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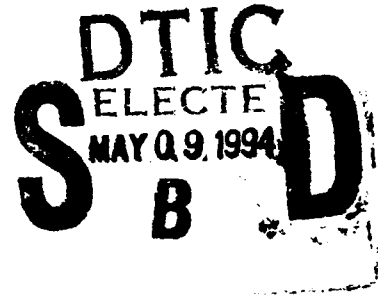
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LOT ACCEPTANCE VIA ATTRIBUTES  
SAMPLING (LAVAS) USER'S GUIDE

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System Engineering and Production Directorate  
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March 1994




**U.S. ARMY MISSILE COMMAND**  
Redstone Arsenal, Alabama 35898-5000

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<p>This user's guide describes an automation which will assist the user in the design and risk assessment of attributes sampling plans used in lot acceptance or for quality surveillance. This automation, entitled Lot Acceptance Via Attributes Sampling (LAVAS), provides for the construction of Operating Characteristic (OC) Curves and Average Sample Number (ASN) plots for single sampling, double sampling, multiple sampling, sequential sampling, and truncated sequential sampling plans. The OC Curves and ASN plots make exclusive use of the Binomial or Hypergeometric distributions for probability calculations, depending upon the conditions of application. This probabilistic approach will increase the precision of the probability of acceptance and the expected sample size to a decision since no approximation techniques, such as the Poisson and/or Normal, are used. Additionally, LAVAS provides specific design options which will expedite the design of sampling plans which are subject to risk constraints at specified quality levels.</p>			
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## **I. LOT ACCEPTANCE VIA ATTRIBUTE SAMPLING (LAVAS)**

### **A. Acceptance Sampling Scope**

A substantial portion of quality assurance deals with acceptance sampling. One facet of this ongoing effort deals specifically with attribute sampling in which a sampled unit is judged to be conforming or nonconforming, good or bad, successful or unsuccessful, hit or miss, reliable or failed, and so on. A unit's performance is classified in one of two ways. The purpose of acceptance sampling attributes is to perform a hypothesis test which will lead to a decision to accept or reject an inference concerning the ratio of the number of units possessing one attribute classification to the total number of units comprising the population. In the case of missiles and/or rockets, acceptance sampling is performed as a milestone which precedes the initial acceptance of a lot and as a means of monitoring stockpile reliability after the lot becomes government property.

It is pertinent to emphasize that acceptance sampling is not an attempt to estimate or control lot quality. Moreover, it is but one part of the decision process which ultimately leads to the acceptance or rejection of defined inferences pertaining to lot quality. The act of accepting or rejecting is subject to the possibility of being the wrong act. That is, one might accept when the correct decision should be to reject, or one might reject when the correct decision should be to accept. A comprehensive analysis of any sampling plan should include a complete assessment of the probability of making the wrong decision. Additionally, the comprehensive analysis should also assess the sampling burden imposed by the sampling plan. The classical approach to these two assessments involve the construction of two schematics, the Operating Characteristic (OC) curve and the Average Sample Number (ASN) plot. The OC curve provides a graphical representation of the relationship between the sampling plan's probability of acceptance and the appropriate quality characteristic. The ASN plot serves the purpose of graphically illustrating the relationship between the expected number of samples to a decision, to accept or reject, and the appropriate quality characteristic. These two schematics will be discussed in greater detail subsequently.

### **B. Types of Attribute Acceptance Sampling Plans**

The simplest type of acceptance sampling plan is the single sampling plan. The mechanics are straightforward in that a random sample of size  $n$  is drawn from a lot or process. If the total number of defectives is less than or equal to the acceptance number ( $c_1$ ) the lot is accepted (i. e., the hypothesis that quality is at an acceptable level cannot be rejected). Single sampling plans are the simplest, conceptually, but they require a relatively large sample size when compared to other types of plans.

To reduce the expected sampling burden subject to constraints on the risks, double sampling plans are sometimes used. A double sampling plan is specified by five numbers,  $c_1$ ,  $c_2$ ,  $c_3$ ,  $n_1$ , and  $n_2$ . The mechanics of the plan involve drawing a random sample of  $n_1$  units. If  $c_1$  or less defectives are found in the sample, the lot is accepted without further sampling. If the sample contains  $c_2$  or more defectives, the lot is rejected with no further sampling done on the lot. If the total number of defectives is greater than  $c_1$  but less than  $c_2$ , a second random sample of size  $n_2$  is drawn from the lot. If the cumulative number of defectives, from both samples, is less than or equal to  $c_3$ , the lot is accepted. Otherwise, the lot is rejected. The economies realized in total samples required to a decision by instigating double sampling in lieu of single sampling are somewhat offset by the complexity associated with implementation. However, in the case of high unit cost, destructive testing, and relatively small lot sizes, the complexity involved with the implementation will yield significant dividends.



The minimum expected number of samples to a decision is obtained by the use of a sequential sampling plan, such as Wald's item-by-item sequential sampling plan. A detailed discussion of Wald's plan can be found in Reference 1. Let it suffice to say that a lot can be accepted or rejected after the sampling of a single unit. Some restrictions apply pertaining to the minimum sample size for both the acceptance and rejection ranges. There are several distinct disadvantages to Wald's plan which in many cases prevent it from being applied. Specifically, the administration burden of the plan is extremely high, the number of units sampled to a decision is variable for lots of equal quality, and the possibility exists that an entire lot can be sampled without a decision to accept or reject. Sequential sampling plans are often truncated to limit the maximum sample size and preclude the possibility of sampling the entire lot. When this is done, the resulting plan is no longer a theoretical sequential plan. It becomes a multiple sampling plan.

Multiple sampling plans specify drawing a random sample whose size is a design specification of the plan. If the total number of defectives observed in the sample is less than or equal to the first sampling tier's acceptance number, the lot is accepted. If the total number of defectives is greater than or equal to the first tier's rejection number, the lot is rejected. In either case, the decision is made and sampling ceases. If the number of defectives is greater than the acceptance number and less than the rejection number, another sample is drawn. It is not often the case nor is it necessary for the sample sizes to be equal. Each sampling tier's sample size, acceptance number, and rejection number are design parameters of the plan. After this subsequent sample is drawn and the cumulative number of defectives tabulated, the composite number of defectives is compared to the new tier's acceptance number and rejection number. If the cumulative number of defectives lies between the acceptance and rejection numbers, another sample is drawn and the procedure is repeated.

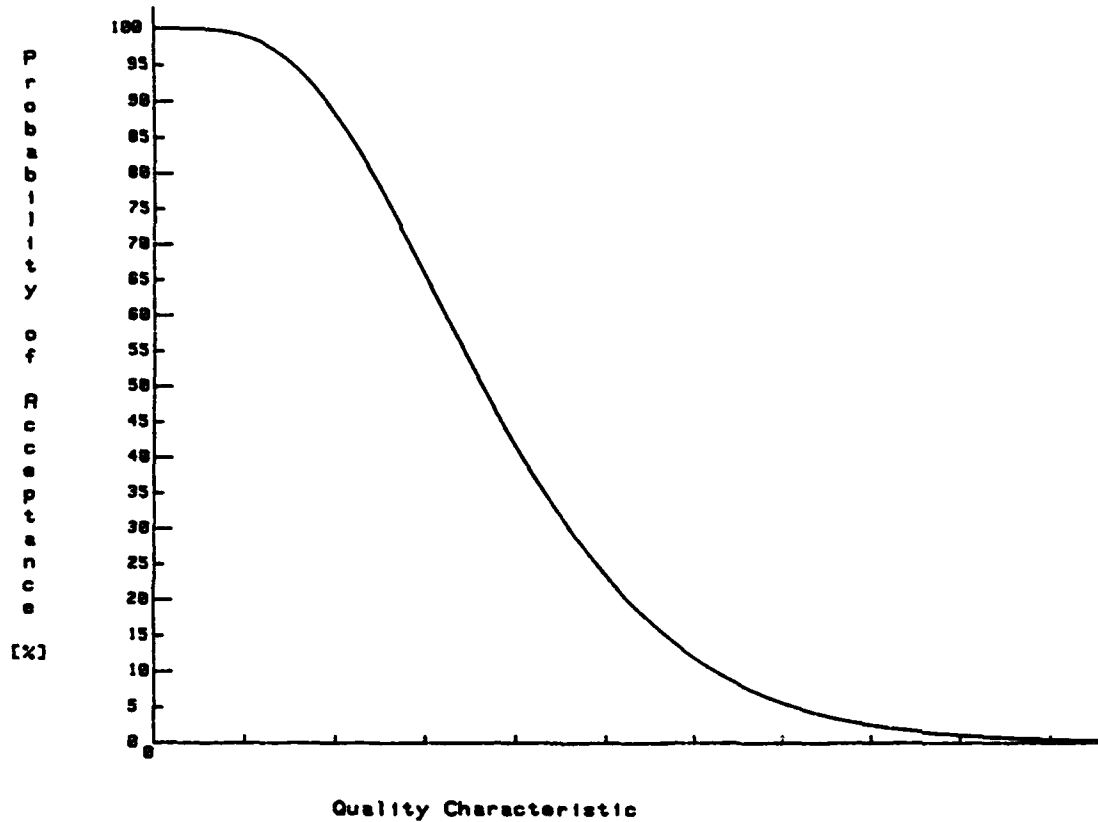
This repetitive procedure continues until the lot is accepted or rejected. A decision is guaranteed with a multiple sampling plan since the plan converges on the last sample. Convergence occurs when the acceptance number plus one equals the rejection number. In other words, there are no continuation numbers at the convergence sampling tier. Even though multiple sampling plans possess expected sample sizes to a decision which are numerically greater than those obtainable through sequential sampling, multiple sampling plans are more commonly used. This is probably due to the convergence feature and the somewhat reduced implementation burden.

### **C. Sampling Plan Evaluation**

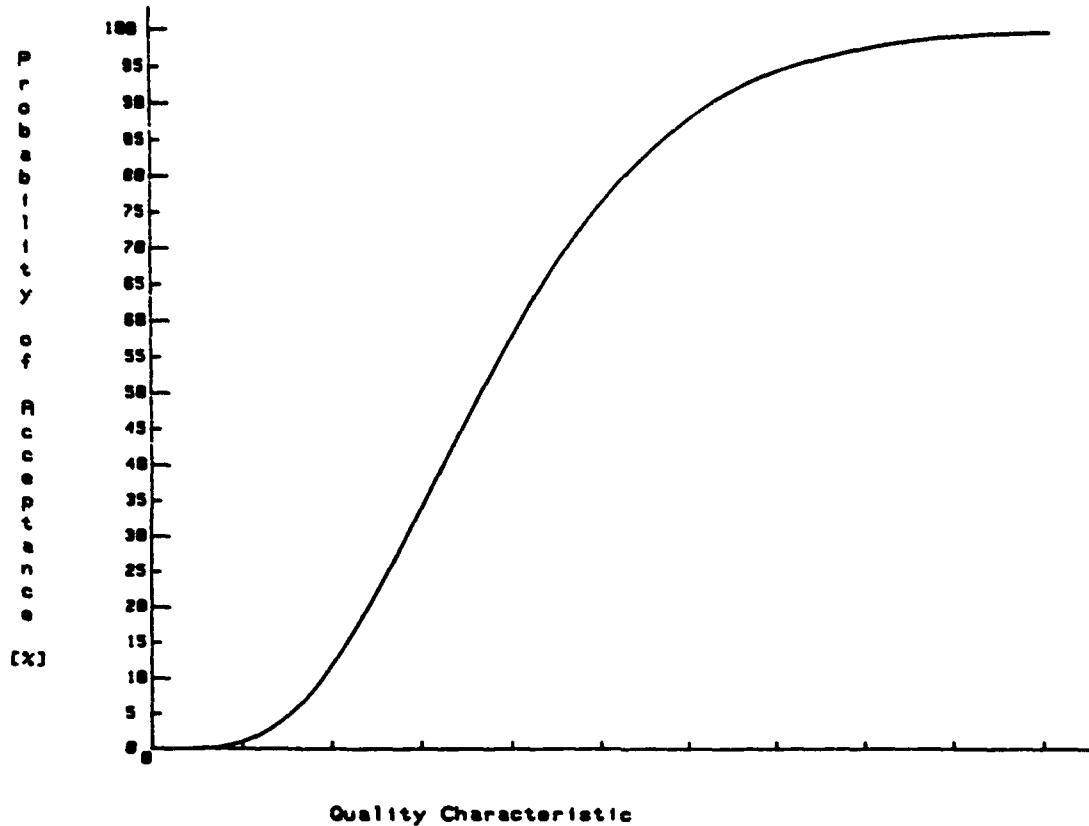
The evaluation of a sampling plan generally consists of two parts, an evaluation of the plan's effectiveness stated in terms of probability of acceptance versus the chosen quality characteristic and an evaluation of the plan's operating cost stated in terms of the expected number of units sampled to a decision versus the chosen quality characteristic. Both evaluations require consideration of the probabilistic aspects of the sampling implementation.

The probability of acceptance of a given sampling plan is a function of the plan itself and a function of the quality of the population of units from which the samples are drawn. The designer can exercise control over the specifics of the sampling plan, such as the numeric values of sample size and acceptance numbers, but no control is extended to the quality of the population. Therefore, the probability of acceptance must be examined over the entire range of values the quality characteristic can take on. This exercise is customarily accomplished by the use of a two-dimensional schematic called an operating characteristic curve, or simply OC curve. Figures 1 and 2 provide examples of OC curves commonly utilized. Figure 1 illustrates the case where the lower the numeric value of the quality characteristic, the better. Therefore, the

probability of acceptance is high for low values of the quality characteristic and is low for high values. The OC curve form shown in Figure 1 is the most frequently encountered and is appropriate when the quality characteristic is fraction defective or number of defectives per lot. Figure 2 provides an illustration of the case where the higher the numeric value of the quality characteristic, the better. This type of OC curve is frequently used when the quality characteristic is unit reliability or hit probability. Regardless of the numeric desirability of the quality characteristic, the OC curve provides a plot of the sampling plan's probability of acceptance versus the entire range over which the quality characteristic can take on values.



*Figure 1. OC Curve for a 'Lower is Better' Quality Characteristic*



*Figure 2. OC Curve for a 'Higher is Better' Quality Characteristic*

In a similar fashion, the expected number of units sampled to a decision is plotted versus the full range of the quality characteristic. This type of plot is called an ASN plot. Care must be exercised in dealing with ASN plots since there are two types, those in which sampling is terminated, or curtailed, and those in which sampling is not terminated. In the case of sample termination fewer units are sampled because sampling stops as soon as an appropriate rejection number is reached. Other economies are incurred via sample termination which further reduce the expected number sampled to a decision. Consider a single sampling plan in which the sample size is 50 with an acceptance number of 2. If 48 units are inspected and none are defective, the lot would be accepted without sampling the remaining 2 units.

Figure 3 illustrates ASN plots which illustrate the contrast of instigating sample termination in this single sampling case as opposed to not instigating it. The plot shown in Figure 3 is based on a Binomial probability evaluation of the single sampling example.

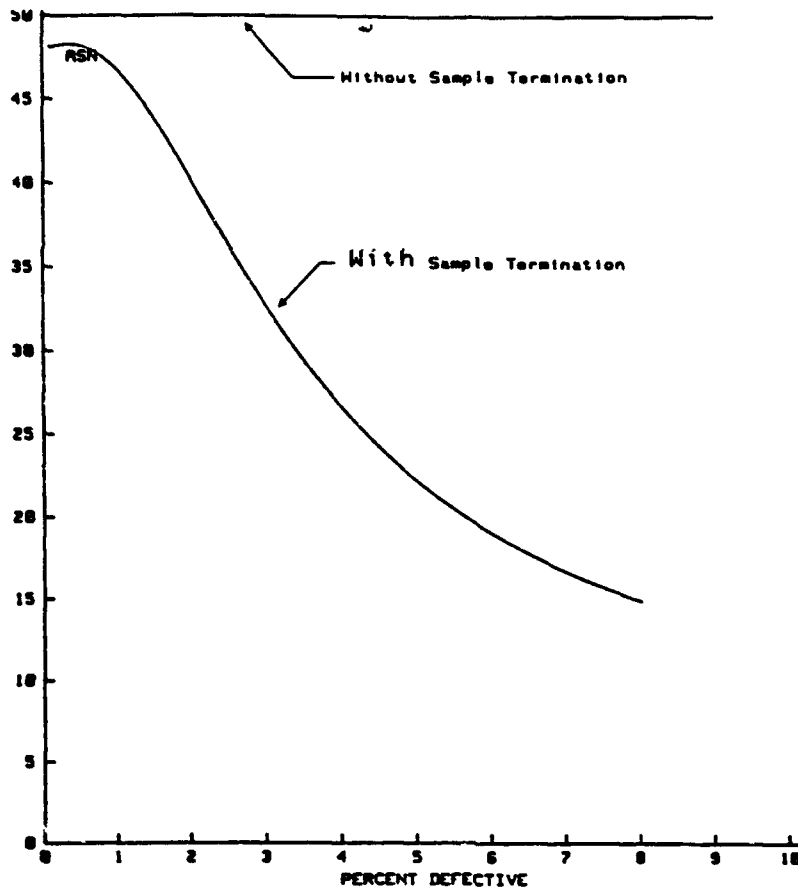


Figure 3. ASN Plot for  $n=50$ ,  $c=2$  with and without Sample Termination

#### D. Binomial Versus Hypergeometric Applications

In lot acceptance sampling of attribute variables, event probabilities should be calculated by either the Binomial distribution or the Hypergeometric distribution. Historically, approximation techniques involving the Poisson distribution and the Normal distribution have been used to alleviate much of the calculation burden associated with the Binomial and the Hypergeometric. With the proliferation of personal computers and their expanding computational capabilities, it is no longer necessary to resort to these approximation techniques and incur the resulting error. This increase in precision can be extremely important in applications involving the destructive testing of high dollar units such as missiles or rockets.

This increased precision is the rationale upon which the software described herein is based. All sampling plan assessments performed by this software are based strictly on one of two scenarios:

- (1) Scenario #1 – A lot is submitted for sampling which possesses a finite size,  $N$ , and a finite number of defectives,  $M$ . When  $n$  units are sampled at random, the probability that exactly  $X$  defectives will be found in the sample is given by the Hypergeometric distribution as,

$$p(X, n, M, N) = \frac{(N - M)! M! n! (N - n)!}{(n - X)! (N - M - n + X)! X! (M - X)! N!} \quad (1)$$

Reference 1 states that this type of analysis leads to a Type A OC curve. To avoid confusion between Type A and Type B OC curves, all Type A curves provided by this source code will possess an X axis which is labeled defectives per lot. All Type B curves' X axis will be labeled percent defective.

- (2) Scenario #2 – If the units of production come from a process which is in 'statistical control', producing products which possess a probability of being defective equal to p, and one desires the proportion of lots of size N that will be accepted, then the Binomial distribution should be used to calculate the probability. Specifically, when n units are randomly selected, the probability that exactly X will be defective is given by the expression,

$$p(X, n, M, N) = \frac{n!}{X! (n - X)!} p^X (1 - p)^{n - X} \quad (2)$$

All probability evaluations provided by this software are based on either Equation (1) or Equation (2). The appropriate selection is a user option which can be exercised via embedded response prompts.

#### E. Summary

Section II provides a series of examples that, taken as a whole, constitute an exhaustive illustration of the software's applicability, input requirements, and output descriptions. The examples begin with single sampling plan design and assessment and progressively step through double sampling, multiple sampling, sequential sampling, and sequential plan truncation. In each case, the output will consist of an OC curve and an ASN plot which are free from approximation. Therefore, no spikes or points of discontinuity will be present in the schematics as is often the case when one switches approximation techniques. Section III provides a brief conclusion and extension discussion of the program's current status and envisioned enhancements. An attempt is made throughout this guide to provide a generic description of this software to divorce the use from a particular type of computer.

The appendixes contain the existing source code for the entire program. As currently programmed, the code is written in Hewlett-Packard Enhanced BASIC which is acceptable on an HP9<sup>45</sup>B desktop computer. Upon reviewing the code contained in the appendixes, the reader will quickly see the similarity between the Enhanced BASIC code and classical FORTRAN (i.e., IMAGE statements are FORMAT statements, FOR/NEXT loops are DO loops, and variable names are structured alike except that in Enhanced BASIC only the first letter of the variable name is capitalized). In short, minimal effort will be required to reprogram the source code to FORTRAN or BASIC for compatibility with various host computers. The graphical segments of the source code provided may be more challenging to convert, but the simplistic design of the logic flow is readily transferable to modern graphic packages.

## II. SOFTWARE ILLUSTRATIONS

### A. Lot Acceptance Via Attribute Sampling (LAVAS)

The main program, entitled Lot Acceptance Via Attribute Sampling (LAVAS), serves to dimension the program variables, to input the standard values, to display the main menu containing the primary analysis options, and to load and execute the selected option. The source code comprising LAVAS is provided as Appendix A to this report. Figure 4 provides an illustration of the main menu which contains the five analyses options. This menu is displayed at the outset of program execution and immediately precedes the first user prompt for interactive input. The remainder of this section is devoted to describing, by example, each of the five options itemized in Figure 4.

LOT ACCEPTANCE SAMPLING OPTIONS	
<u>Option Description</u>	<u>Select Code</u>
> Single Sampling Design And Assessment .....	1
> Double Sampling Design And Assessment .....	2
> Multiple Sampling Design And Assessment .....	3
> Sequential Sampling Design And Assessment .....	4
> Truncated Sequential Sampling or Any Convergent Plan Assessment (i.e., OC Curve & ASN Curve) .....	5
> Program Termination .....	6

ENTER THE SELECT CODE OF THE DESIRED OPTION.

*Figure 4. Main Menu*

### B. Single Sample Design and Assessments

This segment of the software deals exclusively with single sampling by attributes and allows for five design and/or assessment options as shown in Figure 5. The first option, entitled 'OC Curve/Risk Assessment for a Specific Plan', is the fundamental risk assessment for single sampling plans. These single sampling plan are completely described by a sample size and an acceptance number. The rejection number is assumed to be equal to the acceptance number plus one, in all cases. By entering a 1 after the prompt shown in Figure 5, the user will access an option that will provide an operating characteristic curve for any specified single sampling plan. A series of user prompts will be display at that time which are designed to accrue the input required for the assessment.

> Single Sampling Plan Option Menu <

<u>Option Description</u>	<u>Select Code</u>
>OC Curve/Risk Assessment for a Specific Plan .....	1
>Plan Derivation for Given AQL, LTPD, ALPHA and BETA .....	2
>Plan Derivation for a Single Point of Control at the Indifference Quality (Poisson Based) .....	3
>Plan Derivation Using J.M. Cameron's Poisson Approximation of the OC Curve .....	4
>Plan Derivation Via MIL-STD-105D Search for Specified AQL, LTPD, ALPHA, and BETA .....	5
EXIT This Segment of the Program .....	6

ENTER THE SELECT CODE OF THE DESIRED OPTION.

*Figure 5. Single Sampling Menu*

1. OC Curve/Risk Assessment for a Specific Plan

Two types of assessments are available, one based on a Binomial distribution evaluation of probabilities and one based on a Hypergeometric evaluation of probabilities. Dr. Acheson J. Duncan provides a detailed discussion of the assumptions and conditions pertaining to the applicability of each assessment type [1]. Therefore, a discussion of this topic will not be reiterated. Moreover, let it suffice to say that if a finite lot size is under investigation, the Hypergeometric should be used. Otherwise, the Binomial is appropriate.

