 1981): 50–56. Discusses some basic considerations for the use of statistical sampling and some sources of assistance available to the auditor.

ANDERSON, RODNEY J., and A. D. TEITLEBAUM. "Dollar Unit Sampling: A Solution to the Audit Sampling Dilemma." *C.A. Magazine* 102 (April 1973): 30–38. Discusses probability-proportional-to-size sampling and presents the arguments in favor of widespread use of the technique. Avoids technical details.

BAGGETT, WALTER. "Using Time-Sharing Facilities for Statistical Sampling." *The CPA Journal* 47 (October 1977): 85–86. An introduction to the performance of statistical computations on a time-sharing terminal. Useful for statistical sampling. An elementary summary for anyone unfamiliar with the subject.

BAKER, REVENOR C. "Determining Sample Size." *The Internal Auditor* 34 (August 1977): 36–42. Summarizes sample-size estimation formulas applicable to the most common mean-per-unit sampling situations. Includes several case studies to illustrate how the formulas are applied. Useful for classical variables sampling.

CARMICHAEL, D. R. "Tests of Transactions—Statistical and Otherwise." *Journal of Accountancy* 125 (February 1968): 36. A comprehensive discussion of the nature of audit sampling objectives and sampling techniques, including how to choose sampling techniques to best achieve audit objectives. Useful for both statistical and nonstatistical sampling.

DAVIS, MAURICE. "Using Statistical Sampling for Inventory Observation." *The CPA Journal* 67 (February 1978): 73–75. Describes a practical case in which the use of variables sampling increased audit efficiency and benefited a client by reducing downtime at the inventory observation. Useful for classical variables sampling.

ELLIOTT, ROBERT K. "Basic Concepts of Statistics and Hypothesis Testing for Auditing." In *Handbook of Modern Accounting*. New York: McGraw-Hill, 1977. Presents an approach to the use of statistical sampling in auditing that deals primarily with the concept of hypothesis testing. Useful for classical variables sampling.

ELLIOTT, ROBERT K., and JOHN R. ROGERS. "Relating Statistical Sampling to Audit Objectives." *Journal of Accountancy* 134 (July 1972): 46–55. Presents a sampling plan that specifically controls both types of risk accepted by an auditor who makes a decision based on a sample. Illustrates the implications of not controlling both types of risks. Useful for classical variables sampling.

GIBBS, THOMAS E., and CLYDE T. STAMBAUGH. "Problems in Determining Audit Sample Size." *The Internal Auditor* 34 (December 1977): 52–57. Describes several considerations which an auditor should be aware of when using population estimators to determine sample size and when choosing between statistical techniques. Useful for classical variables sampling.

GOODFELLOW, JAMES L., JAMES K. LOEBBECKE, and JOHN NETER. "Some Perspectives on CAV Sampling Plans." *C.A. Magazine* 105 (October and November 1974): part I: 22–30, part II: 46–53. Part I discusses the basic concepts of probability-proportional-to-size sampling plans; part II identifies the strengths and weaknesses of PPS plans and calls for additional research into their application. Problems of understatement and partial errors are illustrated. Useful for PPS sampling.

GUY, DAN M., WILLIAM C. DENT, and FREDERICK A. HANCOCK. "Some

Practical Guidelines for Using Attribute Sampling." *The Practical Accountant* 12 (April/May 1979): 35–40. Discusses the authors' experiences using attributes sampling. Includes an attribute sampling review checklist. Discusses nine attribute sampling areas, including block sampling, systematic sampling, random-number tables, sequential sampling, representative samples, selection of reliability levels, selection of tolerable rates, sample evaluation, and error analysis.

HALL, WILLIAM D. "Inventory Determinations by Means of Statistical Sampling Where Clients Have Perpetual Records." *Journal of Accountancy* 123 (March 1967): 65–71. Presents basic concepts in determining inventories by means of statistical sampling. Useful for classical variables sampling.

IJIRI, YUJI, and ROBERT S. KAPLAN. "The Four Objectives of Sampling in Auditing: Representative, Corrective, Protective and Preventive." *Management Accounting* 52 (December 1970): 42–44. Presents considerations in the design of statistical and nonstatistical sampling plans.