The assessment, in this single sampling case, is primarily the OC curve. The ASN plot is a horizontal line, if sampling termination is not imposed, hence a plot option was not included. However, an average sample number plot, with sampling termination, is obtainable for sample sizes of 50 or less by exercising Option 5 of the main menu. This will be illustrated for the Binomial case, and it is also available for the Hypergeometric case. Sample termination alters the average sample plot and the OC curve from that derived for the single sampling application because sampling termination transforms the single sampling plan into a multiple sampling plan.

a. Binomial Evaluation of Single Sampling

The two assessment types, discussed above, are applied at the user's discretion and are readily chosen by the prompt responses. Specifically, immediately following the entry of a 1 for the prompt shown in Figure 5 the user will be prompted for sample size. Then a prompt will signal entry of the acceptance number. These two entries are required for either assessment type. After the acceptance number is entered, the software will display the prompt, 'DO YOU HAVE A FINITE LOT SIZE?'. If the appropriate response is 'YES', then a Hypergeometric assessment will be performed which will be valid only for the finite lot size. If the appropriate response is 'NO', then a Binomial assessment will be performed. To illustrate the output, a sample size of 50 and an acceptance number of 1 was used to respond to the identified prompts. The response to the finite lot size prompt was 'NO'.

The curve shown in Figure 6 was obtained after entering a specification of the desired range on the percent defective axis and a desired labeling interval. These entries were prompted. Table 1 contains specific points from the OC curve. The printing of such a table is a user option. Any number of points of interest can be included in such a table. The 13 points shown are provided purely for illustration purposes.

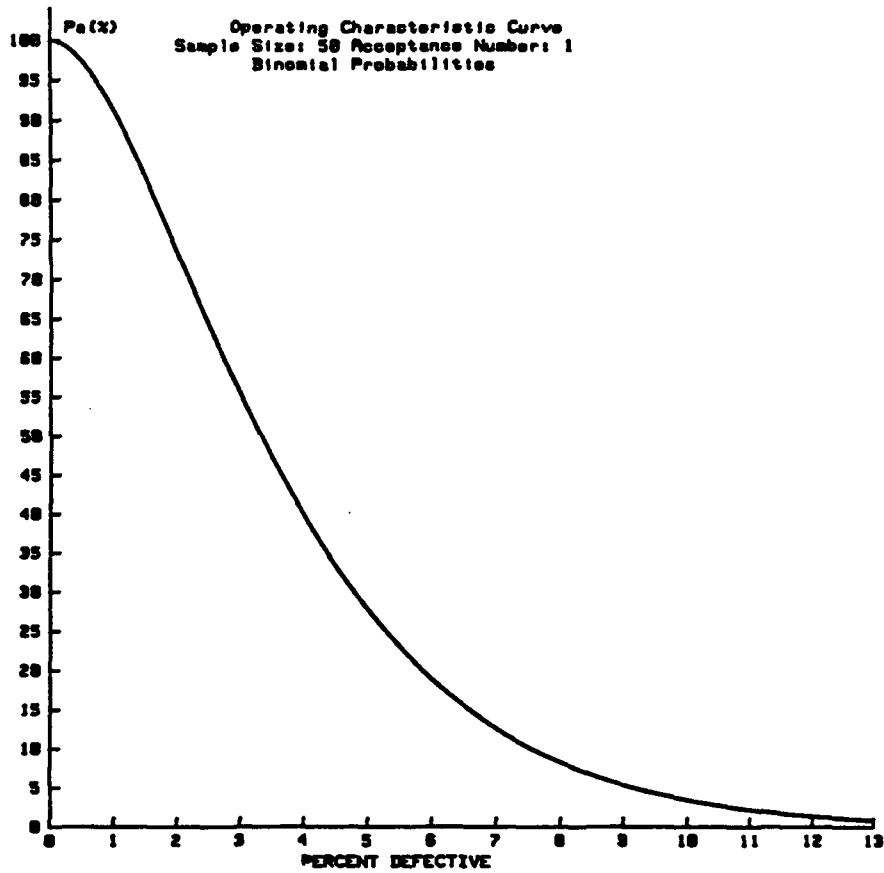


Figure 6. Binomial OC Curve for  $n=50, c=1$



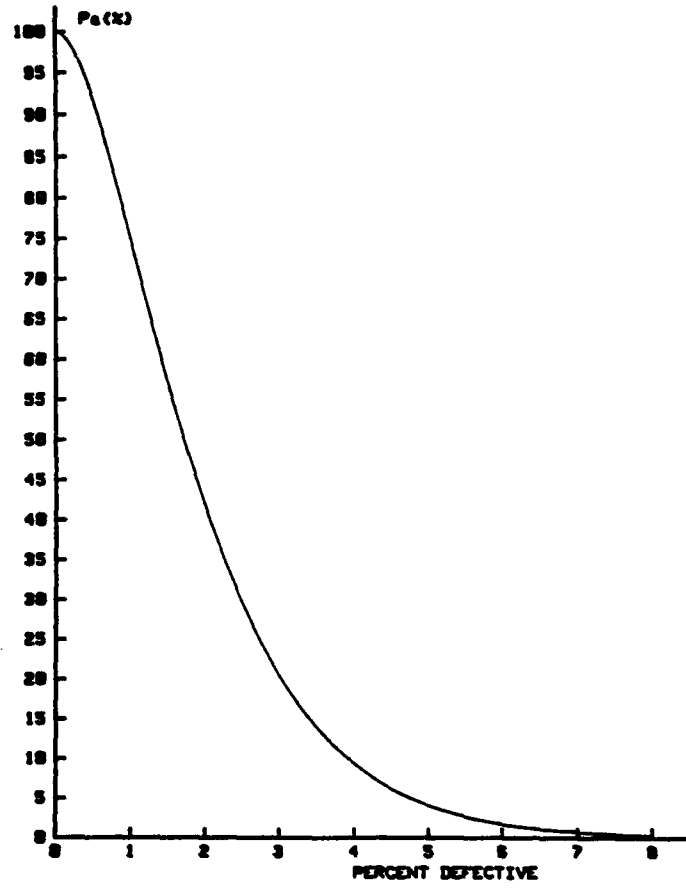
**Table 1. Tabular OC Curve Points for n=50, c=1**

Operating Characteristic (OC) Curve Single Sampling Plan: n = Sample and c = 1 (Binomial Distribution Probabilities)	
Percent Defective	Probability of Acceptance
.5000	97.3868
1.0000	91.0565
2.0000	73.5771
3.0000	55.5280
4.0000	40.0481
5.0000	27.9432
6.0000	19.0003
7.0000	12.6493
8.0000	8.2712
9.0000	5.3238
10.0000	3.3786
12.0000	1.3099
15.0000	.2905

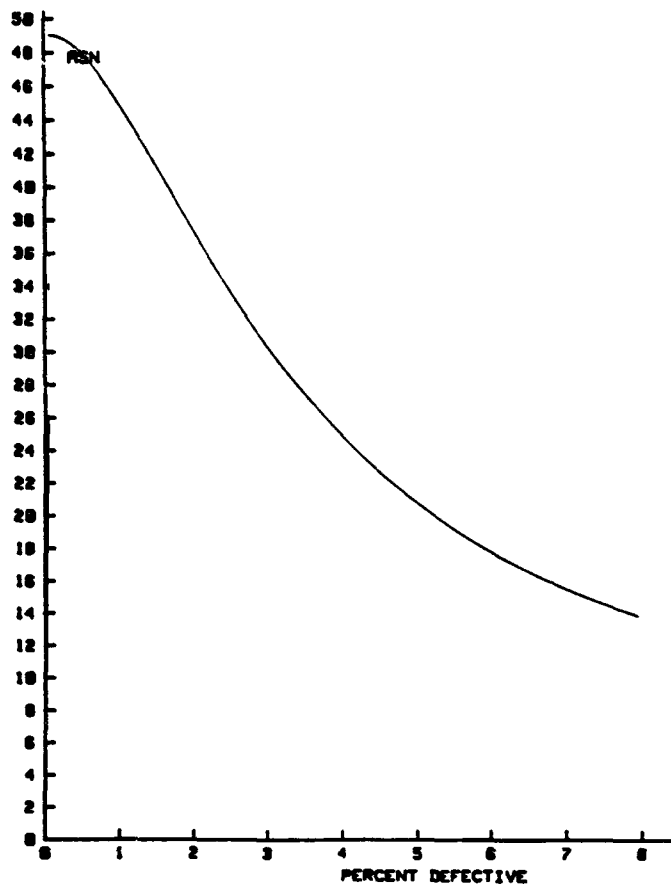
Before proceeding to the Hypergeometric assessment, it is pertinent to point out that sampling termination impacts both the OC curve and the ASN plot for single sampling. To illustrate this, suppose in the previous example that sampling terminates if two defectives have accrued at any point in the sampling of 50. Further, if zero defectives have occurred after the 49th unit, the 50th unit is not sampled. Under this scenario, the single sampling plan becomes the multiple sampling plan tabularized in Table 2. By exercising Option 5 of LAVAS's menu, the output shown as Figures 7 and 8 can be obtained. A detailed discussion of the use and operation of Option 5 will be provided in a following section. This discussion of sample termination is presented here to emphasize that if the assumptions and conditions imposed by single sampling are modified in anyway, the resulting risks and expected sample size are also altered and require evaluation.

Table 2. Single Sampling with Termination

Total Number of Units Sampled	Cumulative Acceptance Number (A)	Cumulative Continuance Numbers (c)											Cumulative Rejection Number (R)	
2	...	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
3	...	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
4	...	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
5	...	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
6	...	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
7	...	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
8	...	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
9	...	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
10	...	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
11	...	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
12	...	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
13	...	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
14	...	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
15	...	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
16	...	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
17	...	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
18	...	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
19	...	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
20	...	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
21	...	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
22	...	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
23	...	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
24	...	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
25	...	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
26	...	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
27	...	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
28	...	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
29	...	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
30	...	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
31	...	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
32	...	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
33	...	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
34	...	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
35	...	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
36	...	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
37	...	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
38	...	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
39	...	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
40	...	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
41	...	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
42	...	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
43	...	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
44	...	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
45	...	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
46	...	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
47	...	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
48	...	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
49	0	x	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
50	1	x	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2



*Figure 7. Sampling Termination OC Curve*



*Figure 8. Sampling Termination ASN Plot*

Upon comparing Figure 6 and Figure 7, it should be noted that the probability of acceptance differs for specific values of percent defective and that the shape of the curve differs for percent defective values less than or equal to 4 percent. Finally, the ASN plot, Figure 8, will continue the exhibited decay until it reaches a percent defective of 100 percent. At a percent defective of 100 percent, the plot stops at an ASN of two.

**b. Hypergeometric Evaluation of Single Sampling**

If the response to the prompt concerning a finite lot size is 'YES', sampling from a finite population containing  $M$  units of one classification and  $N-M$  units of another classification is assumed, where  $N$  represents the lot's size. The conditions are such that the Hypergeometric distribution is the appropriate vehicle for calculating probabilities of specific events. Heretofore, without the aid of computing equipment, analysts have resorted to approximation techniques, such as the Poisson and/or Normal, to avoid the calculation burden of the Hypergeometric. While expedient and labor saving for the analyst, the results are that approximations of risk and expected sample size have been applied to multi-million dollar tests. The cost of error resulting from approximations need not be incurred, henceforth.

To illustrate the output features, a sample size of 50, an acceptance number of 1, and a finite lot size of 144 were entered as responses to the sequential prompts. Paralleling the Binomial output, Figure 9 provides the operating characteristic curve and Table 3 provides the optional output of number of defectives per lot versus the probability of acceptance. Since the number of defectives per lot is a finite, integer, random variable, percent defective is also a finite random variable (i.e., number of defectives per lot times 100 divided by lot size). The instigation of sampling termination will alter the OC curve and the ASN plot in this application as it did in the Binomial evaluation discussed in the previous section. Option 5 of the main program's menu (Fig. 4) can be used to evaluate this scenario, as required for either the Binomial or the Hypergeometric case.

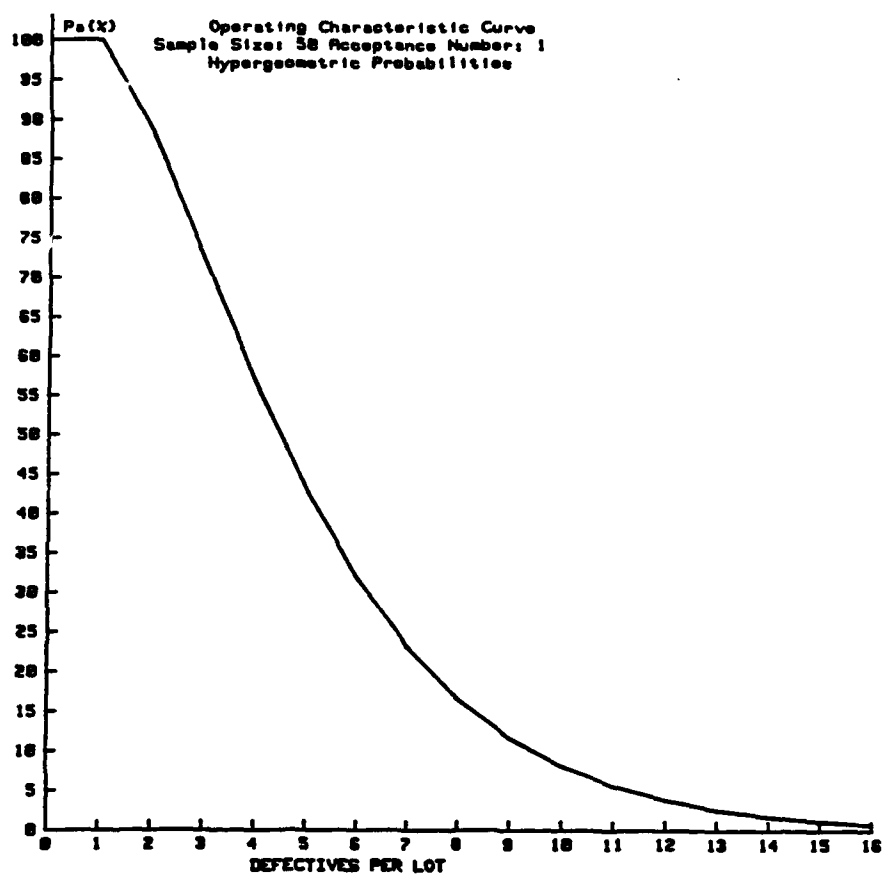


Figure 9. Hypergeometric OC Curve for  $n=50$ ,  $c=1$ , and Lot Size=144

Table 3. Tabular OC Curve Points for  $n=50$ ,  $c=1$ , and Lot Size=144

Operating Characteristic (OC) Curve Single Sampling Plan: $n=50$ and $c=1$ (Hypergeometric Distribution Probabilities)	
Defectives per Lot	Probability of Acceptance
0	100.0000
1	100.0000
2	88.1022
3	72.3501
4	56.7657
5	43.1107
6	31.9362
7	23.1910
8	16.5629
9	11.6614
10	8.1079
11	5.5738
12	3.7924
13	2.5557
14	1.7068
15	1.1302
20	.1279
24	.0196
30	.0009
35	.0001
36	.0000

2. Plan Derivation for Given AQL, LTPD, ALPHA, and BETA

This design option assists in the derivation of single sampling plans which pass, or nearly pass, through two points on the OC curve. The two points are (AQL,  $1-\text{ALPHA}$ ) and (LTPD, BETA). The use of this symbolism is in accordance with that most commonly encountered in statistical quality control literature where AQL is considered to be an acceptable quality level, LTPD is an unacceptable quality level, ALPHA is the producer's risk and BETA is the consumer's risk. In reality, any two desired points on the OC curve can be used equally effectively as design goals.

In its current software configuration, this option derives single sampling plans which meet design specifications on risks by strict use of the Binomial distribution to calculate event probabilities. This limitation is not considered to be restrictive since any plan derived with the Hypergeometric distribution would be valid only for the imposed lot size. The approach utilizing the Binomial distribution will enhance the precision of the design process over that achieved by using a Poisson or Poisson/Normal approximation approach.

Upon entering a 2 for the prompt illustrated in Figure 5, the user will be sequentially prompted for AQL, LTPD, ALPHA, and BETA. The inputting of these four percentages establishes the design goals of the plan. It is very improbable, due to the nature of the discrete random variables in this analysis, that a single sampling plan can be found which passes, exactly, through the two design goal points on the OC curve. Therefore, the next two prompts will request tolerance limits on the producer's risk and on the consumer's risk. The tolerance limits need not be equal to each other, and they can be zero if no tolerances exist. In an effort to address economical considerations, a prompt has been included to allow the user to place an upper limit on the sample size. If no upper limit is placed on the sample size, the software sets the limit equal to one-million. Additionally, the user has the option to limit the size of the acceptance number. After plans are analyzed for a specific acceptance number, the user will be prompted concerning the desire to increase the acceptance number by one and to continue the search.

To illustrate the use of the software, the data shown in Table 4 was used to respond to the serial prompts. Additionally, the search was limited to acceptance numbers less than or equal to five. In this application, 27 single sampling plans were found which met the design specifications and constraints. These plans are enumerated in Table 5.

Table 4. Option 2 Prompt Response Summary

Prompt Request	Response
AQL	2
LTPD	10
ALPHA	2
BETA	10
ALPHA Tolerance	1
BETA Tolerance	5
Maximum Sample Size	144

Table 5. Optional Feasible Single Sampling Plans

Optional Single Sampling Plans which Producer's Risk = 2.00 ± 1.00% Consumer's Risk = 10.00 ± 5.00% For AQL = 2.00% and LTPD = 10.00% (Binomial Probabilities)			
Sample Size	Acceptance Number	Producer's Risk	Consumer's Risk
72	4	1.48%	14.17%
73	4	1.56%	13.37%
74	4	1.65%	12.62%
75	4	1.74%	11.89%
76	4	1.83%	11.21%
77	4	1.93%	10.56%
78	4	2.03%	9.94%
79	4	2.13%	9.35%
80	4	2.24%	8.80%
81	4	2.34%	8.27%
82	4	2.46%	7.77%
83	4	2.57%	7.30%
84	4	2.69%	6.85%
85	4	2.81%	6.43%
86	4	2.94%	6.03%
91	5	1.01%	9.76%
92	5	1.06%	9.22%
93	5	1.11%	8.70%
94	5	1.17%	8.21%
95	5	1.23%	7.75%
96	5	1.29%	7.31%
97	5	1.35%	6.89%
98	5	1.41%	6.49%
99	5	1.48%	6.12%
100	5	1.55%	5.76%
101	5	1.62%	5.42%
102	5	1.69%	5.10%

If no plans are found which meet the design specifications, the user will be prompted to that effect and allowed to loosen the design tolerances and rerun the search procedure. If loosening the design tolerances is infeasible, the user may exit the design routine.

3. Plan Derivation for a Single Point of Control at the Indifference Quality (Poisson Based)

Indifference quality, sometimes called the point of control, is the fraction defective at which the probability of acceptance equals 50 percent. Conversely, the probability of rejection equals 50 percent, also. Single sample lot acceptance plans can be derived for this situation by simply calculating the sample size as

$$n = (C + .067)/p(50%), \tag{3}$$



where C is the acceptance number and p(50 percent) is the fraction defective at which the probability of acceptance is to be 50 percent. This relationship is credited to G.A. Cambell and is based on a Poisson distribution [2].

To access this segment of the software, the user must enter a 3 for the prompt shown in Figure 5. After doing so, the user will be prompted for the percent defective which is to possess a probability of acceptance of 50 percent. This is the only input required. The algorithm calculates sample size via Equation (3), integerizes the results, and prints the results for acceptance numbers ranging from 0 to 50. Since the resulting plans are based on a Poisson Assumption, the user should exercise Option 1 (Fig. 5), to obtain an exact risk evaluation for the use environment anticipated, be it Binomial or Hypergeometric. To illustrate the application of this option, an indifference quality of 10 percent was entered. The resulting plans are tabularized in Table 6.

Table 6. Single Sampling Plans for an Indifference Quality of 10 percent

Sample Size	Acceptance Number	Sample Size	Acceptance Number	Sample Size	Acceptance Number
7	0	177	17	347	34
17	1	187	18	357	35
27	2	197	19	367	36
37	3	207	20	377	37
47	4	217	21	387	38
57	5	227	22	397	39
67	6	237	23	407	40
77	7	247	24	417	41
87	8	257	25	427	42
97	9	267	26	437	43
107	10	277	27	447	44
117	11	287	28	457	45
127	12	297	29	467	46
137	13	307	30	477	47
147	14	317	31	487	48
157	15	327	32	497	49
167	16	337	33	507	50

Any of these plans can be evaluated by exercising Option #1

#### 4. Plan Derivation Using J.M. Cameron's Poisson Approximation of the OC Curve

As used within this computer program, Mr. J.M. Cameron's original intent has been somewhat modified. Reference 2 provides a detailed discussion of Mr. Cameron's approach to designing single sampling plans via Poisson approximations and two desired points from the OC curve. As applied herein, Mr. Cameron's Industrial Quality Control, Vol. 9, July 1952 table is utilized to provide the user with a single point of control at specific points on the OC curve. Namely, the user can stipulate the probability of acceptance to be 1, 5, 10, 50, 90, 95, or 99 percent for any specified percent defective. The resulting plans will approximate, via the Poisson, this single point of control for acceptance numbers ranging from 0 to 50. Exact risk assessments, via the Binomial or Hypergeometric are available through Option 1 of the menu shown in Figure 5.

Table 7 contains the output generated by entering a point of control of 2 percent and a probability of acceptance of 99 percent. Table 8 provides similar output derived from a point of control of 12 percent and a probability of acceptance of 5 percent.

**Table 7. Single Sampling Plans for Point of Control Equal 2 Percent and Probability of Acceptance Equal 99 Percent**

Single Sample Sampling Plans J. M. Cameron's Poisson Approximations where the Probability of Acceptance is 99.00% when the Percent Defective is 2.00%								
Sample Size	Acceptance Number	Percent Defective Specifications for which the Poisson Approximation of the Probability of Acceptance is						
		99%	95%	90%	50%	10%	5%	1%
1	0	1.00	5.10	10.50	69.30	230.30	299.60	460.50
8	1	1.86	4.44	6.65	20.98	48.63	59.30	82.98
22	2	1.98	3.72	5.01	12.15	24.19	28.62	38.21
42	3	1.96	3.25	4.15	8.74	15.91	18.46	23.92
64	4	2.00	3.08	3.80	7.30	12.49	14.30	18.13
90	5	1.98	2.90	3.50	6.30	10.31	11.68	14.56
117	6	1.99	2.81	3.33	5.70	9.00	10.12	12.45
146	7	1.99	2.73	3.19	5.25	8.06	9.01	10.96
176	8	1.99	2.67	3.09	4.93	7.38	8.20	9.89
207	9	2.00	2.62	3.01	4.67	6.86	7.59	9.07
239	10	2.00	2.58	2.94	4.46	6.45	7.10	8.43
272	11	2.00	2.55	2.88	4.29	6.10	6.69	7.90
305	12	2.00	2.52	2.83	4.15	5.83	6.37	7.48
340	13	1.99	2.49	2.79	4.02	5.58	6.08	7.10
374	14	2.00	2.47	2.75	3.92	5.38	5.85	6.80
410	15	2.00	2.45	2.72	3.82	5.19	5.63	6.52
445	16	2.00	2.43	2.69	3.75	5.05	5.46	6.30
481	17	2.00	2.42	2.67	3.67	4.91	5.30	6.09
518	18	2.00	2.40	2.64	3.60	4.78	5.15	5.90
555	19	2.00	2.39	2.62	3.54	4.67	5.02	5.74
592	20	2.00	2.38	2.60	3.49	4.57	4.91	5.59
629	21	2.00	2.37	2.58	3.44	4.48	4.81	5.46
667	22	2.00	2.36	2.56	3.40	4.40	4.71	5.34
705	23	2.00	2.35	2.55	3.36	4.32	4.62	5.23
743	24	2.00	2.34	2.54	3.32	4.25	4.54	5.12
782	25	2.00	2.33	2.52	3.28	4.18	4.46	5.03
977	30	2.00	2.30	2.47	3.14	2.90	4.16	4.65
1177	35	2.00	2.27	2.43	3.03	3.73	3.94	4.37
1380	40	2.00	2.25	2.39	2.95	3.58	3.77	4.16
1586	45	2.00	2.23	2.37	2.88	3.46	3.64	3.99
1794	50	2.00	2.22	2.35	2.82	3.36	3.53	3.85

Any of these plans can be evaluated by exercising Option #1

**Table 8. Single Sampling Plans for Point of Control Equal 12 Percent  
and Probability of Acceptance Equal 5 Percent**

Single Sample Sampling Plans J. M. Cameron's Poisson Approximations where the Probability of Acceptance is 5.00% when the Percent Defective is 12.00%								
Sample Size	Acceptance Number	Percent Defective Specifications for which the Poisson Approximation of the Probability of Acceptance is						
		99%	95%	90%	50%	10%	5%	1%
25	0	.04	.20	.42	2.77	9.21	11.98	18.42
40	1	.37	.89	1.33	4.20	9.73	11.86	16.60
53	2	.82	1.54	2.08	5.05	10.04	11.88	15.86
65	3	1.27	2.10	2.68	5.65	10.28	11.93	15.45
77	4	1.66	2.56	3.16	6.07	10.38	11.89	15.07
88	5	2.03	2.97	3.58	6.44	10.54	11.95	14.90
99	6	2.35	3.32	3.93	6.74	10.64	11.96	14.72
110	7	2.64	3.62	4.23	6.97	10.70	11.95	14.55
121	8	2.90	3.88	4.49	7.16	10.74	11.93	14.38
131	9	3.15	4.14	4.75	7.38	10.84	11.99	14.34
142	10	3.36	4.34	4.94	7.51	10.85	11.95	14.19
152	11	3.57	4.56	5.15	7.68	10.92	11.98	14.14
163	12	3.74	4.72	5.30	7.77	10.91	11.93	14.00
173	13	3.92	4.89	5.47	7.90	10.96	11.95	13.95
183	14	4.09	5.05	5.63	8.02	11.00	11.96	13.90
193	15	4.24	5.20	5.77	8.12	11.03	11.97	13.86
203	16	4.38	5.34	5.90	8.21	11.06	11.97	13.81
213	17	4.51	5.46	6.02	8.29	11.08	11.97	13.76
223	18	4.64	5.58	6.13	8.37	11.10	11.97	13.71
233	19	4.76	5.69	6.23	8.44	11.12	11.97	13.67
243	20	4.87	5.79	6.33	8.51	11.13	11.96	13.62
253	21	4.97	5.89	6.42	8.56	11.14	11.95	13.58
262	22	5.09	6.00	6.53	8.65	11.19	11.99	13.59
272	23	5.18	6.08	6.61	8.70	11.20	11.98	13.54
282	24	5.27	6.16	6.68	8.75	11.20	11.97	13.50
291	25	5.37	6.26	6.78	8.82	11.24	12.00	13.51
340	30	5.74	6.60	7.09	9.02	8.33	11.97	13.35
387	35	6.08	6.91	7.38	9.22	11.34	11.99	13.28
434	40	6.36	7.16	7.61	9.37	11.38	12.00	13.21
481	45	6.59	7.37	7.81	9.49	11.14	11.99	13.15
528	50	6.79	7.55	7.97	9.60	11.43	11.99	13.08

Any of these plans can be evaluated by exercising Option #1

**5. Plan Derivation Via MIL-STD-105D Search for Specified AQL, LTPD, ALPHA, and BETA**

The last single sampling option, (select code 5 in Fig.5), provides a risk assessment of the sampling plans contained in MIL-STD-105D against user specified risk thresholds. Specifically, all feasible combinations of acceptance numbers and sample sizes from MIL-STD-105D's Single Sample Normal Inspection, Reduced Inspection, and Tightened Inspection are considered. Each possible plan's probability of acceptance is calculated for AQL and LTPD. The associated risks are then compared to the producer's and consumer's risk thresholds. If the calculated risks simultaneously meet the specified thresholds, the plan is printed for user consideration. Otherwise, the plan is not printed, and the search continues. The software's logic flow enables the user to: (1) input two desired points from the OC curve (i. e., [AQL, 1-ALPHA] and [LTPD, BETA]); (2) input acceptable tolerances on the risks; (3) constrain the maximum sample size; and (4) choose either the Binomial or Hypergeometric as a means for calculating event probabilities.

After accruing the specified input, the examination of the possible MIL-STD-105D plans begins. If a plan meets all design constraints, it is printed. Otherwise, the search continues until all feasible single sampling plans contained in MIL-STD-105D are exhausted. To illustrate the use of this software segment, an AQL of 1 percent, an LTPD of 12 percent, a producer's risk of 5 percent, a consumer's risk of 25 percent, 5 percent tolerances on the risks, and a maximum sample size of 50 were entered in response to the sequential prompts. The results of the Binomial evaluation are summarized in Table 9. Additionally, the results of the Hypergeometric evaluation are summarized in Table 10 for a lot size of 200. Note that the risks for the same plans, in the two tables, are different. This is due to the finite lot size associated with the Hypergeometric. The risks will converge as the lot size approaches infinity.

**Table 9. Binomially Feasible MIL-STD-105D Single Sampling Plans**

<b>Optional Single Sampling Plans Via MIL-STD-105D</b>			
<b>For AQL = 1.00% and LTPD = 12.00%</b>			
<b>That meet Producer's Risk = 5.00 ± 5.00%</b>			
<b>And meet Consumer's Risk = 25.00 ± 5.00%</b>			
<b>****Binomial Probabilities****</b>			
<b>Maximum Sample Size Constraint: 50</b>			
<b>Sample Size</b>	<b>Acceptance Number</b>	<b>Producer's Risk</b>	<b>Consumer's Risk</b>
20	1	1.69%	28.91%
32	2	.40%	24.40%

A complete OC Curve for any of these plans can be obtained by exercising Option 1 of this program segment.

**Table 10. Hypergeometric Feasible MIL-STD-105D Single Sampling Plans**

**Optional Single Sampling Plans Via MIL-STD-105D**  
**For AQL = 1.00% and LTPD = 12.00%**  
**That meet Producer's Risk = 5.00 ± 5.00%**  
**That meet Consumer's Risk = 25.00 ± 5.00%**  
**Lot size = 200**  
**\*\*\*\*Hypergeometric Probabilities\*\*\*\***  
**Maximum Sample Size Constraint: 50**

Sample Size	Acceptance Number	Producer's Risk	Consumer's Risk
20	1	.95%	27.38%
32	2	0.00%	21.96%

A complete OC Curve for any of these plans can be obtained by exercising Option 1 of this program segment.

**C. Double Sampling Design and Assessment**

Though conceptually easy to understand, single sampling is an expensive means of accomplishing acceptance sampling to control percent defective. A more economical means, probabilistically speaking, is available through double sampling. The potential savings are possible even when producer's risk and consumer's risk are constrained to be constant at the levels incurred with single sampling. References 1 and 2 provide comprehensive discussions of the advantages of double sampling over single sampling; therefore, the reader can refer to those texts if further information is desired.

If a 2 is entered for the prompt shown in Figure 4, the double sampling code will be loaded and executed. Shown in Figure 10 is a narrative which briefly describes the three double sampling options currently available. Option 1, accessed by a select code of 1, provides a probabilistic risk assessment of any specified double sampling plan using either the Binomial or the Hypergeometric distribution, depending upon the sampling constraints.

> Double Sampling Plan Option Menu <	
<u>Option Description</u>	<u>Select Code</u>
> Double Sample Operating Characteristic Curve Construction and Risk Assessment .....	1
> Double Sampling Plan Derivation, Via Poisson Approximation of ALPHA = 5% and BETA = 10% for Given Specifications of AQL and LTPD .....	2
> Double Sampling Plan Derivation from MIL-STD-105D Acceptance/Rejection Numbers and all Stated Sample Sizes. This option provides a Binomial or Hypergeometric Assessment of Alpha and Beta for Stated AQL and LTPD values. The assessments are limited to the feasible combinations of sample size and accept reject numbers specified in MIL-STD-105D .....	3
> EXIT this Selected Option .....	4
ENTER THE SELECT CODE OF THE DESIRED OPTION.	

*Figure 10. Double Sampling Menu*

Additionally, this option provides an ASN plot which is simply a plot of the expected number sampled to a decision to accept or reject versus the quality characteristic. The provided ASN plot is based on the assumption that no sample termination is allowed, that is two events are possible. Once a decision is made after the first sample, or the decision is made after the second sample. No decisions can be made except at these two points in testing. If sample termination is to be allowed for economic and/or logic reasons, the user can evaluate the impact of this departure, for double sampling plans with combined sample sizes less than or equal to 50, by using Option 5 of the main menu, (Fig. 4). This evaluation will take the form of an OC curve and an ASN plot which take into consideration the sample termination policy. Sampling termination basically transforms the double sampling plan into a multiple sampling plan.

Option 2 of the double sampling section provides an automation which will assist in the design of double sampling plans in which the producer's risk is 5 percent and the consumer's risk is 10 percent. The two fraction defective values, corresponding to these two risk specifications, are considered to be variable user inputs. It is pertinent to point out that the AQL must be numerically smaller than the LTPD. The design algorithm is based upon the Poisson approximation procedure as identified by the Chemical Corps Engineering Agency [6].

The final double sampling option provides an automation which searches all feasible double sampling plans contained in MIL-STD-105D for those that satisfy the user's inputted design specifications. In other words, this portion of the software combines MIL-STD-105D sample sizes with acceptance/rejection numbers for Normal Inspection, Reduced Inspection, and Tightened Inspection; calculates the producer's risk and consumer's risk for the inputted AQL and LTPD; compares these calculated risks to the user inputted target values plus or minus the tolerances, and prints the plan if the calculated risks are within the tolerance specifications. The exhaustive search includes all double sampling plans contained in MIL-STD-105D. A feasible double sampling plan is one in which the acceptance and rejection numbers are less than the corresponding sample size.

Before proceeding to the illustration of these three software options, a word of caution must be given concerning double sampling plan specifications. A double sampling plan is specified by six numbers. The first of these numbers is the first sample's size and the second number is the acceptance number on the first sample. Often overlooked is the third number, the rejection number on the first sample. If the first sample's rejection number is not specified, it is customary to assume that it is equal to the rejection number on the second sample. The rejection number on the second sample must be numerically equal to the acceptance number on the second sample plus one. To avoid confusion and possible misunderstanding, the best choice is to specify all six numbers.

### 1. Double Sampling OC Curve Construction and Risk Assessment

Option 1 of Figure 10 is the basic assessment algorithm for double sampling in that it provides an evaluation of the probability of acceptance, OC curve, and an ASN evaluation. If selected, the user will be serially prompted for the first sample's size, the second sample's size, the first sample's acceptance number, the second sample's acceptance number, the first sample's rejection number and the second sample's rejection number. These six inputs completely specify the double sampling plan. Attention is then focused on the conditions under which the sampling will be done (i. e., from a finite lot size or from lots such that the probability of a defective is constant from trial to trial).

Following the plan specification, the user will be prompted to enter a YES or a NO concerning the existence of a finite lot size. If the response is NO, the Binomial distribution is assumed applicable for computing probabilities. Otherwise, the Hypergeometric is assumed. To illustrate the Binomial evaluation, the data shown in Table 11 was entered for the serial prompts. When the finite lot size prompt was displayed, a NO was entered. Figure 11 provides a graphical illustration of the resulting OC curve while Figure 12 displays the plot of the ASN. The ASN plot shown in Figure 12 is based upon the assumption that no sample termination is instigated. Table 12 provides an itemization of the analysis findings for user inputted percent defectives. The scope of coverage of this table is left to the user's discretion.

Table 11. Double Sampling Binomial Option Input

PROMPT	RESPONSE
First Sample's Size	12
Second Sample's Size	24
First Sample's Acceptance Number	0
Second Sample's Acceptance Number	3
First Sample's Rejection Number	3
Second Sample's Rejection Number	4

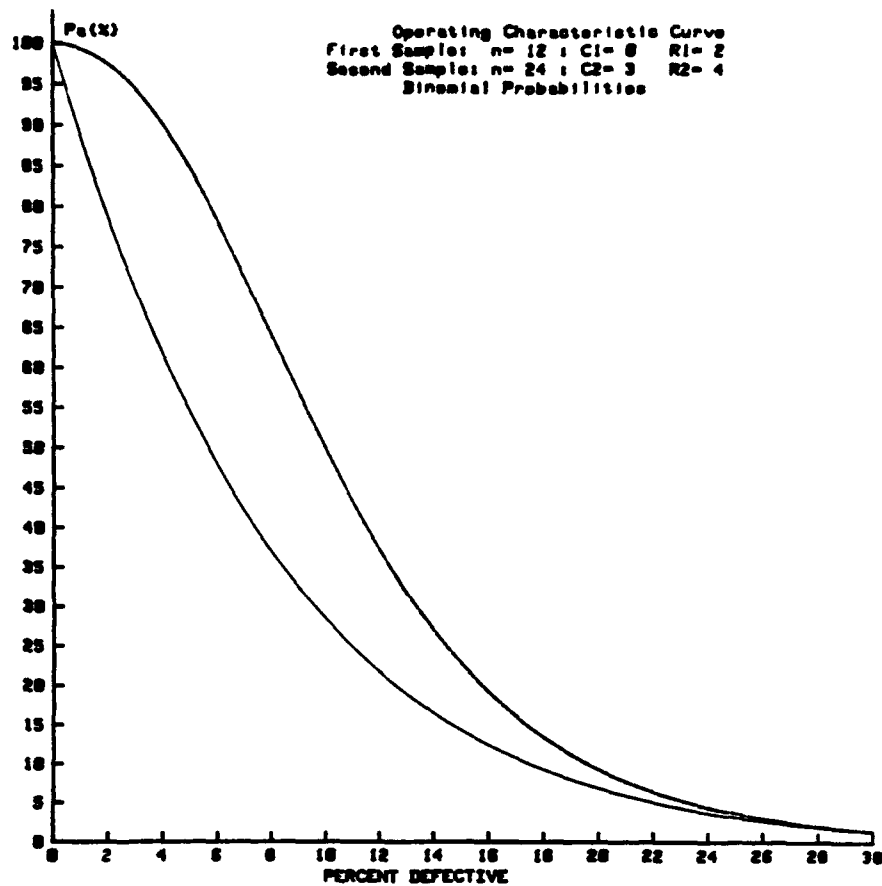


Figure 11. Double Sampling Binomial OC Curve

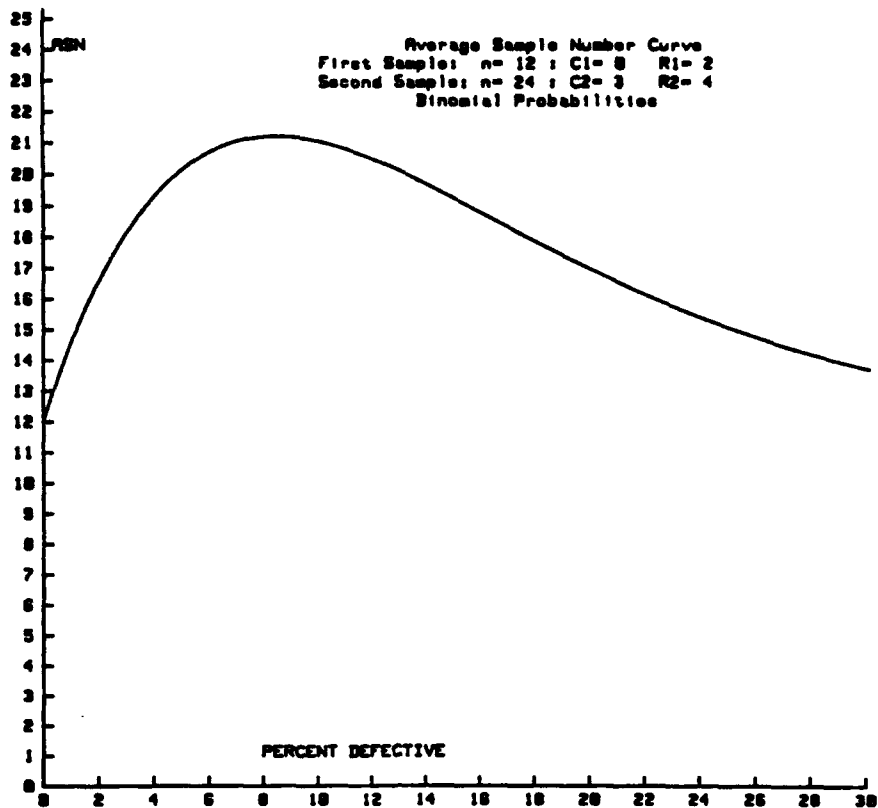
Table 12. OC Curve and ASN Points Versus Percent Defective For Double Sampling (Binomial)

Risk Evaluation for the Double Sampling Plan First Sample: $n=12$ Accept on 0, Reject on 2 Second Sample: $n=24$ Accept on 3, Reject on 4 (Binomial Distribution Probabilities)						
Percent Defective	First Sample Risks			Plan Risks		Average Sample Number
	Acceptance Probability	Continue Probability	Rejection Probability	Acceptance Probability	Rejection Probability	
0.0000	100.0000	0.0000	0.0000	100.0000	0.0000	12.00
1.0000	88.6385	10.7441	.6175	99.3640	.6360	14.58
2.0000	78.4717	19.2176	2.3108	97.4619	2.5381	16.61
3.0000	69.3842	25.7509	4.8649	94.2558	5.7442	18.18
4.0000	61.2710	30.6355	8.0935	89.7838	10.2162	19.35
5.0000	54.0360	34.1280	11.8360	84.2071	15.7929	20.19
6.0000	47.5920	36.4535	15.9545	77.7819	22.2181	20.75
7.0000	41.8596	37.8087	20.3317	70.8113	29.1887	21.07
8.0000	36.7666	38.3652	24.8682	63.5993	36.4007	21.21
9.0000	32.2475	38.2718	29.4806	56.4187	43.5813	21.19
10.0000	28.2430	37.6573	34.0998	49.4920	50.5080	21.04
11.0000	24.6990	36.6323	38.6687	42.9845	57.0155	20.79
12.0000	21.5671	35.2916	43.1412	37.0059	62.9941	20.47
13.0000	18.8032	33.7160	47.4808	31.6163	68.3837	20.09



Table 12. OC Curve and ASN Points Versus Percent Defective for Double Sampling (Binomial)  
(continued)

Risk Evaluation for the Double Sampling Plan						
First Sample: n=12 Accept on 0, Reject on 2 Second Sample: n=24 Accept on 3, Reject on 4 (Binomial Distribution Probabilities)						
Percent Defective	First Sample Risks			Plan Risks		Average Sample Number
	Acceptance Probability	Continue Probability	Rejection Probability	Acceptance Probability	Rejection Probability	
14.0000	16.3675	31.9737	51.6589	26.8356	73.1644	19.67
15.0000	14.2242	30.1218	55.6540	22.6531	77.3469	19.23
16.0000	12.3410	28.2081	59.4509	19.0365	80.9635	18.77
17.0000	10.6890	26.2718	63.0392	15.9402	84.0598	18.31
18.0000	9.2420	24.3448	66.4132	13.3109	86.6891	17.84
19.0000	7.9766	22.4528	69.5706	11.0932	88.9068	17.39
20.0000	6.8719	20.6158	72.5122	9.2328	90.7672	16.95
21.0000	5.9092	18.8494	75.2414	7.6785	92.3215	16.52
22.0000	5.0715	17.1650	77.7635	6.3838	93.6162	16.12
23.0000	4.3440	15.5707	80.0853	5.3076	94.6924	15.74
24.0000	3.7133	14.0716	82.2151	4.4138	95.5862	15.38
25.0000	3.1676	12.6705	84.1618	3.6719	96.3281	15.04
26.0000	2.6964	11.3685	85.9351	3.0560	96.9440	14.73
27.0000	2.2902	10.1647	87.5451	2.5442	97.4558	14.44
28.0000	1.9408	9.0573	89.0019	2.1185	97.8815	14.17
29.0000	1.6410	8.0431	90.3160	1.7641	98.2359	13.93
30.0000	1.3841	7.1184	91.4975	1.4687	98.5313	13.71
31.0000	1.1646	6.2789	92.5565	1.2221	98.7779	13.51
32.0000	.9775	5.5199	93.5026	1.0162	98.9838	13.32
33.0000	.8183	4.8364	94.3454	.8441	99.1559	13.16
34.0000	.6832	4.2232	95.0936	.7002	99.2998	13.01
35.0000	.5688	3.6753	95.7559	.5800	99.4200	12.88
36.0000	.4722	3.1876	96.3402	.4795	99.5205	12.77
37.0000	.3909	2.7550	96.8540	.3956	99.6044	12.66
38.0000	.3226	2.3729	97.3045	.3256	99.6744	12.57
39.0000	.2654	2.0365	97.6981	.2673	99.7327	12.49
40.0000	.2177	1.7414	98.0409	.2188	99.7812	12.42
45.0000	.0766	.7523	99.1711	.0767	99.9233	12.18
50.0000	.0244	.2930	99.6826	.0244	99.9756	12.07
60.0000	.0017	.0302	99.9681	.0017	99.9983	12.01
70.0000	.0001	.0015	99.9985	.0001	99.9999	12.00
75.0000	.0000	.0002	99.9998	.0000	100.0000	12.00



*Figure 12. Double Sampling Binomial, No Sampling Termination, ASN Plot*

To illustrate the Hypergeometric evaluation, a YES was entered for the finite lot size prompt. The preceding input prompts were repeated, from the Binomial illustration. Following the finite lot prompt, the user is prompted to enter the lot size. One-hundred forty-four was entered in this illustration example. Figures 13 and 14 provide schematics of the resulting OC curve and ASN plot, respectively. Table 13 contains selected points on the OC curve and the plot. Again, the number of points included in this table is the user's discretion.