KAPLAN, ROBERT S. "Statistical Sampling Methods for Auditing and Accounting." In *Handbook of Modern Accounting.* New York: McGraw-Hill, 1977. An introduction to statistical methods in auditing and accounting, including estimation techniques and hypothesis testing. Useful for statistical sampling.

KINNEY, WILLIAM R., and WILFRED C. UECKER. "Judgmental Error in Evaluating Sample Results." *The CPA Journal* 47 (March 1977): 61–62. Research study on the effectiveness of judgmental evaluations of attributes sampling results. Demonstrates the unreliability of judgmental estimates of population error rates based on random samples. Useful for nonstatistical sampling and attributes sampling.

KLINE, WILLIAM H. "Statistical Sampling for Small Audits." *Delaware CPA* 3 (November 1976): 9–12, 35. Makes a case for the use of statistical sampling in smaller engagements. Goes through the steps required to use attributes sampling in an audit situation. Useful for attributes sampling.

MYERS, CAROL A. "Determining Nonstatistical (Judgmental) Sample Sizes." *The CPA Journal* 49 (October 1979): 72–74. Describes the factors that influence the determination of sample sizes for both compliance and substantive tests. Concludes by stating that if these factors are carefully evaluated, sample sizes determined judgmentally should be substantially the same as sample sizes obtained using statistical sampling methods. Useful for nonstatistical sampling.

NAUS, JAMES H. "Effective Uses of Statistical Sampling in the Audit of a Small Company." *The Practical Accountant* 11 (March/April 1978): 33–45. Discusses the use of attributes sampling and difference estimation sampling in a small company audit. Practical working paper techniques and sample selection criteria are included in the article. Useful for attributes sampling and classical variables sampling.

RENEAU, JAMES. "Guidelines for Selecting Sampling Procedures." *Internal Auditor* 37 (June 1980): 77–82. A brief introduction to sampling estimation methods used in auditing. Contains a flowchart to assist in selecting an appropriate estimation method; this flowchart might be helpful to auditors having some understanding of statistical concepts. Useful for statistical sampling.

ROBERTS, DONALD M. "Sample Size Determination for Attributes." *Journal of Accountancy* 139 (June 1975): 46–47. Answers an inquiry concerning determination of sample size for an attributes sample using the table in an AICPA continuing professional education individual study program, *Sampling for Attributes: Estimation and Discovery.* Useful for attributes sampling.

SAWYER, LAWRENCE B. "Simple Sampling: How to Stop Worrying and Learn to Love Statistical Tables." *The Internal Auditor* 25 (July/August 1968): 9–26. Discusses basic concepts of statistical sampling without technical terms and sets forth ten principles for the auditor. Useful for attributes sampling and classical variables sampling.

STRINGER, KENNETH W. "Statistical Sampling in Auditing: The State of the Art." *Annual Accounting Review* 1 (1979): 113–127. Describes the development and use of statistical sampling in auditing.

TAYLOR, ROBERT G. "Error Analysis in Audit Tests." *Journal of Accountancy* 137 (May 1974): 78–82. Discusses the importance of classifying errors by type and nature as part of the evaluation of sample results. The cause of the error might be more important than its quantitative evaluation. Useful for both statistical and nonstatistical sampling.

VAN MATRE, JOSEPH, and LOUDELL ELLIS. "The Ratio Estimate—Conceptual Review and a Case Illustration." *Woman CPA* 40 (April 1978): 12–15. Explains ratio estimation and provides a case study.

WARREN, CARL S. "Interpreting and Evaluating Attribute Sampling." *Internal Auditor* 32 (July/August 1975): 45–46. Gives the auditor insight into proper statistical inferences and interpretations of attributes sampling, including a discussion of the risk of overreliance and the risk of underreliance.

WARREN, CARL S., STEPHEN V. N. YATES, and GEORGE R. ZUBER. "Audit Sampling: A Practical Approach." *Journal of Accountancy* 153 (January 1982): 62–72. Presents a framework for planning, performing, and evaluating audit samples.

Articles Requiring Intermediate Expertise

These articles require a familiarity with basic statistical sampling concepts and experience in the performance of statistical sampling applications. The reader need not have received any formal education in statistics. The articles assume a basic knowledge of auditing procedures and standards.

AKRESH, ABRAHAM D., and D. R. FINLEY. "Two-Step Attributes Sampling in Auditing." *The CPA Journal* 49 (December 1979): 19–24. Explains a two-step method of statistical attributes sampling in compliance testing. The method is designed to minimize sample sizes for populations with very low expected population deviation rates.