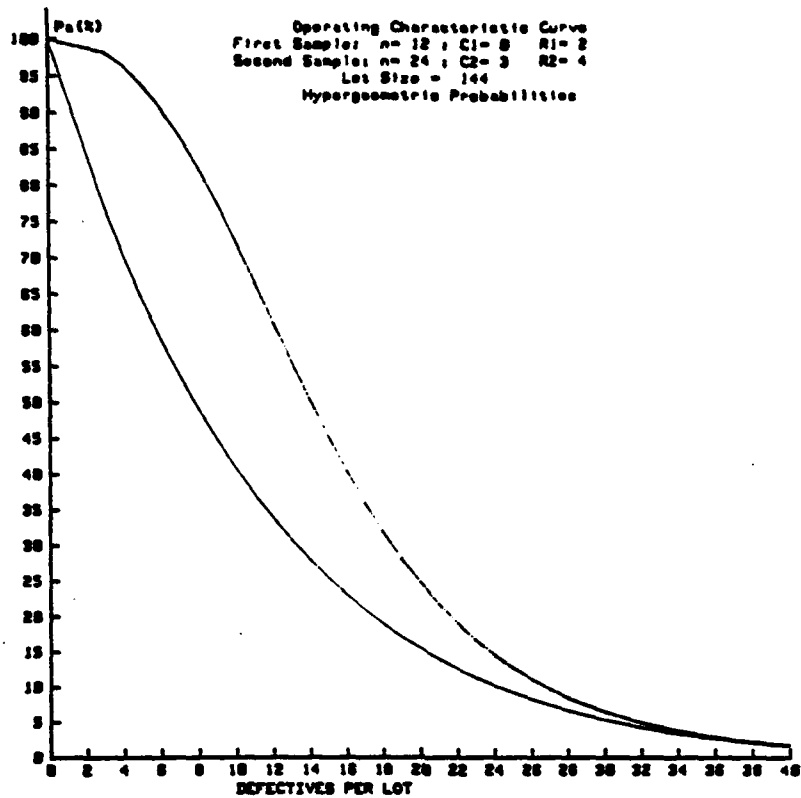


Figure 13. Double Sampling Hypergeometric OC Curve

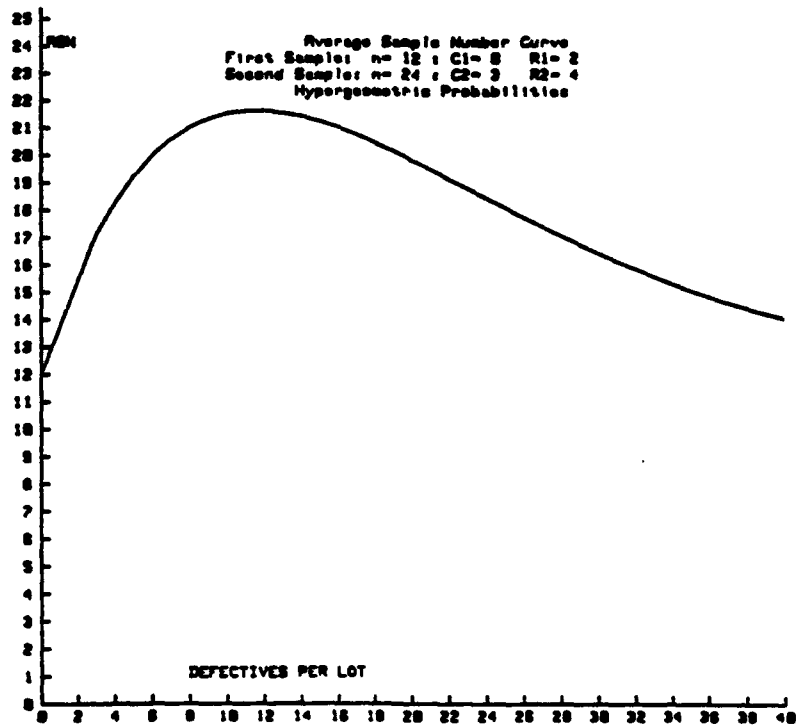


Figure 14. Double Sampling Hypergeometric, No Sampling Termination, ASN Plot

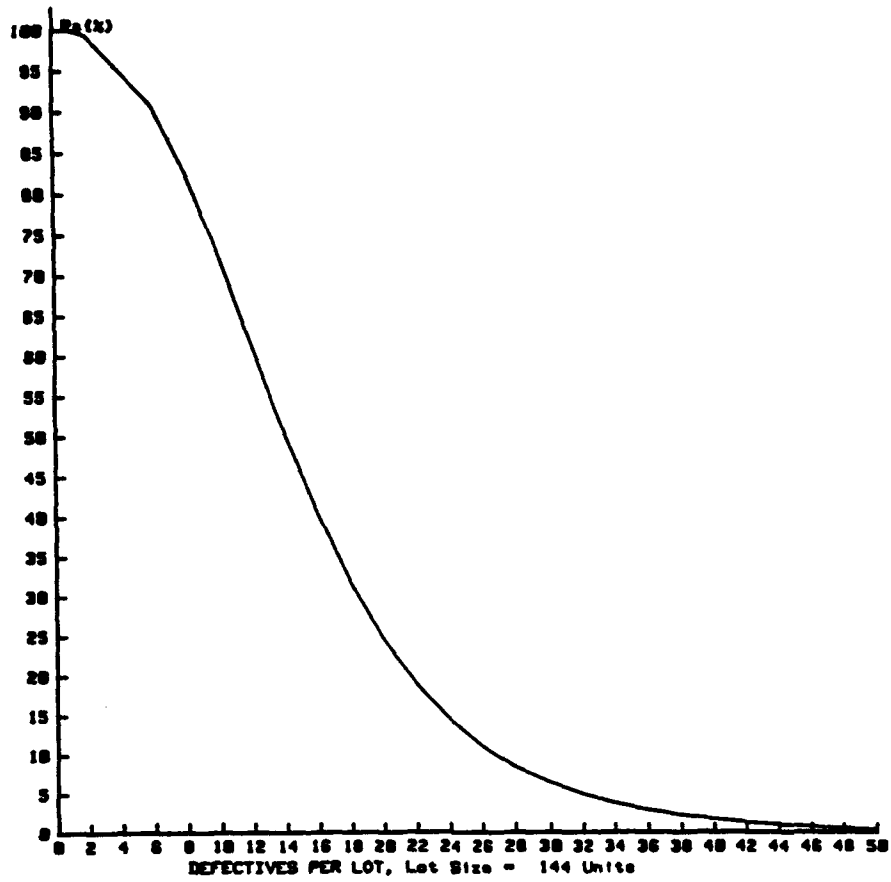
**Table 13. OC Curve and ASN Points Versus Percent Defective for Double Sampling  
(Hypergeometric)**

Risk Evaluation for the Double Sampling Plan						
First Sample: n=12 Accept on 0, Reject on 2 Second Sample: n=24 Accept on 3, Reject on 4						
Lot Size = 144 (Hypergeometric Distribution Probabilities)						
Defective Per Lot	First Sample Risks			Plan Risks		Average Sample Number
	Acceptance Probability	Continue Probability	Rejection Probability	Acceptance Probability	Rejection Probability	
0	100.0000	0.0000	0.0000	100.0000	0.0000	12.00
1	91.6667	8.3333	-.0000	100.0000	-.0000	14.00
2	83.9744	15.3846	.6410	99.3590	.6410	15.69
3	76.8779	21.2893	1.8328	98.1672	1.8328	17.11
4	70.3351	26.1712	3.4937	96.3650	3.6350	18.28
5	64.3064	30.1436	5.5500	93.8782	6.1218	19.23
6	58.7548	33.3098	7.9354	90.6770	9.3230	19.99
8	48.9468	37.5911	13.4621	82.3030	17.6970	21.02
10	40.6610	39.6693	19.6697	72.0200	27.9800	21.52
12	33.6796	40.0815	26.2389	60.9395	39.0605	21.62
14	27.8131	39.2656	32.9213	50.0868	49.9132	21.42
16	22.8973	37.5751	39.5276	40.1896	59.8104	21.02
18	18.7900	35.2925	45.9175	31.6419	68.3581	20.47
20	15.3684	32.6409	51.9906	24.5619	75.4381	19.83
24	10.1746	26.8834	62.9420	14.4320	85.5680	18.45
25	9.1571	25.4365	65.4063	12.6036	87.3964	18.10
30	5.3301	18.6296	76.0402	6.4119	93.5881	16.47
35	3.0242	12.9607	84.0151	3.3138	96.6862	15.11
40	1.6682	8.6102	89.7216	1.7349	98.2651	14.07
45	.8921	5.4741	93.6338	.9053	99.0947	13.31
50	.4609	3.3315	96.2076	.4631	99.5369	12.80
60	.1090	1.0755	98.8154	.1091	99.8909	12.26
70	.0212	.2824	99.6965	.0212	99.9788	12.07
75	.0085	.1320	99.8595	.0085	99.9915	12.03
80	.0032	.0574	99.9394	.0032	99.9968	12.01
100	.0000	.0007	99.9992	.0000	100.0000	12.00

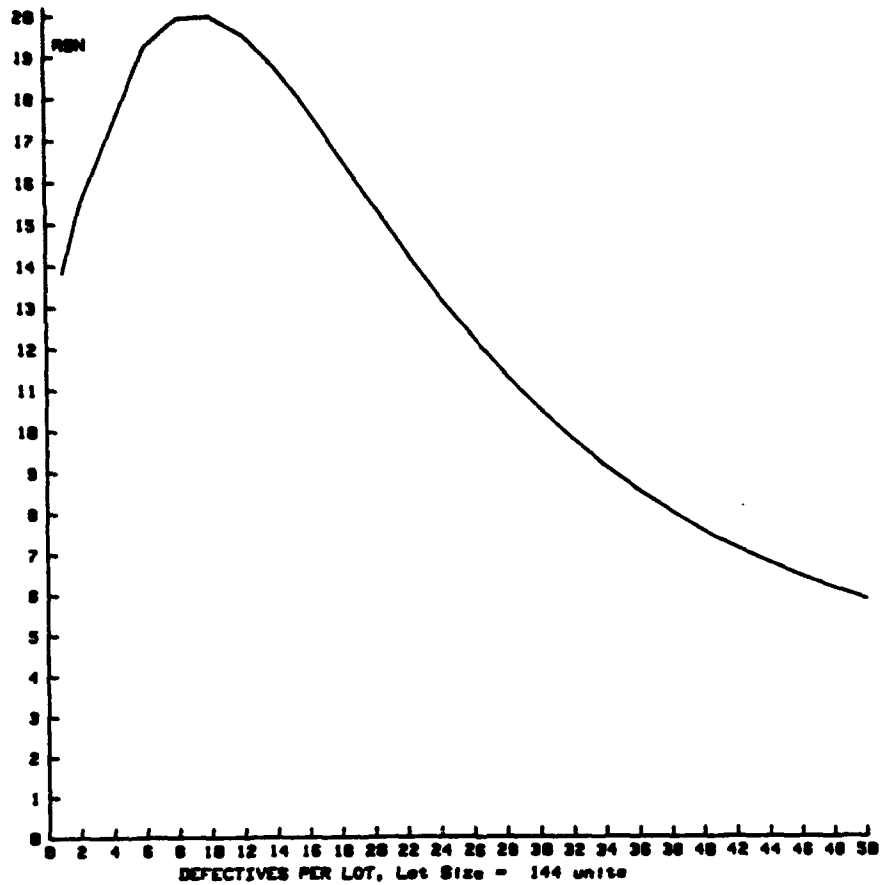
In the discussion of single sampling, the instigation of sample termination was discussed for the Binomial case. To illustrate the effect of sample termination in the Hypergeometric case, the previous double sampling plan was modified to reflect the effect of sample termination. The resulting multiple sampling plan is shown in Table 14. Loading Option 5 of the Main Menu (Fig. 4), and entering the plan shown in Table 14, resulted in the OC curve and ASN plot shown herein as Figure 15 and Figure 16, respectively. For comparison purposes, Table 15 was printed with common defectives per lot. Note that no significant differences exist between the probabilities of acceptance for specific defectives per lot; however economies of expected sampled units are accrued. These inferences are valid only for lot sizes of 144.

Table 14. Multiple Sampling Plan Resulting from Sample Termination of Double Sampling Plan

Multiple Plan Specification													
Total Number of Units Sampled	Cumulative Acceptance Number (A)	Cumulative Continuance Numbers (c)										Cumulative Rejection Number (R)	
2	***	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
3	***	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
4	***	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
5	***	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
6	***	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
7	***	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
8	***	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
9	***	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
10	***	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
11	***	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
12	0	x	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
13	0	x	1	2	3	xxx	xxx	xxx	xxx	xxx	xxx	xxx	4
14	0	x	1	2	3	xxx	xxx	xxx	xxx	xxx	xxx	xxx	4
15	0	x	1	2	3	xxx	xxx	xxx	xxx	xxx	xxx	xxx	4
16	0	x	1	2	3	xxx	xxx	xxx	xxx	xxx	xxx	xxx	4
17	0	x	1	2	3	xxx	xxx	xxx	xxx	xxx	xxx	xxx	4
18	0	x	1	2	3	xxx	xxx	xxx	xxx	xxx	xxx	xxx	4
19	0	x	1	2	3	xxx	xxx	xxx	xxx	xxx	xxx	xxx	4
20	0	x	1	2	3	xxx	xxx	xxx	xxx	xxx	xxx	xxx	4
21	0	x	1	2	3	xxx	xxx	xxx	xxx	xxx	xxx	xxx	4
22	0	x	1	2	3	xxx	xxx	xxx	xxx	xxx	xxx	xxx	4
23	0	x	1	2	3	xxx	xxx	xxx	xxx	xxx	xxx	xxx	4
24	0	x	1	2	3	xxx	xxx	xxx	xxx	xxx	xxx	xxx	4
25	0	x	1	2	3	xxx	xxx	xxx	xxx	xxx	xxx	xxx	4
26	0	x	1	2	3	xxx	xxx	xxx	xxx	xxx	xxx	xxx	4
27	0	x	1	2	3	xxx	xxx	xxx	xxx	xxx	xxx	xxx	4
28	0	x	1	2	3	xxx	xxx	xxx	xxx	xxx	xxx	xxx	4
29	0	x	1	2	3	xxx	xxx	xxx	xxx	xxx	xxx	xxx	4
30	0	x	1	2	3	xxx	xxx	xxx	xxx	xxx	xxx	xxx	4
31	0	x	1	2	3	xxx	xxx	xxx	xxx	xxx	xxx	xxx	4
32	0	x	1	2	3	xxx	xxx	xxx	xxx	xxx	xxx	xxx	4
33	0	x	1	2	3	xxx	xxx	xxx	xxx	xxx	xxx	xxx	4
34	1	x	2	3	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	4
35	2	x	3	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	4
36	3	x	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	4



*Figure 15. Multiple Sampling Via Double Sample with Sample Termination, OC Curve*



*Figure 16. Multiple Sampling Via Double Sample with Sample Termination Average Sample Number Plot*

**Table 15. OC Curve and ASN Points from Multiple Sampling Via Double Sample with Sample Termination**

Defectives Per Lot	Acceptance Probability	Sample Number
1	100.00%	13.8
3	98.17%	16.7
4	96.36%	17.8
6	90.68%	19.2
9	77.33%	20.0
10	72.02%	20.0
12	60.94%	19.5
16	40.19%	17.7
20	24.56%	15.4
24	14.43%	13.2
25	12.60%	12.7
30	6.41%	10.5
35	3.31%	8.8
40	1.73%	7.5
45	.91%	6.6
50	.46%	5.8
60	.11%	4.8
70	.02%	4.1

2. Double Sampling Plan Derivation Via Poisson Approximation of ALPHA=5 Percent and BETA=10 Percent for given Specifications of AQL and LTPD

This option provides the capability to derive double sampling plans for specified values of AQL and LTPD in which the ALPHA is 5 percent and BETA is 10 percent. Additionally, two types of double sampling plans are considered, those in which the first sample is equal in size to the second sample, and those in which the second sample is twice the first sample's size. The design algorithm is based on a Poisson approximation technique, as identified by the Chemical Corps Engineering Agency, [6].

The procedure for using this option is straightforward. A 2 is entered for the prompt shown in Figure 10 to access the software. If it is desired to have the second sample's size to be twice the first sample's size, a 1 should be entered for the prompt requesting the selection. The only other two user inputs are the numeric values of AQL and LTPD which will be entered via prompts and must be stated as percents. To obtain an output for illustration, an AQL of 2 percent and an LTPD of 8 percent were entered. Table 16 provides a copy of the resulting output. In this case, 32 double sampling plans are itemized which approximate the design specifications. Plan number 13 is very close to the desired risk values. To implement the plan, one would draw a sample of 49 units. If no defectives are found in these units, the lot is accepted with no further sampling. If six defectives are found, the lot is rejected with no further sampling. Otherwise, a second sample, consisting of 98 units must be drawn. If the cumulative number of defectives, from both samples, is less than six, the lot is accepted. If this cumulative number is six or more, the lot is rejected. The footnote at the bottom of the table is printed to remind the user that a Binomial and/or a Hypergeometric risk assessment is available for any plan selected from the table.

Table 16. Poisson Approximated Double Sampling Plans in which the Second Sample is Twice the First

Plan Option Number	Sampling Plan Specification				Percent Defective at which the P(Acceptance) is Approximately Equal			Average Sample Number Pa=95%
	Sample Size		Acceptance On		95%	50%	10%	
	First Sample	Second Sample	First Sample	Second Sample				
1	9	18	0	1	2.0000	9.3333	25.7778	11.46
2	30	60	0	1	.5333	2.8000	8.0000	38.19
3	16	32	0	2	2.0000	6.6875	15.1250	24.18
4	31	62	0	2	.9677	3.4516	8.0000	46.84
5	31	62	0	3	2.0000	5.8065	12.5484	38.38
6	49	98	0	3	1.2245	3.6735	8.0000	60.66
7	25	50	0	3	2.0000	5.4000	10.5600	44.28
8	34	68	0	3	1.4412	3.9706	8.0000	60.21
9	39	78	0	4	2.0000	5.0513	10.0513	53.00
10	50	100	0	4	1.5400	3.9400	8.0000	67.95
11	35	70	0	4	2.0000	4.6857	8.3714	69.48
12	37	74	0	4	1.8378	4.4324	8.0000	73.45
13	49	98	0	5	2.0000	4.4490	8.2041	73.40
14	51	102	0	5	1.8824	4.2745	8.0000	76.40
15	59	118	0	6	2.0000	4.1356	7.0678	97.11
16	53	106	0	6	2.1887	4.6038	8.0000	87.24



Table 16. Poisson Approximated Double Sampling Plans in which the Second Sample is 7 times the First (continued)

Plan Option Number	Sampling Plan Specification				Percent Defective at which the P(Acceptance) is Approximately Equal			Average Sample Number Pa=95%
	Sample Size		Acceptance On		95%	50%	10%	
	First Sample	Second Sample	First Sample	Second Sample				
17	85	170	0	8	2.0000	3.8588	6.4353	125.46
18	69	138	0	8	2.4348	4.7536	8.0000	101.84
19	114	228	0	10	2.0000	3.6228	5.8947	158.23
20	85	170	0	10	2.6706	4.8588	8.0000	117.98
21	124	248	0	11	2.0000	3.5161	5.5000	182.03
22	86	172	0	11	2.8605	5.0698	8.0000	126.25
23	154	308	0	13	2.0000	3.3831	5.2273	214.68
24	101	202	0	13	3.0369	5.1584	8.0000	140.79
25	165	330	0	14	2.0000	3.2727	4.9152	242.88
26	102	204	0	14	3.2255	5.2941	8.0000	150.14
27	171	342	0	15	2.0000	3.1579	4.4152	322.85
28	95	190	0	15	3.5895	5.6842	8.0000	179.36
29	238	476	0	20	2.0000	2.9496	3.9286	482.90
30	117	234	0	20	4.0598	6.0000	8.0000	237.39
31	373	746	0	30	2.0000	2.7641	3.4745	831.79
32	163	326	0	30	4.5706	6.3252	8.0000	363.49

Exact risk assessments are available for any selected plan by exercising selection number 1 of the Double Sampling Menu.

If it is desired that both sample sizes be equal, a 2 should be entered after the prompt requesting the decision. The AQL and LTPD are entered in the same manner as discussed above. Table 17 was obtained by entering an AQL of 2 percent and an LTPD of 8 percent. In this case, 34 plans are provided for the user's consideration. These plans approximate the design risk specifications and possess equal sample sizes for both samples.

Table 17. Poisson Approximated Double Sampling Plans in which the First and Second Samples are Equal

Plan Option Number	Sampling Plan Specification				Percent Defective at which the P(Acceptance) is Approximately Equal			Average Sample Number Pa=95%
	Sample Size		Acceptance On		95%	50%	10%	
	First Sample	Second Sample	First Sample	Second Sample				
1	11	11	0	1	2.0000	9.0909	22.7273	12.87
2	32	32	0	1	.6563	3.1250	8.0000	37.44
3	27	27	0	2	2.0000	6.7407	14.5185	29.19
4	50	50	0	2	1.0400	3.6400	8.0000	54.05
5	22	22	0	2	2.0000	6.4545	13.4545	29.48
6	38	38	0	2	1.1316	3.7368	8.0000	50.92
7	39	39	0	3	2.0000	5.4103	10.5385	45.59
8	52	52	0	3	1.4615	4.0577	8.0000	60.79
9	59	59	0	4	2.0000	4.9153	9.1356	65.20
10	68	68	0	4	1.7059	4.2647	8.0000	75.14
11	53	53	0	4	2.0000	4.7170	8.3396	67.52
12	56	56	0	4	1.8571	4.4643	8.0000	71.34
13	72	72	0	5	2.0000	4.4444	7.7083	84.24
14	70	70	0	5	2.0429	4.5714	8.0000	81.90
15	94	94	0	6	2.0000	4.2340	7.2128	105.00
16	85	85	0	6	2.2000	4.6824	8.0000	94.95
17	87	87	0	6	2.0000	4.0920	6.6897	108.58
18	73	73	0	6	2.3562	4.8767	8.0000	91.10
19	108	108	0	7	2.0000	3.9537	6.3981	126.68
20	87	87	0	7	2.4713	4.9080	8.0000	102.05
21	132	132	0	8	2.0000	3.8030	6.1364	148.37
22	102	102	0	8	2.5686	4.9216	8.0000	114.65
23	146	146	0	9	2.0000	3.6507	5.6575	170.38
24	104	104	0	9	2.7885	5.1250	8.0000	121.37
25	185	185	0	11	2.0000	3.4595	5.1676	215.71
26	120	120	0	11	3.0667	5.3333	8.0000	139.92
27	201	201	0	12	2.0000	3.3483	4.8607	244.22
28	123	123	0	12	3.2520	5.4715	8.0000	149.45
29	218	218	0	13	2.0000	3.2385	4.6239	277.08
30	127	127	0	13	3.4252	5.5591	8.0000	161.42
31	236	236	0	14	2.0000	3.1864	4.4280	314.12
32	131	131	0	14	3.5878	5.7405	8.0000	174.36
33	270	270	0	16	2.0000	3.1111	4.2259	392.04
34	143	143	0	16	3.7692	5.8741	8.0000	207.64

Exact risk assessments are available for any selected plan by exercising selection number 1 of the Double Sampling Menu.

3. Double Sampling Plan Derivation from MIL-STD-105D Acceptance Rejection Numbers and All Stated Sample Sizes

This final double sampling option, illustrated in Figure 10, provides a search of the feasible double sampling contained in MIL-STD-105D for Normal Inspection, Tightened Inspection and Reduced Inspection. The search is initiated by inputting the AQL, LTPD, producer's risk, consumer's risk, producer's risk tolerance and consumer's risk tolerance. To expedite the search, a provision has been added within the source code to allow the user to specify a maximum total sample size. If no maximum is entered, one-million is assumed. Additionally, if the search is being conducted for a specific lot size (i. e., Hypergeometric evaluation), the user will be prompted for the numeric value of the finite lot size.

The search algorithm begins with the formulation of a double sampling plan from MIL-STD-105D. Any plan in which the acceptance, rejection, and sample numbers are compatible is considered to be feasible. The producer's risk and consumer's risk are calculated for the generated plan. If the risks are simultaneously within the risk tolerance limits, the plan is printed for user consideration. Otherwise, the plan is not printed. In either case, the formulation of another plan is initiated and the process is repeated. This iterative formulation, evaluation, and comparison is continued until all of the possible plans contained in MIL-STD-105D have been exhausted.

To illustrate this design option, the data shown in Table 18 was entered for the indicated prompts. Since the Binomial option has a faster processing time, no constraint on sample size was imposed. Table 19, contains the five MIL-STD-105D plans, output for this scenario, found to possess risks that are within the risk design tolerances. Similarly, the Hypergeometric evaluation was constrained to a total sample size of 100 or less units and a finite lot size of 250. The results of the MIL-STD-105D search are the two plans shown in Table 20.

Table 18. Double Sampling Prompt/Response Data

Prompt	Response
AQL	2
LTPD	8
ALPHA	5
BETA	10
ALPHA Tolerance	5
BETA Tolerance	8

**Table 19. MIL-STD-105D Double Sampling Plans Meeting the Design Tolerances  
(Binomial Evaluation)**

Binomial Probability Evaluation Optional MIL-STD-105D Sampling Plans AQL = 2% and LTPD = 8% Producer's Risk = 5 ± 5% and Consumer's Risk = 10 ± 8%													
Sample Size		Accept/Reject Criteria				Risk and Sampling Burden at Desired Specification							
		First		Second		Acceptable Quality Level				Tolerance % Defective			
1st	2nd	Acc	Rej	Acc	Rej	Pa	Pc	Alpha	ASN	Beta	Pc	Pr	ASN
50	50	1	4	4	5	95.2	24.6	4.8	62.3	13.2	34.3	86.8	67.1
80	80	2	5	6	7	95.5	19.3	4.5	95.5	5.2	18.3	94.8	94.6
80	80	3	7	8	9	99.5	7.6	.5	86.1	15.8	43.1	84.2	114.5
125	125	5	9	12	13	99.8	3.9	.2	129.9	7.5	26.4	92.5	158.0
200	200	9	14	23	24	100.0	.7	.0	201.5	6.8	22.7	93.2	245.5

**Table 20. MIL-STD-105D Double Sampling Plans Meeting the Design Tolerances  
(Hypergeometric Evaluation)**

Hypergeometric Probability Evaluation Optional MIL-STD-105D Sampling Plans AQL = 2% and LTPD = 8% Producers Risk = 5 ± 5% and Consumer's Risk = 10 ± 8% Maximum Total Sample Constraint: 120 Lot Size = 250													
Sample Size		Accept/Reject Criteria				Risk and Sampling Burden at Desired Specification							
		First		Second		Acceptable Quality Level				Tolerance % Defective			
1st	2nd	Acc	Rej	Acc	Rej	Pa	Pc	ALPHA	ASN	BETA	Pc	Pr	ASN
50	50	1	4	4	5	98.8	25.6	1.2	62.8	8.7	34.3	91.3	67.1

A complete assessment of any of these plans is obtainable by exercising Option #1 of this software segment.

**D. Multiple Sampling Plan Design and Assessment**

Multiple sampling plans, in the form presented herein, are rarely utilized. Though somewhat more complex than double sampling, multiple sampling is instigated in an effort to reduce the expected number of units sampled to a decision for constant, specified risk levels. As used in this application, multiple sampling involves the repetitive drawing of an incremental sample size, usually represented by n. After each incremental sample is drawn, the total number of defectives is tabulated and compared to the progressive acceptance/rejection numbers. If the cumulative number of defectives is less than or equal to the acceptance number, the lot is accepted. If the cumulative number of defectives is greater than or equal to the rejection number, the lot is rejected. Otherwise, the next incremental sample size is drawn. The analyses associated with this segment of the software deal exclusively with plans in which this incremental sample size is constant. The procedure described above is repeated until the lot is either accepted or rejected. A decision to accept or reject is guaranteed since all of these plans converge. Convergence occurs when the acceptance number plus one equals the rejection number. References 1, 2, 6, and 7 provide extensive discussions and examples of these type of plans. Specifically, MIL-STD-105D provides tables of multiple sampling plans for Normal Inspection, Tightened Inspection, and Reduced Inspection, but these plans are not indexed as functions of acceptable quality, unacceptable quality, and risks. Reference 6 does provide plans indexed in the specified manner, but the risks are approximated by the use of the Poisson distribution.

However, when a plan is specified, precise risks can and should be evaluated with either the Binomial distribution or the Hypergeometric, depending upon the conditions under which the plan is to be implemented.

To assist the user in designing multiple sampling plans whose OC curves pass, or early pass, through two desired points, Option 3 of Figure 4 was created. If this option is exercised, the two design aids illustrated in Figure 17 will be displayed on the CRT. Option 1's software provides an algorithm based on the article entitled, 'Master Sampling Plans for Single, Duplicate, Double, and Multiple Sampling' by Enters and Hamaker [6]. These plans possess the common trait that they approximate a producer's risk of 5 percent for an inputted AQL and/or they approximate a consumer's risk of 10 percent for an inputted LTPD. The approximation is based on a Poisson distribution. Once the plans are identified, the algorithm uses the Binomial distribution to assess the actual risk levels. The option was not added to obtain a Hypergeometric assessment since it is anticipated that in the plan design phase the user is primarily concerned with generic lot sizes. If warranted, the Hypergeometric option can and should be included. This departure from the Chemical Corps Engineering Agency's procedure will provide a more accurate risk assessment.

<b>Multiple Sampling Design Options</b>	
<u>Option Description</u>	<u>Select Code</u>
> Barnard-Enters-Hamaker's Poisson Approximation of Sample Size for Producer's Risk of Five Percent & Consumer's Risk of Ten Percent. Achieved Risks are Calculated Via the Binomial .....	1
> MIL-STD-105D Alternate Plans For Specified AQL, Producer's Risk, LTPD, and Consumer's Risk. Achieved risks are Calculated Via the Binomial .....	2
<b>ENTER THE SELECT CODE OF THE DESIRED OPTION.</b>	

*Figure 17. Multiple Sampling Plan Design Menu*

To illustrate the option's use, an AQL of 2 percent and an LTPD of 12 percent were used as responses to the appropriate prompts. The Chemical Corps Engineering Agency procedure indicated a ratio of six (i.e., LTPD/AQL). This yields an incremental sample size of 12. As illustrated in Figure 18, the software prints, as output, a series of plans which are derived by a sensitivity analysis of the incremental sample size (i.e., the incremental sample size ranges from 11 to 15). This feature was included to provide a measure of the marginal relationship between the achieved risks and the incremental values of n. Upon reviewing Figure 18, it will be noted that each multiple sampling plan specification is followed by a note which states that a complete risk assessment is obtainable by exercising Option 5 of the main menu, (Fig. 4). If this feature is chosen, a complete Binomial assessment is available. Additionally, a complete Hypergeometric assessment is available if the plan is to be evaluated against a specified finite lot size. To illustrate the use of Option 5 in this application, a Binomial assessment was chosen. A Hypergeometric assessment will be illustrated later within this section.

Optional Sampling Plan 0 1  
 Which Approximates Producer's Risk = 5% & Consumer's Risk = 10 %  
 The Binomial Distribution Point Estimate of Producer's Risk is 3.009903029 %,  
 and the Point Estimate of Consumer's Risk is 11.4304997299 %.

Multiple Plan Specification

Total Number of Units Sampled	Cumulative Acceptance Number (A)	Cumulative Continuance Numbers (C)	Cumulative Rejection Number (R)
1	0	1	0
2	0	2	0
3	0	3	0
4	0	4	0
5	0	5	0
6	0	6	0
7	0	7	0
8	0	8	0
9	0	9	0
10	0	10	0
11	0	11	0
12	1	10	1
13	1	9	2
14	1	8	3
15	1	7	4
16	1	6	5
17	1	5	6
18	1	4	7
19	1	3	8
20	1	2	9
21	1	1	10
22	2	0	10
23	2	0	10
24	2	0	10
25	2	0	10
26	2	0	10
27	2	0	10
28	2	0	10
29	2	0	10
30	2	0	10
31	2	0	10
32	2	0	10
33	2	0	10
34	2	0	10
35	2	0	10
36	2	0	10
37	2	0	10
38	2	0	10
39	2	0	10
40	2	0	10
41	2	0	10
42	2	0	10
43	2	0	10
44	2	0	10
45	2	0	10
46	2	0	10
47	2	0	10
48	2	0	10
49	2	0	10
50	2	0	10
51	2	0	10
52	2	0	10
53	2	0	10
54	2	0	10
55	2	0	10
56	2	0	10
57	2	0	10
58	2	0	10
59	2	0	10
60	2	0	10
61	2	0	10
62	2	0	10
63	2	0	10
64	2	0	10
65	2	0	10
66	2	0	10
67	2	0	10
68	2	0	10
69	2	0	10
70	2	0	10
71	2	0	10
72	2	0	10
73	2	0	10
74	2	0	10
75	2	0	10
76	2	0	10
77	2	0	10
78	2	0	10
79	2	0	10
80	2	0	10
81	2	0	10
82	2	0	10
83	2	0	10
84	2	0	10
85	2	0	10
86	2	0	10
87	2	0	10
88	2	0	10
89	2	0	10
90	2	0	10
91	2	0	10
92	2	0	10
93	2	0	10
94	2	0	10
95	2	0	10
96	2	0	10
97	2	0	10
98	2	0	10
99	2	0	10
100	2	0	10

A complete risk assessment is obtainable by exercising Option 5 of the Main Menu.

Optional Sampling Plan 0 4  
 Which Approximates Producer's Risk = 5% & Consumer's Risk = 10 %  
 The Binomial Distribution Point Estimate of Producer's Risk is 10.06761099 %,  
 and the Point Estimate of Consumer's Risk is 4.00130964023 %.

Multiple Plan Specification

Total Number of Units Sampled	Cumulative Acceptance Number (A)	Cumulative Continuance Numbers (C)	Cumulative Rejection Number (R)
1	0	1	0
2	0	2	0
3	0	3	0
4	0	4	0
5	0	5	0
6	0	6	0
7	0	7	0
8	0	8	0
9	0	9	0
10	0	10	0
11	0	11	0
12	0	12	0
13	0	13	0
14	0	14	0
15	0	15	0
16	0	16	0
17	0	17	0
18	0	18	0
19	0	19	0
20	0	20	0
21	0	21	0
22	0	22	0
23	0	23	0
24	0	24	0
25	0	25	0
26	0	26	0
27	0	27	0
28	0	28	0
29	0	29	0
30	0	30	0
31	0	31	0
32	0	32	0
33	0	33	0
34	0	34	0
35	0	35	0
36	0	36	0
37	0	37	0
38	0	38	0
39	0	39	0
40	0	40	0
41	0	41	0
42	0	42	0
43	0	43	0
44	0	44	0
45	0	45	0
46	0	46	0
47	0	47	0
48	0	48	0
49	0	49	0
50	0	50	0
51	0	51	0
52	0	52	0
53	0	53	0
54	0	54	0
55	0	55	0
56	0	56	0
57	0	57	0
58	0	58	0
59	0	59	0
60	0	60	0
61	0	61	0
62	0	62	0
63	0	63	0
64	0	64	0
65	0	65	0
66	0	66	0
67	0	67	0
68	0	68	0
69	0	69	0
70	0	70	0
71	0	71	0
72	0	72	0
73	0	73	0
74	0	74	0
75	0	75	0
76	0	76	0
77	0	77	0
78	0	78	0
79	0	79	0
80	0	80	0
81	0	81	0
82	0	82	0
83	0	83	0
84	0	84	0
85	0	85	0
86	0	86	0
87	0	87	0
88	0	88	0
89	0	89	0
90	0	90	0
91	0	91	0
92	0	92	0
93	0	93	0
94	0	94	0
95	0	95	0
96	0	96	0
97	0	97	0
98	0	98	0
99	0	99	0
100	0	100	0

A complete risk assessment is obtainable by exercising Option 5 of the Main Menu.

Optional Sampling Plan 0 2  
 Which Approximates Producer's Risk = 5% & Consumer's Risk = 10 %  
 The Binomial Distribution Point Estimate of Producer's Risk is 7.16070007 %,  
 and the Point Estimate of Consumer's Risk is 8.07290612099 %.

Multiple Plan Specification

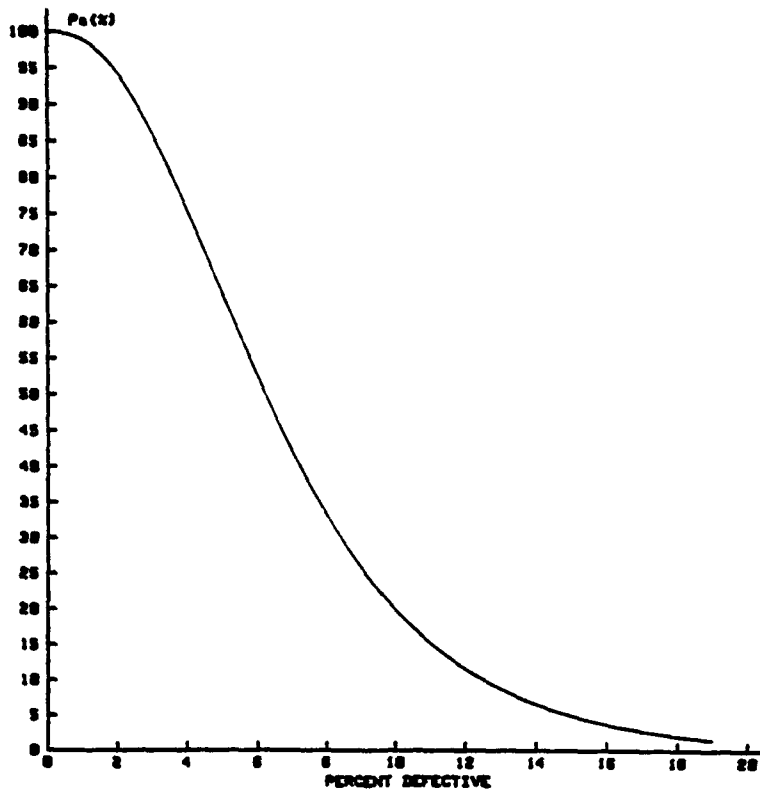
Total Number of Units Sampled	Cumulative Acceptance Number (A)	Cumulative Continuance Numbers (C)	Cumulative Rejection Number (R)
1	0	1	0
2	0	2	0
3	0	3	0
4	0	4	0
5	0	5	0
6	0	6	0
7	0	7	0
8	0	8	0
9	0	9	0
10	0	10	0
11	0	11	0
12	0	12	0
13	0	13	0
14	0	14	0
15	0	15	0
16	0	16	0
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24	0	24	0
25	0	25	0
26	0	26	0
27	0	27	0
28	0	28	0
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30	0	30	0
31	0	31	0
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33	0	33	0
34	0	34	0
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36	0	36	0
37	0	37	0
38	0	38	0
39	0	39	0
40	0	40	0
41	0	41	0
42	0	42	0
43	0	43	0
44	0	44	0
45	0	45	0
46	0	46	0
47	0	47	0
48	0	48	0
49	0	49	0
50	0	50	0
51	0	51	0
52	0	52	0
53	0	53	0
54	0	54	0
55	0	55	0
56	0	56	0
57	0	57	0
58	0	58	0
59	0	59	0
60	0	60	0
61	0	61	0
62	0	62	0
63	0	63	0
64	0	64	0
65	0	65	0
66	0	66	0
67	0	67	0
68	0	68	0
69	0	69	0
70	0	70	0
71	0	71	0
72	0	72	0
73	0	73	0
74	0	74	0
75	0	75	0
76	0	76	0
77	0	77	0
78	0	78	0
79	0	79	0
80	0	80	0
81	0	81	0
82	0	82	0
83	0	83	0
84	0	84	0
85	0	85	0
86	0	86	0
87	0	87	0
88	0	88	0
89	0	89	0
90	0	90	0
91	0	91	0
92	0	92	0
93	0	93	0
94	0	94	0
95	0	95	0
96	0	96	0
97	0	97	0
98	0	98	0
99	0	99	0
100	0	100	0

A complete risk assessment is obtainable by exercising Option 5 of the Main Menu.

Optional Sampling Plan 0 3  
 Which Approximates Producer's Risk = 5% & Consumer's Risk = 10 %  
 The Binomial Distribution Point Estimate of Producer's Risk is 11.66730007 %,  
 and the Point Estimate of Consumer's Risk is 3.99720010442 %.

Multiple Plan Specification

Total Number of Units Sampled	Cumulative Acceptance Number (A)	Cumulative Continuance Numbers (C)	Cumulative Rejection Number (R)
1	0	1	0
2	0	2	0
3	0	3	0
4	0	4	0
5	0	5	0
6	0	6	0
7	0	7	0
8	0	8	0
9	0	9	0
10	0	10	0
11	0	11	0
12	0	12	0
13	0	13	0
14	0	14	0
15	0	15	0
16	0	16	0
17	0	17	0
18	0	18	0
19	0	19	0
20	0	20	0
21	0	21	0
22	0	22	0
23	0	23	0
24	0	24	0
25	0	25	0
26	0	26	0
27	0	27	0
28	0	28	0
29	0	29	0
30	0	30	0
31	0	31	0
32	0	32	0
33	0	33	0
34	0	34	0
35	0	35	0
36	0	36	0
37	0	37	0
38	0	38	0
39	0	39	0
40	0	40	0
41	0	41	0
42	0	42	0
43	0	43	0
44	0	44	0
45	0	45	0
46	0	46	0
47	0	47	0
48	0	48	0
49	0	49	0
50	0	50	0
51	0	51	0
52	0	52	0
53	0	53	0
54	0	54	0
55	0	55	0
56	0	56	0
57	0	57	0
58	0	58	0
59	0	59	0
60	0	60	0
61	0	61	0
6			



*Figure 19. OC Curve for Optional Multiple Sampling Plan #1*

**Table 21. OC Curve/ASN Points for Optional Multiple Sampling Plan #1**

Percent Defective	Acceptance Probability	Average Sample Number
1.00%	98.83%	24.7
2.00%	94.11%	27.4
3.00%	85.82%	29.4
4.00%	75.16%	30.6
5.00%	63.57%	31.0
6.00%	52.25%	30.7
7.00%	41.97%	30.0
8.00%	33.11%	28.9
9.00%	25.75%	27.6
10.00%	19.81%	26.3
11.00%	15.11%	24.9
12.00%	11.46%	23.6
13.00%	8.64%	22.4
14.00%	6.49%	21.2
15.00%	4.86%	20.1
16.00%	3.63%	19.2
17.00%	2.71%	18.3
18.00%	2.01%	17.5
19.00%	1.49%	16.7
20.00%	1.10%	16.1

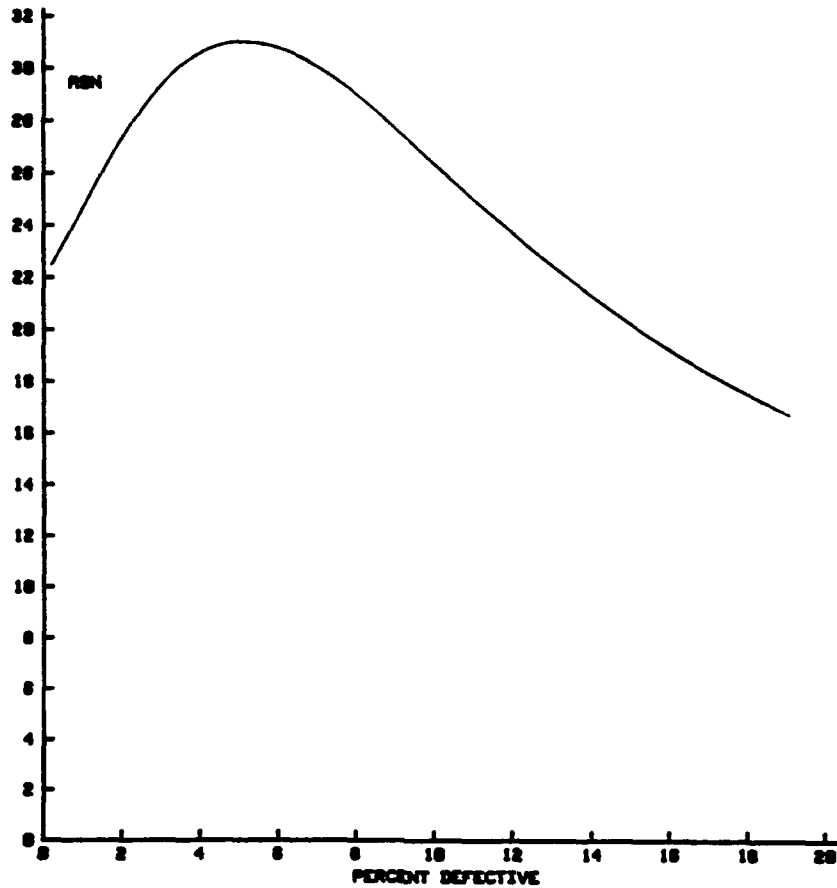


Figure 20. ASN Plot for Optional Multiple Sampling Plan #1 (without Sample Termination)

Option 2 of Figure 17 provides the user with the capability of searching the multiple sampling plan possibilities contained in MIL-STD-105D. The search is conducted to determine which plan contained therein comes closest to meeting the desired, inputted quality levels and risks. The 'closeness' criteria specified herein is stated quantitatively as

$$D = \sqrt{(\text{Prisk} - \text{Alpha})^2 + (\text{Crisk} - \text{Beta})^2} \quad (4)$$

where Prisk is the computed producer's risk for an identified plan Crisk is the identified plan's consumer's risk, Alpha is the desired producer's risk, and Beta is the desired consumer's risk. To illustrate the operation of this option, an AQL of 2 percent, an LTPD of 12 percent, a producer's risk of 5 percent and a consumer's risk of 10 percent was entered for the corresponding input prompts. The resulting output is illustrated in Figure 21. Of the multiple plans contained in MIL-STD-105D, the plan with the incremental sample size of 11 and the acceptance/rejection numbers shown in the lower right-hand corner of Figure 21 is the closest to the design criteria, where closeness is computed by Equation (4). To illustrate the complete assessment capability of Option 5 of Figure 4, the derived multiple sampling plan and a finite lot size of 500 were provided as input. The resulting Hypergeometric assessment is summarized in Figure 22, Figure 23, and Table 22. It is pertinent to point out that the results illustrated for this application are valid only for lots containing 500 units and that the ASN plot is further constrained by the assumption of no sample termination.





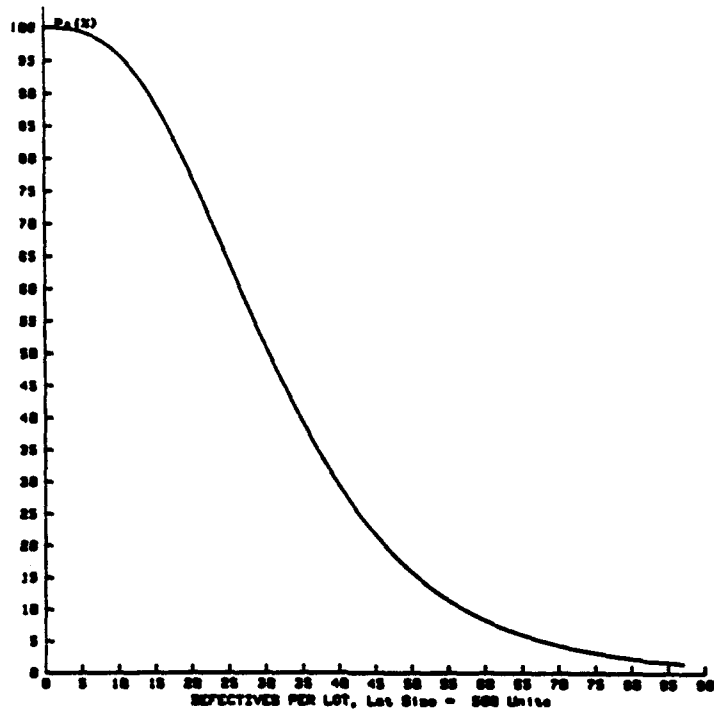


Figure 22. OC Curve for MIL-STD-105D Multiple Sampling Plan

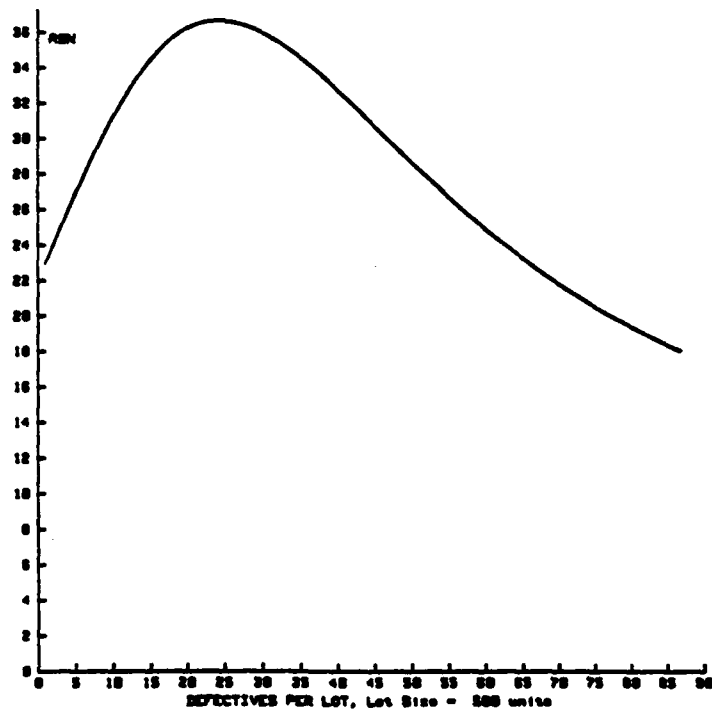


Figure 23. ASN Plot for MIL-STD-105D Multiple Sampling Plan

Table 22. OC Curve/ASN Points for MIL-STD-105D Multiple Sampling Plan

Defectives Per Lot	Acceptance Probability	Sample Number
1	100.00%	23.0
4	99.66%	25.9
10	95.89%	31.1
20	77.00%	36.2
30	50.86%	36.0
40	29.33%	32.8
50	15.71%	28.7
60	8.21%	25.0
70	4.31%	21.9
80	2.31%	19.4
90	1.26%	17.5
100	.69%	16.1

### E. Sequential Sampling Design and Assessment

The final design aid provided by this automation deals with Wald's Sequential Sampling Theory. Mr. Acheson J. Duncan, [1], provides a comprehensive and thorough discussion of Wald's Sequential Sampling Plan design and assessment; therefore, Mr. Duncan's discussion will not be reiterated here. Let it suffice to say that the software contained herein, as Option 4 in Figure 4 simply automates Mr. Duncan's approach. This automation is inclusive of the operating characteristic curve and average sample number plot construction via the parametric equation approach. The software comprising this option is attached as Appendix D of this report.