BOATSMAN, JAMES R., and G. MICHAEL CROOCH. "An Example of Controlling the Risk of a Type II Error for Substantive Tests in Auditing." *Accounting Review* 50 (July 1975): 10–15. Discusses the risks of incorrect rejection and acceptance and demonstrates the importance of considering the risk of incorrect acceptance and properly controlling that risk. Useful for classical variables sampling.

DEMING, W. EDWARDS, and T. NELSON GRICE, JR. "An Efficient Procedure for Audit of Accounts Receivable." *Management Accounting* 51 (March 1970): 17–27. Studies the practical application of statistical theory to the audit of a trucking company's freight bills receivable. Useful for classical variables sampling.

HATHERLY, DAVID. "Segmentation and the Audit Process." *Accounting and Business Research* 9 (Spring 1979): 152–56. An article in an English journal discussing the segmentation of populations based on auditor risk assessments to increase the efficiency of probability-proportional-to-size sampling.

LOEBBECKE, JAMES K., and JOHN NETER. "Statistical Sampling in Confirming Receivables." *Journal of Accountancy* 135 (June 1973): 44–50. Presents an approach to evaluating statistical samples using both positive and negative confirmation requests. Discusses the role of alternative procedures. Useful for classical variables sampling.

———. "Considerations in Choosing Statistical Sampling Procedures in Auditing." *Journal of Accounting Research* 13 (1975 supplement): 38–52. Discusses considerations in the auditor's choice of statistical estimators in the auditing process. Useful for classical variables sampling.

Articles Requiring Advanced Expertise

These articles require extensive experience with statistical sampling applications. The reader should also have extensive knowledge of statistics and other quantitative techniques. The articles assume a basic knowledge of auditing procedures and standards.

BAKER, R. L., and R. M. COPELAND. "Evaluation of the Stratified Regression Estimator for Auditing Accounting Populations." *Journal of Accounting Research* 17 (Autumn 1979): 606–17. Investigates some statistical properties of the regression estimator by using simulation and comparison with previously examined estimators. Finds the performance of the regression estimator to be similar to that of the difference and ratio estimators. Useful for classical variables sampling.

GARSTKA, STANLEY J. "Models for Computing Upper Error Limits in Dollar-Unit Sampling." *Journal of Accounting Research* 15 (Autumn 1977): 179–92. Suggests seven alternative methods of computing upper error limits. Uses the compound Poisson process to model the error rate and the distribution of error sizes. The seven methods are tested by simulation, with a challenge to test them in real auditing situations. Useful for probability-proportional-to-size sampling.

GARSTKA, STANLEY J., and P. A. OHLSON. "Ratio Estimation in Accounting Populations With Probabilities of Sample Selection Proportional to Size of Book Values." *Journal of Accounting Research* 17 (Spring 1979): 23–59. Presents an improvement on conventional variable estimation for dollar-unit sampling that replaces the t-statistic of Student's distribution with a new statistic, C, based on the binomial distribution. Strengths and weaknesses of the new procedure are presented and discussed. Useful for classical variables sampling and PPS sampling.

KAPLAN, ROBERT S. "Sample Size Computations for Dollar-Unit Sampling." *Journal of Accounting Research: Studies on Statistical Methodology in Auditing* 13 (1975 supplement): 126–33. Presents a procedure to compute sample sizes in probability-proportional-to-size sampling applications that will control the risks of incorrect acceptance and incorrect rejection.

———. "Statistical Sampling in Auditing With Auxiliary Information Estimators." *Journal of Accounting Research* 2 (March 1973): 238–58. Describes problems in variables sampling because of a general low error rate in accounting populations. Discusses the advantages and usefulness of various estimators for use in variable estimation techniques. Useful for classical variables sampling.

NETER, JOHN, ROBERT A. LEITCH, and STEPHEN E. FEINBERG. "Dollar Unit Sampling: Multinomial Bounds for Total Overstatement and Understatement Errors." *Accounting Review* 53 (January 1978): 77–93. Presents an evaluation approach to probability-proportional-to-size sampling based on the multinomial distribution. The author claims "the auditor is assured of the specified confidence level. . . ." The approach hinges on the definition of the *underevaluation set* (*S-set*). Useful for PPS sampling.