Before proceeding to an example, it must be stated that the OC curve and average sample number plot, obtained via the cited parametric evaluation, are valid only if the sequential plan is adopted in its entirety. That is, no modification of any type is permitted. If this compliance is met, the austere possibility exists that an entire lot can be sampled without an acceptance or rejection decision. If destructive testing and/or high unit test cost are associated with the sampling, sequential sampling is often abandoned because of this possibility. Notwithstanding this austere possibility and the relative complexity of applying the the plan, Wald's Sequential Sampling Plans do minimize the expected number of units sampled to a decision, for specified quality levels and risks. Additionally, the sequential plans often provide the basis of tailor made plans which result from truncations of the sequential sampling. If the user requires a more indepth discussion of this topic, Reference 1 should be consulted.

Upon entering a 4 for the prompt, illustrated in Figure 4 the user will be sequentially prompted for the AQL, LTPD, the producer's risk, and the consumer's risk. To illustrate the use of the sequential portion of the software, 2 percent, 12 percent, 5 percent, and 10 percent were entered for the identified prompts. The first output segment provided is an option to print the computed acceptance line and the computed rejection line. For this application, the lines were

$$\text{Acceptance Line: } X = -(1.18527087142) + .0566659067544n \quad (5)$$

and

$$\text{Rejection Line: } X = (1.52173674436) + .0566659067544n \quad (6)$$

where  $n$  is the chronological number of the unit sampled. The acceptance and rejection numbers are undefined for  $X$  values less than zero. Additionally, for application purposes the rejection line values are always rounded up to the higher integer while the acceptance numbers are always rounded down to the lower integer. This procedure tends to widen the continue region and does cause variation in the actual probability of acceptance and expected sample size from those expected via the aforementioned parametric evaluations. These departures are customarily assumed to be negligible.

Table 23 contains a output summary of the derived sequential sampling plan which was derived by calculating the acceptance and and rejection numbers for  $n$  values ranging from 1 to 100. It is pertinent to point out that the plan infinitely extends beyond a sample of 100. The acceptance and rejection numbers provided in Table 23 have been subjected to the rounding procedure previously discussed. Table 24 contains the results of applying the parametric equations discussed by Mr. Duncan. As such, these points, for both the probability of acceptance and the expected sample size to a decision, constitute estimates. Figures 24 and 25 provide schematics of the OC curve and the ASN plot which were derived from the points shown in Table 24. A word of caution is in order. The OC curve and the ASN plot are valid estimates only for the unbounded Wald Sequential Sampling Plan defined by the parallel lines stated as Equations (5) and (6). Any alteration of the plan in any way invalidates the referenced schematics. Alterations usually take the form of sequential plan truncation which will be subsequently addressed.

Table 23. Integerized Sequential Sampling Plan Specification

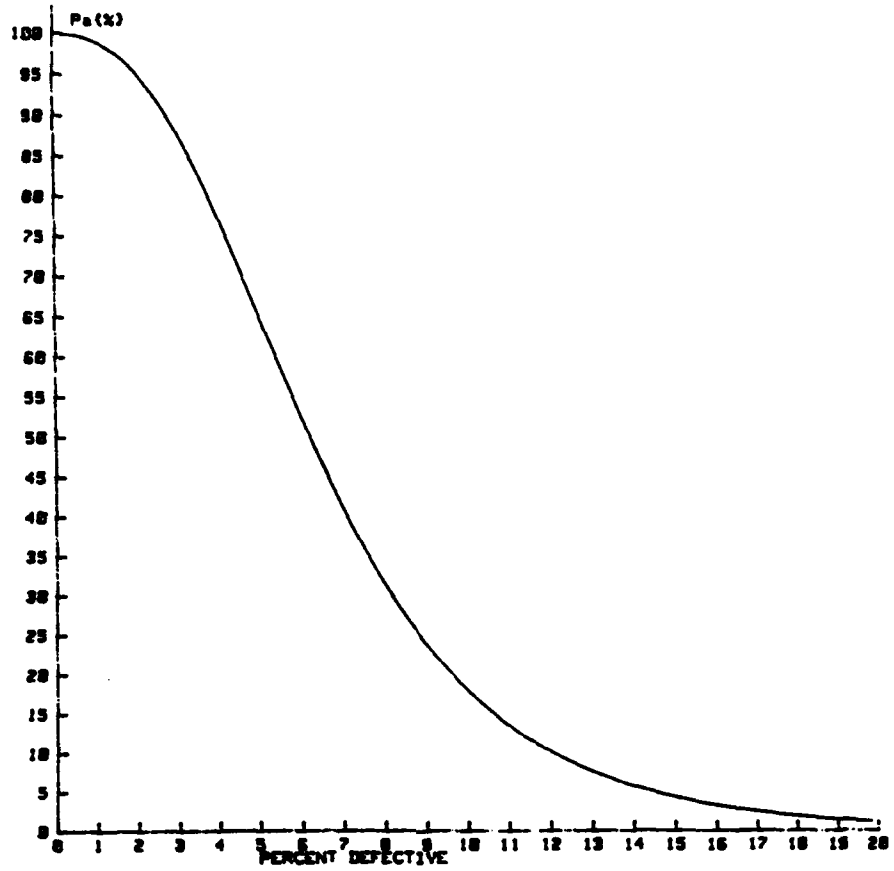
Wald's Sequential Sampling Table											
AQL = 2% and LTPD = 12%, Producer's Risk = 5% Consumer's Risk = 10%,											
Number of Units Sampled	If Total Defective		Number of Units Sampled	If Total Defective		Number of Units Sampled	If Total Defective		Number of Units Sampled	If Total Defective	
	Acpt	Rejt		Acpt	Rejt		Acpt	Rejt		Acpt	Rejt
1	***	***	26	0	3	51	1	5	76	3	6
2	***	2	27	0	4	52	1	5	77	3	6
3	***	2	28	0	4	53	1	5	78	3	6
4	***	2	29	0	4	54	1	5	79	3	6
5	***	2	30	0	4	55	1	5	80	3	7
6	***	2	31	0	4	56	1	5	81	3	7
7	***	2	32	0	4	57	2	5	82	3	7
8	***	2	33	0	4	58	2	5	83	3	7
9	***	3	34	0	4	59	2	5	84	3	7
10	***	3	35	0	4	60	2	5	85	3	7
11	***	3	36	0	4	61	2	5	86	3	7
12	***	3	37	0	4	62	2	6	87	3	7
13	***	3	38	0	4	63	2	6	88	3	7
14	***	3	39	1	4	64	2	6	89	3	7
15	***	3	40	1	4	65	2	6	90	3	7
16	***	3	41	1	4	66	2	6	91	3	7
17	***	3	42	1	4	67	2	6	92	4	7
18	***	3	43	1	4	68	2	6	93	4	7
19	***	3	44	1	5	69	2	6	94	4	7
20	***	3	45	1	5	70	2	6	95	4	7
21	0	3	46	1	5	71	2	6	96	4	7
22	0	3	47	1	5	72	2	6	97	4	8
23	0	3	48	1	5	73	2	6	98	4	8
24	0	3	49	1	5	74	3	6	99	4	8
25	0	3	50	1	5	75	3	6	100	4	8

Table 24. Parametric OC Curve and ASN Plot Points

Sequential Sampling AQL = 2%, Producer's Risk = 5%, LTPD = 12%, and Consumer's Risk = 10%					
Probability of Acceptance and Average Sample Size Versus Percent Defective					
Percent Defective	Probability of Acceptance	Average Sample Number	Percent Defective	Probability of Acceptance	Average Sample Number
.55	99.69%	23.01	5.78	53.68%	33.48
.58	99.66%	23.13	6.08	51.13%	33.17
.61	99.62%	23.26	6.30	48.58%	32.81
.65	99.57%	23.29	6.51	46.06%	32.41
.69	99.52%	23.53	6.74	43.57%	31.96
.72	99.46%	23.68	6.97	41.11%	31.47
.76	99.39%	23.84	7.20	38.71%	30.95
.81	99.32%	24.01	7.43	36.38%	30.39
.85	99.24%	24.18	7.67	34.12%	29.81
.90	99.15%	24.36	7.92	31.93%	29.20
.95	99.05%	24.56	8.17	29.83%	28.58
1.00	98.93%	24.76	8.42	27.82%	27.94
1.05	98.80%	24.97	8.67	25.90%	27.29
1.10	98.66%	25.19	8.93	24.08%	26.63
1.16	98.50%	25.42	9.20	22.35%	25.97
1.22	98.33%	25.66	9.46	20.72%	25.31
1.29	98.13%	25.91	9.73	19.19%	24.66
1.35	97.91%	26.17	10.01	17.74%	24.00
1.42	97.66%	26.45	10.28	16.39%	23.36
1.50	97.39%	26.73	10.56	15.12%	22.73
1.57	97.09%	27.02	10.84	13.95%	22.10
1.65	96.75%	27.33	11.13	12.85%	21.49
1.73	96.38%	27.64	11.42	11.83%	20.90
1.82	95.96%	27.96	11.71	10.88%	20.32
1.91	95.51%	28.29	12.00	10.00%	19.75
2.00	95.00%	28.63	12.30	9.19%	19.20
2.10	94.44%	28.98	12.59	8.44%	18.67
2.20	93.83%	29.34	12.89	7.74%	18.16
2.30	93.15%	29.70	13.19	7.10%	17.66
2.41	92.41%	30.06	13.50	6.51%	17.18
2.52	91.59%	30.43	13.80	5.97%	16.71
2.63	90.70%	30.79	14.11	5.47%	16.27
2.75	89.73%	31.15	14.42	5.01%	15.84

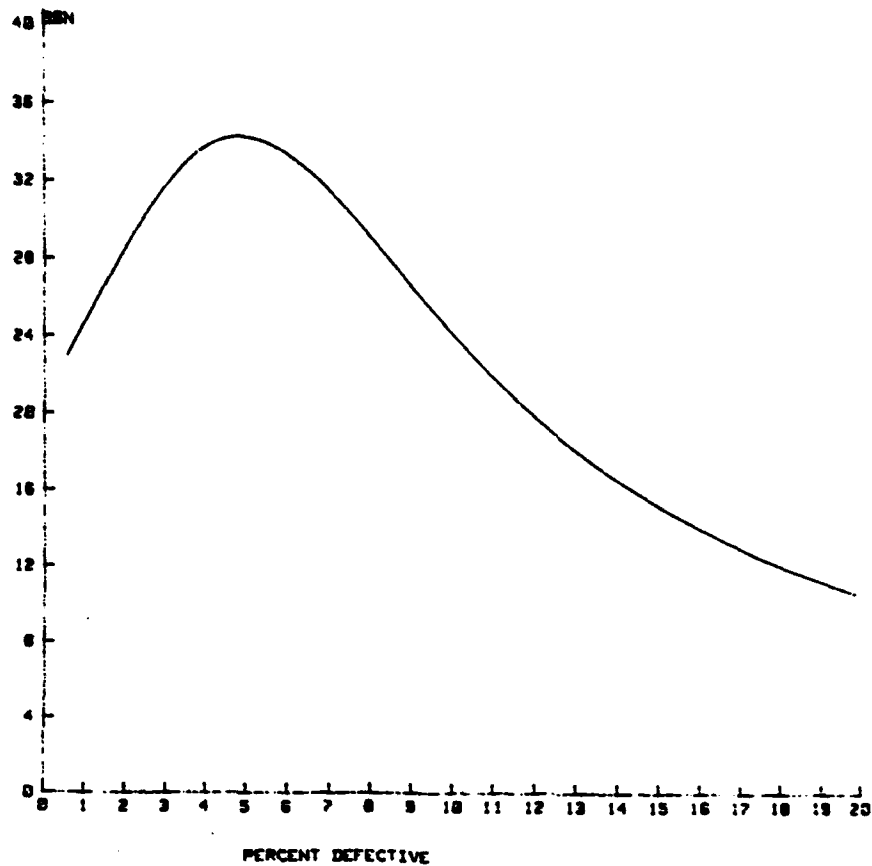
Table 24. Parametric OC Curve and ASN Plot Points (continued)

Percent Defective	Probability of Acceptance	Average Sample Number	Percent Defective	Probability of Acceptance	Average Sample Number
2.88	88.68%	31.51	14.73	4.59%	15.42
3.01	87.53%	31.86	15.04	4.21%	15.02
3.14	86.29%	32.20	15.35	3.85%	14.63
3.28	84.95%	32.53	15.67	3.52%	14.26
3.42	83.52%	32.84	15.98	3.23%	13.90
3.56	81.97%	33.13	16.30	2.95%	13.56
3.71	80.33%	33.40	16.62	2.70%	13.23
3.87	78.58%	33.63	16.93	2.47%	12.91
4.03	76.73%	33.84	17.25	2.26%	12.61
4.19	74.77%	34.01	17.57	2.07%	12.31
4.36	72.72%	34.14	17.89	1.89%	12.03
4.53	70.57%	34.23	18.21	1.73%	11.76
4.71	68.34%	34.27	18.53	1.58%	11.50
4.89	66.03%	34.27	18.85	1.45%	11.25
5.08	63.65%	34.21	19.17	1.32%	11.00
5.27	61.22%	34.11	19.49	1.21%	10.77
5.47	58.73%	33.95	19.81	1.10%	10.55



**Figure 24. Parametric OC Curve for Wald's Sequential Sampling Plan**





*Figure 25. Parametric ASN Plot for Wald's Sequential Sampling Plan*

#### **F. Truncated Sequential Sampling or Any Convergent Plan Assessment**

The greatest disadvantages associated with a sequential sampling plan are the complexity of implementing the plan and the possibility of an indefinite sample size. Consequently, many sequential sampling plans are 'made' to converge by truncating the plan. Truncating a sequential plan simply means that at some point in sampling the acceptance number plus one is made to equal the rejection number. This assures that sampling will not go beyond that point. Further modifications are often made by adjusting the numerical values of either the acceptance number or the rejection number or both. The result of this process is that the maximum sample size is guaranteed to be less than or equal to the  $n$  value associated with the point of convergence. This guarantee is offset by changes in the probability of acceptance and ASN from that assessed for the original sequential sampling plan.

As an example, consider the sequential plan shown in Table 23. Suppose the plan was altered to assure that the maximum sample size would be 50. One such alteration is shown in Table 25. The altered plan is similar to the sequential plan, but upon a close comparison it will be seen that both the acceptance and rejection numbers have been slightly altered for selected values of cumulative sample size. These alterations convert the sequential plan into a multiple sampling plan and as such possesses its own unique OC curve and ASN relationship. Option 5 (Fig. 4) can be used to expedite the assessment of the probability of acceptance and expected

sample size versus the appropriate quality characteristic, percent defective or defectives per lot. The choice of which quality characteristic is dependent on the assumption concerning lot size.

Table 25. A Sequential Sampling Plan Truncation Alternative

Total Number of Units Sampled	Cumulative Acceptance Number (A)	Cumulative Continuance Numbers (C)												Cumulative Rejection Number (R)
		X	0	1	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	
2	***	X	0	1	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	2
3	***	X	0	1	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	2
4	***	X	0	1	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	2
5	***	X	0	1	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	2
6	***	X	0	1	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	2
7	***	X	0	1	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	2
8	***	X	0	1	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	2
9	***	X	0	1	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	2
10	***	X	0	1	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	2
11	***	X	0	1	2	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	3
12	***	X	0	1	2	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	3
13	***	X	0	1	2	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	3
14	***	X	0	1	2	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	3
15	***	X	0	1	2	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	3
16	***	X	0	1	2	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	3
17	***	X	0	1	2	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	3
18	***	X	0	1	2	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	3
19	***	X	0	1	2	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	3
20	0	X	1	2	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	3
21	0	X	1	2	3	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	4
22	0	X	1	2	3	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	4
23	0	X	1	2	3	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	4
24	0	X	1	2	3	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	4
25	0	X	1	2	3	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	4
26	0	X	1	2	3	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	4
27	0	X	1	2	3	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	4
28	0	X	1	2	3	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	4
29	0	X	1	2	3	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	4
30	1	X	2	3	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	4
31	1	X	2	3	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	4
32	1	X	2	3	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	4
33	1	X	2	3	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	4
34	1	X	2	3	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	4
35	1	X	2	3	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	4
36	2	X	3	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	4
37	2	X	3	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	4
38	2	X	3	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	4
39	2	X	3	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	4

Table 25. A Sequential Sampling Plan Truncation Alternative (continued)

Total Number of Units Sampled	Cumulative Acceptance Number (A)	Cumulative Continuance Numbers (C)												Cumulative Rejection Number (R)
		x	3	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	
40	2	x	3	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	4
41	2	x	3	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	4
42	2	x	3	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	4
43	2	x	3	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	4
44	2	x	3	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	4
45	2	x	3	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	4
46	2	x	3	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	4
47	2	x	3	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	4
48	2	x	3	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	4
49	2	x	3	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	4
50	3	x	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	4

The multiple sampling plan shown in Table 25 was entered via the Option 5 prompts in Figure 4. The resulting OC curve is depicted in Figure 26, and the average sample number plot is shown in Figure 27. Table 26 contains selected points from the two referenced schematics. Also, the impacts of altering the sequential sampling plan to assure a maximum, sample size of 50 is shown in Table 27. It is important to point out that the comparisons shown in Table 27 are valid only for the multiple sampling plan contained in Table 25. Any other alteration of the sequential sampling plan would require a similar comparison.

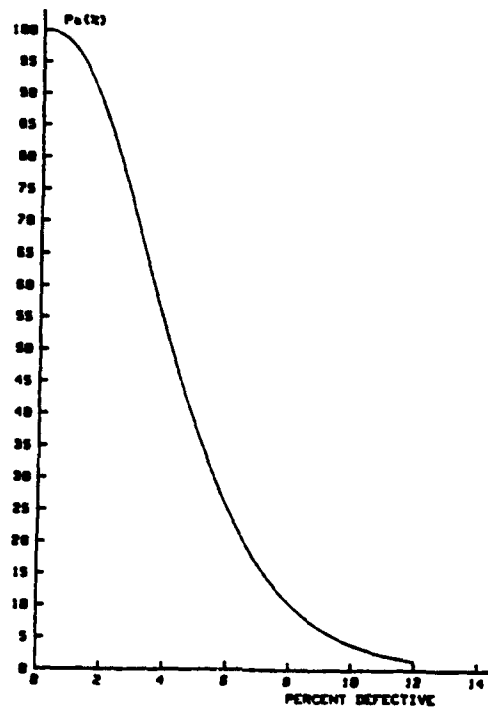


Figure 26. OC Curve for the Truncated Sequential Sampling Plan

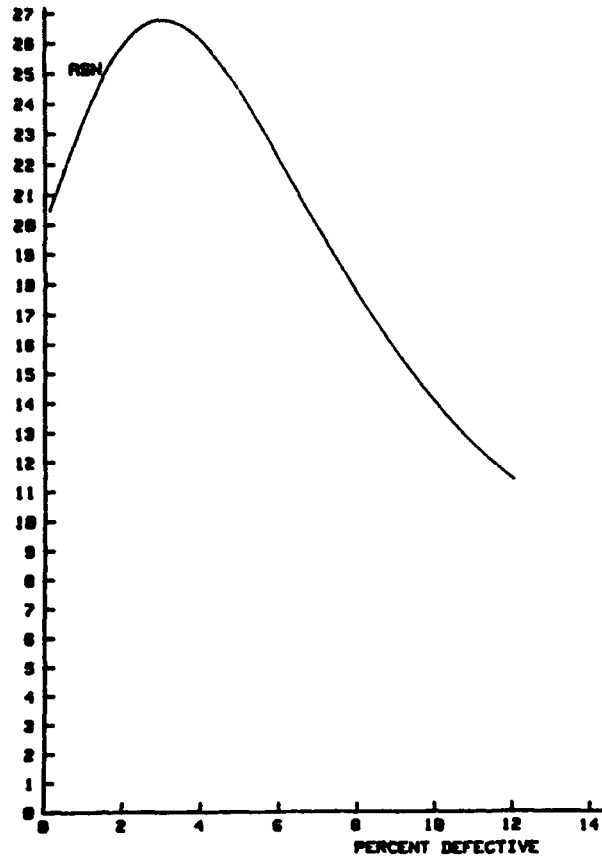


Figure 27. ASN Plot for the Truncated Sequential Sampling Plan

Table 26. Probability of Acceptance and Expected Sample Size for the Truncated Sequential Sampling Plan Alternative

Percent Defective	Acceptance Probability	Average Sample Number
1.00%	97.60%	23.5
2.00%	87.68%	26.0
4.00%	53.59%	26.0
6.00%	25.30%	22.0
8.00%	10.35%	17.6
10.00%	3.93%	14.0
12.00%	1.44%	11.3

Table 27. Sequential Versus Truncated Sequential Comparison

Plan Parameter	Wald's Sequential	Table 25's Truncated Plan
Producer's Risk	5%	12.32%
Consumer's Risk	10%	1.44%
ASN @ AQL	28.63	26.00
ASN @ LTPD	19.20	11.30

It is not the intention of this guide to discuss the relative value of one plan over another. The intent is simply to present automated quantitative techniques to enhance the user's ability to efficiently and precisely design and assess lot acceptance sampling plans. The example discussed above is based on a Binomial evaluation of event probabilities. A Hypergeometric evaluation and another aspect of Option 5 of Figure 4 are discussed below.

The manner in which samples are drawn alters the risks and expected sample sizes, if the method of sampling departs from that specified by the plan. To illustrate, suppose the plan shown in Table 25 is to be used in conjunction with a lot containing 500 units. Instead of the single unit, consecutive sampling indicated in Table 25, the sampling is constrained to be clustered as shown in Table 28. Simply stated, accept/reject decisions can occur only after a sample number has been drawn (i. e., there are thirteen points at which a lot can be accepted or rejected). This type of sampling often occurs in ripple firing or multiple launch missile/rocket firings. The sampling plan shown in Table 25 can easily be modified to accommodate the cluster sampling scenario and can be detailed as shown in Table 29.

Table 28. Cluster Sampling Constraints

Sample Number	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12	#13
Sampling Increment	6	3	2	1	6	2	6	4	6	5	4	3	2
Cumulative Sample Size	6	9	11	12	18	20	26	30	36	41	45	48	50

Table 29. Cluster Sampling Acceptance/Rejection Criteria

Total Number of Units Sampled	Cumulative Acceptance Number (A)	Cumulative Continuance Numbers (C)											Cumulative Rejection Number (R)	
		x	0	1	2	3	xxx	xxx	xxx	xxx	xxx	xxx		xxx
6	***	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
9	***	x	0	1	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2
11	***	x	0	1	2	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	3
12	***	x	0	1	2	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	3
18	***	x	0	1	2	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	3
20	0	x	1	2	3	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	4
26	0	x	1	2	3	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	4
30	1	x	2	3	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	4
36	2	x	3	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	4
41	2	x	3	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	4
45	2	x	3	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	4
48	2	x	3	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	4
50	3	x	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	4

Two alterations of the assumptions under which Figure 26 and Figure 27 were constructed will cause significant departures in the actual operating characteristic curve and average sample number plot of the implemented plan. The first alteration is the fact that a finite lot size of 500 units is known which requires a Hypergeometric evaluation in lieu of a Binomial evaluation. The second alteration is that there are 49 accept/reject decision points in Table 25, and there are only 13 such points in Table 29. The effect of these two alterations can be readily assessed by Option 5 of Figure 4.

Upon entering the sample size values at which accept/reject decisions are made and the respective acceptance numbers and rejection numbers at these sample sizes, via Option 5's prompts the OC curve shown in Figure 28 is obtained. Additionally, the expected number sampled to a decision is shown in the ASN plot included as Figure 29, the effect of clustering the samples, as described above, and the application of a finite lot size of 500 on the truncated sampling plan, shown in Table 25 is summarized in Table 30.

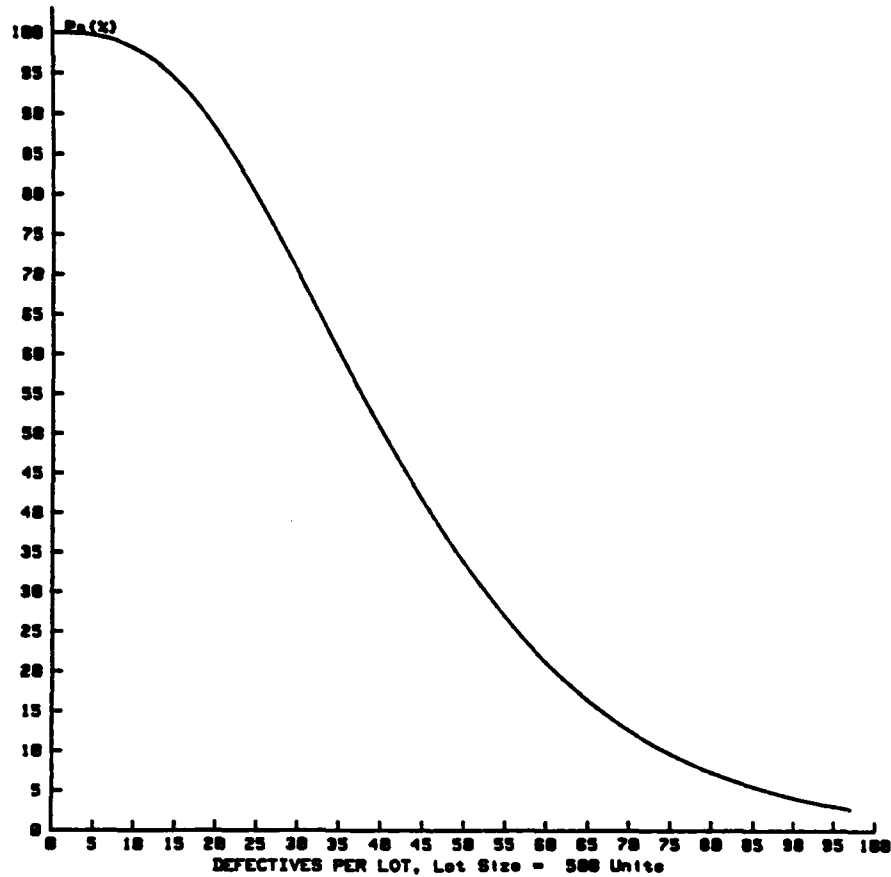


Figure 28. Cluster Sampling OC Curve

Table 30. Truncated Versus Cluster Sampling Comparison

Plan Parameter	Truncated	Clustered
Producer's Risk	12.23%	1.93%
Consumer's Risk	1.44%	21.22%
ASN @ AQL	28.63	28.30
ASN @ LTPD	19.20	23.30

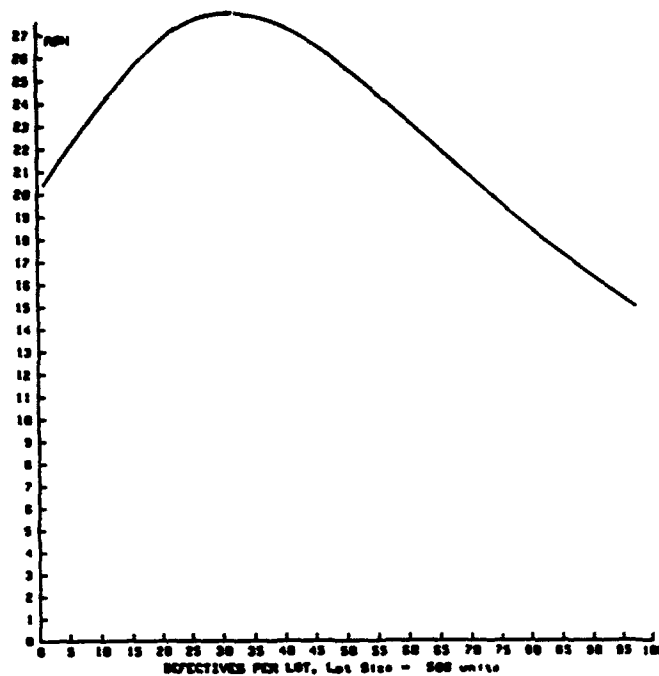


Figure 29. Cluster Sampling ASN Plot

### G. Summary

The purpose of this section is to provide a series of example problems and the associated output which collectively, provide an exhaustive illustration of the scope of application of the software attached hereto as appendixes. The prime consideration, repetitively stated within this section, is that no approximations of event probabilities are made. Moreover, the event probabilities are calculated by the Hypergeometric distribution when finite lot sizes are a consideration, and they are calculated by the Binomial distribution when finite lot sizes are not a consideration.

The increased precision of risk forecasts and expected sample size expenditures to a decision is a significant advantage; however it is only one aspect of this software. Option 5 of Figure 4 is perhaps the most significant advantage in that it affords expedient risk assessments and ASN evaluations for any and all convergent sampling plans. This generic evaluator could, if desired, replace large portions of the software devoted to the evaluation of these parameters in Options 1, 2, and 3.

### III. CONCLUSIONS AND EXTENSIONS

The primary technical advantage provided by the use of LAVAS is the automation of the tremendous calculation burden imposed in performing event probability evaluations using the Binomial or the Hypergeometric distributions. The burden is well recognized as being significant as evidenced by the proliferation of approximation techniques found in current literature pertaining to attribute sampling for lot acceptance. Regardless of the efficiency of a particular approximation technique, it is just that, an approximation technique which infers some degree of error. Destructive testing of modern missiles and/or rockets imposes such austere cost accruals that precision in risk assessments is vital.

Additionally, LAVAS provides risk assessments for any convergent sampling plan, in addition to the common plan types. This feature is particularly useful and expeditious when sequential sampling plans are truncated or when multiple sampling plans with variable incremental sample sizes are to be evaluated. In short, LAVAS can be effectively used to precisely construct OC curves and ASN plots for any attribute sampling plan. LAVAS also includes selected design algorithms which will aid the user in deriving attributes sampling plans which are constrained at specified risk levels. These design features also include provisions set forth in MIL-STD-105D in that risk design thresholds can be provided as input and MIL-STD-105D sampling plans, which meet the inputted risk thresholds will be specified as output. In conclusion, LAVAS can be viewed as a sampling plan design aid and an extensive, precise sampling plan risk assessor.

Future efforts to enhance the methodology automated in LAVAS are envisioned to be focused on two areas. First, faster execution is desirable. To that end, faster techniques will be researched to perform the factorial ratios required for both the Binomial and the Hypergeometric distributions. Additionally, a design feature is desired which will aid in the derivation of tailor made multiple sampling plans with variable incremental sample sizes which will allow the user to constrain the total number sampled at specified risk levels.



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**APPENDIX A**  
**LAVAS's SOURCE CODE**

## APPENDIX A LAVAS's SOURCE CODE

```

10  PRINTER IS 0
20  DIM Pa(10,301),Asn(301),DistS(15),Pd(301),F(10),Jmc(31,9),Con(501),Comp(50
1),Pr(5,501),Cont(501),Ccea(2,17,0),Mila(17,2),Mile(17,2),Mila(17)
30  DIM $105a(17),$105c(15),Nuns(102)(3),TabS(20)(3),Table(501,3),Multi(50,13)
, Fig(51,501),Figg(51,501),Lima(51)
40  DIM Ccat(20,24),Mspiar(15,7,2),Mspian(30)
50  DATA " 1", " 2", " 3", " 4", " 5", " 6", " 7", " 8", " 9", " 10", " 11", " 1
2", " 13", " 14", " 15", " 16", " 17", " 18", " 19", " 20", " 21", " 22", " 23", " 24"
60  DATA " 25", " 26", " 27", " 28", " 29", " 30", " 31", " 32", " 33", " 34", " 35", " 3
6", " 37", " 38", " 39", " 40", " 41", " 42", " 43", " 44", " 45", " 46", " 47", " 48", " 49"
70  DATA " 50", " 51", " 52", " 53", " 54", " 55", " 56", " 57", " 58", " 59", " 60", " 6
1", " 62", " 63", " 64", " 65", " 66", " 67", " 68", " 69", " 70", " 71", " 72", " 73", " 74"
80  DATA " 75", " 76", " 77", " 78", " 79", " 80", " 81", " 82", " 83", " 84", " 85", " 8
6", " 87", " 88", " 89", " 90", " 91", " 92", " 93", " 94", " 95", " 96", " 97", " 98", " 99"
90  DATA "100", " 0", "****"
100 FOR I=1 TO 102
110 READ Nuns(I)
120 NEXT I
130 BEEP
140 FOR I=1 TO 31
150 FOR J=1 TO 9
160 READ Jmc(I,J)
170 NEXT J
180 BEEP
190 NEXT I
200 DATA 0,.01,.051,.105,.693,2.303,2.996,4.605,44.89
210 DATA 1,.149,.355,.532,1.670,3.89,4.744,6.630,10.946
220 DATA 2,.436,.818,1.102,2.674,5.322,6.296,8.406,6.509
230 DATA 3,.823,1.366,1.745,3.672,6.681,7.754,10.045,4.89
240 DATA 4,1.279,1.97,2.433,4.671,7.994,9.154,11.605,4.057
250 DATA 5,1.705,2.613,3.152,5.67,9.275,10.513,13.100,3.549
260 DATA 6,2.33,3.206,3.895,6.67,10.532,11.842,14.571,3.206
270 DATA 7,2.986,3.981,4.656,7.669,11.771,13.148,16.2.957
280 DATA 8,3.507,4.695,5.432,8.669,12.995,14.434,17.403,2.760
290 DATA 9,4.13,5.426,6.221,9.669,14.206,15.705,18.703,2.610
300 DATA 10,4.771,6.169,7.021,10.660,15.407,16.962,20.145,2.497
310 DATA 11,5.420,6.924,7.829,11.660,16.598,18.200,21.49,2.397
320 DATA 12,6.099,7.69,8.646,12.660,17.702,19.442,22.021,2.312
330 DATA 13,6.782,8.464,9.47,13.660,18.950,20.660,24.139,2.24
340 DATA 14,7.477,9.246,10.3,14.660,20.120,21.806,25.446,2.177
350 DATA 15,8.181,10.035,11.135,15.660,21.292,23.090,26.743,2.122
360 DATA 16,8.895,10.831,11.976,16.660,22.452,24.302,28.031,2.073
370 DATA 17,9.616,11.633,12.822,17.660,23.606,25.5.29.31,2.029
380 DATA 18,10.346,12.442,13.672,18.660,24.756,26.692,30.501,1.99
390 DATA 19,11.082,13.254,14.525,19.660,25.902,27.879,31.845,1.954
400 DATA 20,11.825,14.072,15.303,20.660,27.045,29.062,33.103,1.922
410 DATA 21,12.574,14.894,16.244,21.660,28.104,30.241,34.355,1.892
420 DATA 22,13.329,15.719,17.100,22.660,29.32,31.416,35.601,1.865
430 DATA 23,14.088,16.540,17.975,23.660,30.453,32.506,36.841,1.84
440 DATA 24,14.853,17.302,18.844,24.660,31.504,33.752,38.077,1.817
450 DATA 25,15.623,18.210,19.717,25.667,32.711,34.916,39.300,1.795
460 DATA 30,19.532,22.444,24.113,30.667,20.315,40.69,45.4,1.707
470 DATA 35,23.525,26.731,28.556,35.667,43.872,46.404,51.409,1.641
480 DATA 40,27.507,31.066,33.030,40.667,49.39,52.069,57.347,1.59
490 DATA 45,31.704,35.441,37.550,45.667,54.870,57.695,63.231,1.548
500 DATA 50,35.867,39.849,42.009,50.667,60.339,63.207,69.066,1.515
510 FOR I=1 TO 2
520 IF I=1 THEN Lim=16
530 IF I=2 THEN Lim=17
540 FOR J=1 TO Lim
550 FOR K=1 TO 0
560 READ Ccea(I,J,K)
570 NEXT K
580 NEXT J
590 BEEP
600 NEXT I
610 FOR I=1 TO 16
620 READ Mila(I,1),Mila(I,2),Mile(I,1),Mile(I,2)
630 NEXT I
640 FOR I=1 TO 16
650 READ Mila(I)
660 NEXT I
670 BEEP

```

680 DATA 1,14.5,0,1,.16,.84,2.32,1.273,2,8.07,0,2,.3,1.07,2.42,1.511  
690 DATA 3,6.48,1,3,.6,1.0,3.09,1.238,4,5.39,0,3,.49,1.35,2.64,1.771,5,5.09,1,  
4,.77,1.97,3.92,1.359  
700 DATA 6,4.31,0,4,.68,1.64,2.93,1.985,7,4.19,1,5,.96,2.10,4.02,1.498,8,3.6,1  
,6,1.16,2.44,4.17,1.646,9,3.26,2,0,1.69,3.28,5.47,1.476  
710 DATA 10,2.96,3,10,2.27,4.13,6.72,1.388,11,2.77,3,11,2.46,4.36,6.82,1.468,1  
2,2.62,4,13,3.07,5.21,8.05,1.394,13,2.46,4,14,3.29,5.4,8.11,1.472  
720 DATA 14,2.21,3,15,3.41,5.4,7.55,1.088,15,1.97,4,20,4.75,7.02,9.35,2.029,16  
,1.74,6.30,7.45,10.31,12.96,2.23  
730 DATA 1,11.9,0,1,.21,1,2.5,1.17,2,7.54,1,2,.52,1.02,3.92,1.081,3,6.79,0,2,  
43,1.42,2.96,1.34,4,5.39,1,3,.76,2.11,4.11,1.169,5,4.65,2,4,1.16,2.9,5.39,1.105  
740 DATA 6,4.25,1,4,1.04,2.5,4.42,1.274,7,3.88,2,5,1.43,3.2,5.55,1.17,0,3.63,3  
,6,1.07,3.98,6.78,1.117,9,3.38,2,6,1.72,3.56,5.02,1.248  
750 DATA 10,3.21,3,7,2.15,4.27,6.91,1.173,11,3.09,4,0,2.62,5.02,0.1,1.12,12,2  
.05,4,9,2.9,5.33,0.26,1.167,13,2.6,5,11,3.60,6.4,9.56,1.166  
760 DATA 14,2.44,5,12,4.6,73,9.77,1.215,15,2.32,5,13,4.35,7.06,10.28,1.271,16,  
2.22,5,14,4.7,7.52,10.45,1.331,17,2.12,5,16,5.39,0.4,11.41,1.452  
770 DATA 0,1,2,2,0,3,3,4,1,4,4,5,2,6,5,7,3,0,7,9,3,11,7,12,5,12,9,13,6,15,10,1  
6,7,10,11,19,9,23,14,24,11,26,16,27,13,34,20,35,15,34,20,35,17,37,22,38  
780 DATA 23,52,29,53,25,56,31,57  
790 DATA 2,3,5,8,13,20,32,50,00,125,200,315,500,000,1250,2000  
800 DATA 2,3,5,8,13,20,32,50,00,125,200,315,500,000,1250,2000,3150  
810 DATA 1,2,3,5,7,0,10,12,14,10,21,27,30,41,44  
820 DATA 1,10.46,-5,-5,0,0,1,2,3,100,100  
830 DATA 2,2,2,2,3,4,4,100,100  
840 DATA .040,.30,.09,3.243  
850 DATA 2,12.15,-5,-5,-5,0,0,1,2,100,100  
860 DATA 2,2,2,2,2,3,3,100,100  
870 DATA .065,.31,.79,4.373  
880 DATA 3,9.95,-5,-5,0,0,1,2,4,100,100  
890 DATA 2,2,2,3,3,4,5,100,100  
900 DATA .1,.43,1,3,461  
910 DATA 4,8.91,-5,-5,0,0,0,0,2,100,2,2,2,2,2,3,3,3,100,.008,.34,.78,3.876  
920 DATA 5,8.06,-5,-5,0,0,0,0,1,2,2,2,2,3,3,3,3,3,.093,.36,.75,4.077  
930 DATA 6,7.04,-5,0,0,1,1,1,2,3,100,2,3,3,3,4,4,4,100,.18,.62,1.27,2.628  
940 DATA 7,6.20,-5,0,1,1,2,3,4,100,100,2,3,3,3,4,5,5,100,100,.24,.74,1.48,2.51  
5  
950 DATA 8,4.95,-5,0,1,2,4,4,5,100,100,2,3,4,5,6,6,6,100,100,.31,.64,1.55,2.60  
6  
960 DATA 9,4.61,-5,0,0,1,2,3,4,6,100,3,3,4,4,5,6,7,7,100,.31,.70,1.43,3.268  
970 DATA 10,4.29,0,2,3,5,7,8,10,100,100,4,5,7,9,10,11,11,100,100,.63,1.73,2.93  
,1.727  
980 DATA 11,4.02,-5,1,2,3,4,6,7,100,100,3,4,5,6,6,8,0,100,100,.47,1.14,1.89,2.  
300  
990 DATA 12,3.75,-5,1,1,2,3,5,7,100,100,3,4,5,6,6,8,0,100,100,.56,1.23,2.11,2.  
039  
1000 DATA 13,3.56,-5,1,1,3,4,5,7,9,100,3,5,6,7,8,9,10,10,100,.59,1.26,2.10,2.07  
2  
1010 DATA 14,3.23,0,2,3,4,6,8,11,100,100,4,5,0,9,10,12,12,100,100,.96,1.92,3.10  
,2.210  
1020 DATA 15,3.03,0,3,6,8,10,12,14,100,100,4,7,9,11,12,14,15,100,100,1.2,2.34,3  
.64,1.091  
1030 DATA 16,2.69,1,3,6,9,11,14,17,100,100,5,7,10,13,15,18,18,100,100,1.56,2.75  
,4.20,1.039  
1040 DATA 17,2.54,1,3,6,9,13,16,19,100,100,5,8,11,13,16,19,100,100,1.60,2.03  
,4.06,1.911  
1050 DATA 18,2.35,1,5,7,10,13,17,22,100,100,6,9,12,16,19,21,23,100,100,2.00,3.3  
4,4.70,1.982  
1060 DATA 19,2.16,1,5,9,13,18,22,25,100,100,7,10,13,16,22,25,26,100,100,2.40,3.  
77,5.19,2.130  
1070 DATA 20,1.94,3,0,13,18,24,30,36,100,100,8,15,20,25,30,34,37,100,100,3.74,5  
.46,7.26,1.967  
1080 DATA -5,-5,0,0,1,1,2,2,2,2,3,3,3,3  
1090 DATA -5,0,0,1,2,3,4,2,3,3,4,4,5,5  
1100 DATA -5,0,1,2,3,4,6,3,3,4,5,6,6,7  
1110 DATA -5,1,2,3,5,7,9,4,5,6,7,0,9,10  
1120 DATA 0,1,3,5,7,10,13,4,6,8,10,11,12,14  
1130 DATA 0,2,4,6,9,12,14,4,7,9,11,12,14,15  
1140 DATA 0,3,6,8,11,14,18,5,8,10,13,15,17,19  
1150 DATA 0,3,7,10,14,18,21,6,9,12,15,17,20,22  
1160 DATA 1,4,0,12,17,21,25,7,10,13,17,20,23,26  
1170 DATA 1,6,11,16,22,27,32,8,12,17,22,25,29,33  
1180 DATA 2,7,13,19,25,31,37,9,14,19,25,29,33,38  
1190 DATA 3,10,17,24,32,40,48,10,17,24,31,37,43,49  
1200 DATA 4,11,19,27,36,45,53,12,19,27,34,40,47,54

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1210 DATA 6,16,26,37,49,61,72,15,25,36,46,55,64,73
1220 DATA 6,17,29,40,53,65,77,16,27,39,49,58,68,78
1230 DATA 2,3,4,5,6,7,8,9,10,11,12,13,14,15,18,20,24,32,36,48,50
1240 FOR I=1 TO 17
1250 READ $105a(I)
1260 NEXT I
1270 FOR I=1 TO 15
1280 READ $105c(I)
1290 NEXT I
1300 BEEP
1310 FOR I=1 TO 20
1320 FOR J=1 TO 24
1330 READ Ccat(I,J)
1340 NEXT J
1350 BEEP
1360 DISP
1370 NEXT I
1380 FOR I=1 TO 15
1390 FOR J=1 TO 7
1400 READ Msp1ar(I,J,1)
1410 NEXT J
1420 FOR J=1 TO 7
1430 READ Msp1ar(I,J,2)
1440 NEXT J
1450 BEEP
1460 NEXT I
1470 FOR I=1 TO 21
1480 READ Msp1an(I)
1490 NEXT I
1500 BEEP
1510 DISP
1520 DISP "
1530 DISP "
"
1540 DISP "          LOT ACCEPTANCE SAMPLING OPTIONS
"
1550 DISP "   Option Description                                Select Code
"
1560 DISP "   >Single Sampling Design And Assessment.....1
"
1570 DISP "   >Double Sampling Design And Assessment.....2
"
1580 DISP "   >Multiple Sampling Design And Assessment.....3
"
1590 DISP "   >Sequential Sampling Design And Assessment.....4
"
1600 DISP "   >Truncated Sequential Sampling or Any Convergent
"
1610 DISP "   Plan Assessment(i.e., OC Curve & ASN Curve).....5
"
1620 DISP "   >Program Termination.....6
"
"
1630 DISP "
1640 DISP
1650 DISP "ENTER THE SELECT CODE OF THE DESIRED OPTION."
1660 DISP
1670 BEEP
1680 INPUT Sc
1690 IF Sc=6 THEN DISP
1700 IF Sc=6 THEN DISP "Bye Bye!"
1710 IF Sc=6 THEN DISP
1720 IF Sc=6 THEN BEEP
1730 IF Sc=6 THEN STOP
1740 DISP
1750 DISP "          LOADING SELECTED OPTION!          "
1760 DISP
1770 IF Sc=1 THEN LINK "Single:C12",2000
1780 IF Sc=2 THEN LINK "Double:C12",2000
1790 IF Sc=3 THEN LINK "Multi:C12",2000
1800 IF Sc=4 THEN LINK "Seque:C12",2000
1810 IF Sc=5 THEN LINK "Spec:C12",2000
1820 IF (Sc=1) OR (Sc=2) OR (Sc=3) OR (Sc=4) OR (Sc=5) THEN 1960
1830 FOR I=1 TO 11
1840 DISP

```