TEITLEBAUM, A. D., and C. F. ROBINSON. "The Real Risks in Audit Sampling." *Journal of Accounting Research* 13 (1975 supplement): 70–97. Discusses rules in audit sampling, developing situations in which actual sampling risks might be larger than nominal sampling risks. Offers probability-proportional-to-size sampling as a technique to overcome this potential problem. Useful for PPS sampling and classical variables sampling.

Books Requiring Basic Expertise

These books require little or no knowledge of statistical sampling. The reader is not expected to have performed more than a few statistical

sampling applications. However, the books assume a basic knowledge of auditing procedures and standards.

ANDERSON, RODNEY J., DONALD A. LESLIE, and ALBERT D. TEITLEBAUM. *Dollar Unit Sampling.* Chicago: Commerce Clearing House, 1979. Discusses general audit theory, probability-proportional-to-size sampling, and nonstatistical sampling.

ARENS, ALVIN, and JAMES K. LOEBBECKE. *Applications of Statistical Sampling to Auditing.* Englewood Cliffs, N.J.: Prentice-Hall, 1981. A basic introduction to the use of statistical sampling methods.

ARKIN, HERBERT. *Handbook of Sampling for Auditing and Accounting.* New York: McGraw-Hill, 1974. A reference text for the auditor or accountant who wishes to use statistics. Contains numerous tables, an explanation of statistical formulas, and many statistical sampling plans and methods. Useful for attribute sampling and classical variables sampling.

BAILEY, ANDREW. *Statistical Auditing: Review, Concepts, and Problems.* New York: Harcourt Brace Jovanovich, 1981. Gives an overview of stratified sampling; regression-based auxiliary estimators, including difference and ratio estimators; probability-proportional-to-size sampling; and attributes sampling concepts.

CYERT, RICHARD M., and H. JUSTON DAVIDSON. *Statistical Sampling for Accounting Information.* Englewood Cliffs, N.J.: Prentice-Hall, 1962. A general reference and learning text for statistical sampling methods commonly used in accounting and auditing. Problems and solutions are included. Useful for attributes sampling and classical variables sampling.

GUY, DAN M. *An Introduction to Statistical Sampling in Auditing.* New York: John Wiley & Sons, 1981. A basic introduction to the comprehensive use of contemporary statistical sampling.

Books Requiring Intermediate Expertise

These books require a familiarity with basic statistical sampling concepts and experience in the performance of statistical sampling applications. The reader need not have received any formal education in statistics. The books assume a basic knowledge of auditing procedures and standards.

ARKIN, HERBERT. *Sampling Methods for the Auditor: An Advanced Treatment.* New York: McGraw-Hill, 1982. Describes a statistician's approach to some practical audit sampling problems. Provides detailed tables and guidance on two-step sequential sampling, an overview of probability-proportional-to-size sampling, and some techniques to measure sampling risk for samples taken from nonnormal populations.

NEWMAN, MAURICE. *Accounting Estimates by Computer Sampling.* 2d ed. New York: John Wiley & Sons, 1982. Explains the nature and limits of estimation sampling and demonstrates estimates of varying degrees of sophistication in an application-oriented framework. A detailed case study explores the use of a stratified regression estimate to evaluate physical inventory. Useful for classical variables sampling. The appendix provides program modules for various aspects of estimation sampling.

ROBERTS, DONALD H. *Statistical Auditing*. New York: AICPA, 1978. A reference textbook discussing statistical sampling in auditing.

Books Requiring Advanced Expertise

These books require extensive experience with statistical sampling applications. The reader should also have extensive knowledge of statistics and other quantitative techniques. The books assume a basic knowledge of auditing procedures and standards.

COCHRAN, WILLIAM. *Sampling Techniques*. 3d ed. New York: John Wiley & Sons, 1977. A standard reference on statistical theory and formulas used in auditing. Useful for attributes sampling and classical variables sampling.

NETER, JOHN, and JAMES K. LOEBBECKE. *Behavior of Major Statistical Estimators in Sampling Accounting Applications*. New York: AICPA, 1975. Presents an empirical investigation of a variety of important, complex problems in the use of major statistical estimators in accounting populations. Useful for classical variables sampling and probability-proportional-to-size sampling.

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