```
1050 DISP -
1060 DISP -
1070 DISP -
1080 DISP
1090 DISP -
1000 DISP -
1010 DISP -
1020 DISP
1030 BEEP
1040 INPUT R0
1050 GOTO 1510
1060 GOSUB 2000
1070 STOP
```

**APPENDIX B**  
**SINGLE SAMPLING DESIGN AND ASSESSMENT SOURCE CODE**

## APPENDIX B

### SINGLE SAMPLING DESIGN AND ASSESSMENT SOURCE CODE

```

2000 REM          **** SINGLE SAMPLE DESIGN AND/OR RISK ASSESSMENT ****
2010 DISP
2020 DISP "
2030 DISP "          > Single Sampling Plan Option Menu <
"
2040 DISP "          Option Description                                Select Code
"
2050 DISP " >OC Curve/Risk Assessment for a Specific Plan.....1
"
2060 DISP " >Plan Derivation for Given AQL, LTPD, ALPHA & BETA...2
"
2070 DISP " >Plan Derivation for a Single Point of Control at
"
2080 DISP " the Indifference Quality (Poisson Based).....3
"
2090 DISP " >Plan Derivation Using J.H. Cameron's Poisson
"
2100 DISP " Approximation of the OC Curve.....4
"
2110 DISP " >Plan Derivation Via MIL-STD-105D Search for
"
2120 DISP " Specific AQL, LTPD, ALPHA, & BETA.....5
"
2130 DISP " EXIT This Segment of the Program.....6
"
2140 DISP "
2150 DISP "ENTER THE SELECT CODE OF THE DESIRED OPTION."
2160 DISP
2170 BEEP
2180 INPUT Sc
2190 IF Sc=6 THEN RETURN
2200 IF Sc<>1 THEN 4090
2210 DISP
2220 DISP "          ENTER THE SAMPLE SIZE!"
2230 DISP
2240 BEEP
2250 INPUT Sample
2260 DISP
2270 DISP "          ENTER THE THE ACCEPTANCE NUMBER!"
2280 DISP
2290 BEEP
2300 INPUT Accept
2310 DISP
2320 DISP "          DO YOU HAVE A FINITE LOT SIZE?"
2330 DISP
2340 BEEP
2350 INPUT Res
2360 IF Res="NO" THEN Dist="BINOMIAL"
2370 IF Res="NO" THEN 2550
2380 DISP
2390 DISP "          ENTER THE FINITE LOT SIZE "
2400 DISP
2410 BEEP
2420 INPUT Lsize
2430 Ratio=Sample/Lsize
2440 IF Ratio>=.1 THEN Dist="HYPER"
2450 IF Ratio>=.1 THEN 3790
2460 DISP
2470 DISP "Since the ratio of sample size to lot size is less than ten percent,
"
2480 DISP "it maybe acceptable to use a Binomial Approximation to the Hypergeom
etric."
2490 DISP "DO YOU WISH TO USE THIS APPROXIMATION?"
2500 DISP
2510 BEEP
2520 INPUT Res
2530 IF Res="NO" THEN Dist="HYPER"
2540 IF Res="YES" THEN Dist="BINOMIAL"
2550 IF Dist="HYPER" THEN 3790
2560 S=Sample
2570 P=.001
2580 C=Accept
2590 FOR X=0 TO C
2600 GOSUB 2600
2610 IF X=0 THEN Pacpt=Prob
2620 IF X<>0 THEN Pacpt=Pacpt+Prob
2630 NEXT X

```



```

2640 IF Pacpt<.02 THEN 2010
2650 P=P+.001
2660 BEEP
2670 GOTO 2590
2680 REM BINOMIAL SUBROUTINE
2690 IF (S-X<0) OR (X<0) THEN Prob=0
2700 IF (S-X<0) OR (X<0) THEN RETURN
2710 IF (S-X=0) OR (X=0) THEN Prob=P*X*(1-P)^(S-X)
2720 IF (S-X=0) OR (X=0) THEN RETURN
2730 Prob=1
2740 FOR Is=1 TO X
2750 Prob=Prob*P
2760 NEXT Is
2770 FOR Is=1 TO S-X
2780 Prob=Prob*((X+Is)/Is)*(1-P)
2790 NEXT Is
2800 RETURN
2810 DISP
2820 DISP "The probability of Acceptance is ";Pacpt*100;"% at Percent Defective
"
2830 DISP "equal to ";P*100;"%."
2840 DISP
2850 DISP "What range do you want to include on the OC Curve's Percent Defective
Axis?"
2860 DISP "The entry must be stated as a percent(i.e., fifty percent's entry is
50)."

```

```

3360 IF X=0 THEN Pacpt=Prob
3370 IF X<>0 THEN Pacpt=Prob+Pacpt
3380 NEXT X
3390 PRINT USING 3270;P=100,Pacpt=100
3400 PRINT USING 3260
3410 DISP
3420 DISP " DO YOU WANT AN-ORE? "
3430 DISP
3440 BEEP
3450 INPUT Res
3460 IF Res="NO" THEN 2010
3470 GOTO 3200
3480 REM HYPERGEOMETRIC DISTRIBUTION
3490 IF X<0 THEN Prob=0
3500 IF X<M THEN RETURN
3510 IF X>M THEN Prob=0
3520 IF X>M THEN RETURN
3530 Prob=1
3540 F(1)=K
3550 F(2)=N-K
3560 F(3)=M
3570 F(4)=N-M
3580 F(5)=X
3590 F(6)=K-X
3600 F(7)=N-K
3610 F(8)=N-K-M+X
3620 F(9)=M
3630 FOR Is=1 TO 9
3640 IF F(Is)<1 THEN F(Is)=1
3650 NEXT Is
3660 Prob=Prob*(F(1)*F(2)*F(3)*F(4)/(F(5)*F(6)*F(7)*F(8)*F(9))
3670 FOR Is=1 TO 9
3680 F(Is)=F(Is)-1
3690 IF F(Is)<1 THEN F(Is)=1
3700 NEXT Is
3710 Ck=0
3720 FOR Is=1 TO 9
3730 IF F(Is)=1 THEN 3750
3740 Ck=1
3750 NEXT Is
3760 IF Ck=0 THEN RETURN
3770 GOTO 3660
3780 RETURN
3790 N=Sample
3800 K=1

3810 C=Accept
3820 N=Lsize
3830 FOR X=0 TO C
3840 GOSUB 3400
3850 IF X=0 THEN Pacpt=Prob
3860 IF X<>0 THEN Pacpt=Pacpt+Prob
3870 IF Pacpt>1 THEN Pacpt=1
3880 NEXT X
3890 DISP "K=";K;" is Done! Pa";Pacpt
3900 IF Pacpt<.02 THEN 3940
3910 K=K+1
3920 BEEP
3930 GOTO 3830
3940 DISP
3950 DISP "The probability of acceptance is ";Pacpt*100;"% for ";K;"Defectives"
3960 DISP "in the lot."
3970 DISP
3980 DISP "What range do you want to include on the OC Curve's Defectives Per Lot Axis?"
3990 DISP "The entry must be stated as an integer."
"
4000 DISP
4010 BEEP
4020 INPUT Maxx
4030 Maxx=Maxx+1
4040 DISP
4050 DISP "ENTER THE DESIRED LABELING INTERVAL ON THE DEFECTIVES PER LOT AXIS."
4060 DISP "The entry must be stated as an integer."
"
4070 DISP
4080 BEEP

```

```

4090 INPUT Xint
4100 IF Maxx>100 THEN Lin=100
4110 IF Maxx<100 THEN Lin=Maxx
4120 FOR I=1 TO Lin
4130 Pd(I)=I
4140 K=Pd(I)
4150 C=Accept
4160 N=Lsize
4170 S=Sample
4180 FOR X=0 TO C
4190 GOSUB 3400
4200 IF X=0 THEN Pa(1,I)=Prob
4210 IF X<>0 THEN Pa(1,I)=Prob*Pa(1,I)
4220 IF Pa(1,I)>1 THEN Pa(1,I)=1
4230 NEXT X
4240 DISP "Worked K = ";K
4250 NEXT I
4260 GOSUB 4640
4270 DISP
4280 DISP "DO YOU WANT ANY SPECIFIC POINTS PRINTED?"
4290 DISP
4300 BEEP
4310 INPUT Res
4320 IF Res="NO" THEN 2010
4330 PRINT LIN(4);SPAC(10);"Operating Characteristic (OC) Curve "
4340 PRINT SPAC(2);"Single Sampling Plan: n = ";Sample;" & C = ";Accept
4350 PRINT SPAC(4);"(Hypergeometric Distribution Probabilities)";LIN(1)
4360 PRINT USING 4420
4370 PRINT USING 4400
4380 PRINT USING 4410
4390 PRINT USING 4420
4400 IMAGE 20X,"[Defectives| Probability |"
4410 IMAGE +,20X,"| Per Lot |of Acceptance]"
4420 IMAGE 20X,"
4430 IMAGE +,20X,"|",3X,4D,3X,"|",8D,4D,"|"
4440 DISP
4450 DISP "ENTER THE NUMBER OF DEFECTIVES PER LOT...."
4460 DISP
4470 BEEP
4480 INPUT K
4490 FOR X=0 TO C
4500 GOSUB 3400
4510 IF X=0 THEN Pacpt=Prob
4520 IF X<>0 THEN Pacpt=Prob*Pacpt
4530 IF Pacpt>1 THEN Pacpt=1
4540 NEXT X
4550 PRINT USING 4430;K,Pacpt*100
4560 PRINT USING 4420
4570 DISP
4580 DISP " DO YOU WANT ANYMORE? "
4590 DISP
4600 BEEP
4610 INPUT Res
4620 IF Res="NO" THEN 2010
4630 GOTO 4440
4640 REM OC CURVE
4650 PLOTTER IS "9872:
4660 PLOTTER 7,5 IS ON
4670 LOCATE 10,100,10,100
4680 SCALE 0,Maxx,0,100
4690 CSIZE 2
4700 LAXES Xint,5,0,0,-1,1
4710 MOVE 2*Xint,101
4720 LABEL " Operating Characteristic Curve"
4730 LABEL "Sample Size";Sample;"Acceptance Number:";C
4740 IF Dist="HYPER" THEN LABEL " Hypergeometric Probabilities"
4750 IF Dist="BINOMIAL" THEN LABEL " Binomial Probabilities"
4760 PEN 2
4770 MOVE 0,100
4780 FOR I=1 TO Lin
4790 DRAW Pd(I),Pa(1,I)*100
4800 NEXT I
4810 PEN 1
4820 MOVE 4*Xint,-5
4830 IF Dist="BINOMIAL" THEN LABEL "PERCENT DEFECTIVE"
4840 IF Dist="HYPER" THEN LABEL "DEFECTIVES PER LOT"
4850 MOVE Xint/4,101

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4860 LABEL "Pa(x)"
4870 MOVE 120,120
4880 RETURN
4890 IF Sc(>)3 THEN 5220
4900 REM Point of Control at Indifference Quality
4910 DISP
4920 DISP "          ENTER THE INDIFFERENCE QUALITY...."
4930 DISP "          ENTER THIS PERCENT DEFECTIVE AS A PERCENT. "
4940 DISP
4950 BEEP
4960 INPUT P50p
4970 P50p=P50p/100
4980 FOR C=0 TO 50
4990 Asn(C+1)=(C+.67)/P50p
5000 Ck=INT(Asn(C+1))
5010 IF Asn(I)>Ck THEN Asn(I)=Ck+1
5020 Pa(S,C+1)=C
5030 NEXT C
5040 IMAGE 25X,"Single Sample Sampling Plans"
5050 IMAGE 20X,"For An Indifference Quality of ",3D.2D,"%"
5060 IMAGE 10X,"
5070 IMAGE 10X," | Sample | Acceptance | Sample | Acceptance | Sample | Acceptance |
5080 IMAGE 10X," | Size   | Number   | Size   | Number   | Size   | Number   |
5090 IMAGE +,10X," |",3(1X,4D,1X," |",3X,4D,3X," |")
5100 PRINT LIN(4)
5110 PRINT USING 5040
5120 PRINT USING 5050;P50p*100
5130 PRINT USING 5060
5140 PRINT USING 5070
5150 PRINT USING 5080
5160 FOR I=1 TO 17
5170 PRINT USING 5090;Asn(I),Pa(S,I),Asn(I+17),Pa(S,I+17),Asn(I+34),Pa(S,I+34)
5180 PRINT USING 5060
5190 NEXT I
5200 PRINT LIN(2);SPA(10);"Any of these plans can be evaluated by exercising Op
tion 01";LIN(4)
5210 GOTO 2010
5220 IF Sc(>)4 THEN 5050
5230 DISP
5240 DISP " DO YOU HAVE A QUALITY LEVEL AT WHICH YOU WISH A 99%, 95%, 90%, 50%
, 10%
"
5250 DISP " 5% OR 1% PROBABILITY OF ACCEPTANCE.
"
5260 DISP
5270 BEEP
5280 INPUT Rs
5290 IF Rs="NO" THEN 5700
5300 DISP
5310 DISP " ENTER THE QUALITY LEVEL AND THE PROBABILITY OF ACCEPTANCE AT THAT
"
5320 DISP " QUALITY LEVEL. BOTH ENTRIES MUST BE STATED AS PERCENTS.
"
5330 BEEP
5340 INPUT Pert,Pofa
5350 Pert=Pert/100
5360 Pofa=Pofa/100
5370 IF Pofa=.99 THEN Col=2
5380 IF Pofa=.95 THEN Col=3
5390 IF Pofa=.9 THEN Col=4
5400 IF Pofa=.50 THEN Col=5
5410 IF Pofa=.1 THEN Col=6
5420 IF Pofa=.05 THEN Col=7
5430 IF Pofa=.01 THEN Col=8
5440 PRINT LIN(4)
5450 IMAGE 25X,"Single Sample Sampling Plans"
5460 IMAGE 20X,"J.M. Cameron's Poisson Approximations"
5470 IMAGE 17X,"Where The Probability of Acceptance is",3D.2D,"%"
5480 IMAGE 19X,"When The Percent Defective is ",3D.2D,"%",/
5490 PRINT USING 5450
5500 IMAGE "
"
5510 IMAGE " | Percent Defective Specifications For Which The
Poisson | "
5520 IMAGE " |
"

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5530 IMAGE " |Sample|Acceptance| Approximation Of the Probability of Acceptan
ce is "
5540 IMAGE " | Size | Number | 99% | 95% | 90% | 50% | 10% | 5%
| 1% |
5550 IMAGE "+, ",1X,4D,1X,"-,4X,2D,4X,"|",7(4D,2D,"|")
5560 PRINT USING 5460
5570 PRINT USING 5470;Pofac:100
5580 PRINT USING 5480;Perte:100
5590 PRINT USING 5500
5600 PRINT USING 5510
5610 PRINT USING 5530
5620 PRINT USING 5540
5630 FOR I=1 TO 31
5640 F(2)=Jac(I,1)
5650 Sam=Jac(I,Col)/Pert
5660 Ck=INT(Sam)
5670 IF Sam>Ck THEN Sam=Ck+1
5680 F(1)=Sam
5690 F(2)=Jac(I,1)
5700 FOR J=2 TO 9
5710 F(J+1)=100*Jac(I,J)/Sam
5720 NEXT J
5730 PRINT USING 5550;F(1),F(2),F(3),F(4),F(5),F(6),F(7),F(8),F(9)
5740 PRINT USING 5520
5750 NEXT I
5760 PRINT LIN(2);SPA(10);"Any of these plans can be evaluated by exercising Op
tion 01";LIN(4)
5770 GOTO 2010
5780 DISP
5790 DISP " TO EXERCISE THIS OPTION, YOU MUST ENTER ONE OF THE OPTIONAL POINT
S SPECIFIED!"
5800 DISP
5810 BEEP
5820 DISP "
5830 BEEP
5840 GOTO 2010
5850 IF Sc<2 THEN 0010
5860 DISP
5870 FOR I=1 TO 6
5880 IF I=1 THEN DISP " Enter the Acceptable Quality Level, STATED AS A PERC
ENT! "
5890 IF I=2 THEN DISP " Enter the Lot Tolerance Percent Defective,STATED AS
A PERCENT! "
5900 IF I=3 THEN DISP " Enter the Producer's Risk,STATED AS A PERCENT! "
5910 IF I=4 THEN DISP " Enter the Consumer's Risk,STATED AS A PERCENT! "
5920 IF I=5 THEN DISP " Enter the Producer's Risk Tolerance limit,STATED AS
A PERCENT! "
5930 IF I=6 THEN DISP " Enter the Consumer's Risk Tolerance limit,STATED AS
A PERCENT! "
5940 DISP
5950 BEEP
5960 IF I=1 THEN INPUT Aq1
5970 IF I=2 THEN INPUT Ltpd
5980 IF I=3 THEN INPUT Alpha
5990 IF I=4 THEN INPUT Beta
6000 IF I=5 THEN INPUT Atol
6010 IF I=6 THEN INPUT Btol
6020 NEXT I
6030 Aq1=Aq1/100
6040 Ltpd=Ltpd/100
6050 Alpha=Alpha/100
6060 Beta=Beta/100
6070 Btol=Btol/100
6080 Atol=Atol/100
6090 Print#0
6100 Maxn=1000000
6110 DISP
6120 DISP " DO YOU HAVE A MAXIMUM SAMPLE SIZE? "
6130 DISP
6140 BEEP
6150 INPUT Res
6160 IF Res="NO" THEN 6220
6170 DISP
6180 DISP "
6190 DISP " ENTER THE MAXIMUM SAMPLE SIZE"
6200 BEEP

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6210 INPUT Maxn
6220 IMAGE /,/,/,/,10X,"Optional Single Sampling Plans Which "
6230 IMAGE 10X,"Producer's Risk = ",3D.2D,"%",3D.2D,"%",10X,"Consumer's Risk
k = ",3D.2D,"%",3D.2D,"%",10X,"For AQL=",3D.2D,"% & LTPD=",3D.2D,"%",/
6240 IMAGE 10X,"
6250 IMAGE 10X,"
6260 IMAGE 10X,"


| Sample Size | Acceptance Number | Producer's Risk | Consumer's Risk  |
|-------------|-------------------|-----------------|------------------|
| 10X,        | 6D,               | 3X,4D,3X,       | 2X,3D.2D,"%",1X, |


6270 IMAGE +,10X,"|",3D.2D,"%",1X,"|",2X,3D.2D,"%",1X,"|",
6280 Dist="BINOMIAL"
6290 PRINT USING 6220
6300 PRINT USING 6230;Alpha=100,Atol=100,Beta=100,Btol=100,Aql=100,Ltpd=100
6310 PRINT SPA(12);"(Binomial Probabilities)"
6320 PRINT USING 6240
6330 PRINT USING 6250
6340 PRINT USING 6260
6350 REM ***** HOLDING ALPHA *****
6360 C=0
6370 Sample=1
6380 BEEP
6390 IF Sample>Maxn THEN 6620
6399 Pap=1/EXP(Sample*Aql)
6400 Ck=1-Pap
6410 Ck2=Alpha-Atol
6420 IF Ck2<=0 THEN Ck2=.005
6430 IF Ck<Ck2 THEN 6460
6440 Sample=Sample+1
6450 GOTO 6380
6460 IF Sample<10 THEN Lou=C+1
6470 IF Sample>=10 THEN Lou=Sample-10
6480 FOR S=Lou TO Sample+1000
6490 P=Aql
6500 X=0
6510 GOSUB 2600
6520 Prisk=1-Prob
6530 P=Ltpd
6540 X=0
6550 GOSUB 2600
6560 Crisk=Prob
6570 IF (ABS(Prisk-Alpha)<=Atol) AND (ABS(Crisk-Beta)<=Btol) THEN PRINT USING 6
270;S,C,Prisk=100,Crisk=100
6580 IF (ABS(Prisk-Alpha)<=Atol) AND (ABS(Crisk-Beta)<=Btol) THEN Print=Print+1
6590 IF (ABS(Prisk-Alpha)<=Atol) AND (ABS(Crisk-Beta)<=Btol) THEN PRINT USING 6
240
6600 IF Crisk<Beta-Btol+.004 THEN 6620
6610 NEXT S
6620 FOR C=1 TO 50
6630 Sample=C+1
6640 IF Sample>Maxn THEN 7110
6650 Pap=1/EXP(Sample*Aql)
6660 Cum=Pap
6670 FOR Pass=1 TO C
6680 Pap=Pap*Sample*Aql/Pass
6690 Cum=Cum+Pap
6700 IF Cum>1 THEN Cum=1
6710 NEXT Pass
6720 Ck=Alpha
6730 Prisk=1-Cum
6740 IF Prisk<=Ck2 THEN 6780
6750 Sample=Sample+1
6760 IF Sample>Maxn THEN 7110
6770 GOTO 6640
6780 IF Sample>Maxn THEN 7110
6790 IF Sample<25 THEN Lou=C+1
6800 IF Sample>25 THEN Lou=Sample-25
6810 FOR S=Lou TO Sample+1000
6820 IF S>Maxn THEN 7040
6830 P=Aql
6840 FOR X=0 TO C
6850 GOSUB 2600
6860 IF X=0 THEN Prisk=Prob
6870 IF X<>0 THEN Prisk=Prob+Prisk
6880 IF Prisk>1 THEN Prisk=1
6890 NEXT X
6900 Prisk=1-Prisk
6910 P=Ltpd
6920 FOR X=0 TO C

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6930 GOSUB 2600
6940 IF X=0 THEN Crisk=Prob
6950 IF X<0 THEN Crisk=Prob+Crisk
6960 IF Crisk>1 THEN Crisk=1
6970 NEXT X
6980 BEEP
6990 IF (ABS(Prisk-Alpha)<=Atol) AND (ABS(Crisk-Beta)<=Btol) THEN PRINT USING 6
270;S,C,Prisk*100,Crisk*100
7000 IF (ABS(Prisk-Alpha)<=Atol) AND (ABS(Crisk-Beta)<=Btol) THEN PRINT USING 6
240
7010 IF (ABS(Prisk-Alpha)<=Atol) AND (ABS(Crisk-Beta)<=Btol) THEN Print=Print+1
7020 IF Crisk<Beta-Btol+.004 THEN 7040
7030 NEXT S
7040 DISP
7050 DISP "      WHILE HOLDING ALPHA TO WITHIN ";Atol*100;"% OF THE SPECI
FICATION,
"
7060 DISP "DO YOU WANT TO EXAMINE PLANS WITH AN ACCEPTANCE NUMBER EQUAL TO";C+1
7070 DISP
7080 BEEP
7090 INPUT R$
7100 IF R$="NO" THEN 7120
7110 NEXT C
7120 REM ***** HOLDING BETA *****
7130 C=0
7140 BEEP
7150 Sample=1
7160 Pap=1/EXP(Sample*Ltpd)
7170 Ck=Pap
7180 Ck2=Beta-Btol
7190 IF Ck2<=0 THEN Ck2=.005
7200 IF Ck<Ck2 THEN 7240
7210 Sample=Sample+1
7220 IF Sample>Maxn THEN 7420
7230 GOTO 7160
7240 IF Sample<10 THEN Low=C+1
7250 IF Sample>=10 THEN Low=Sample-10
7260 IF Sample>Maxn THEN 7420
7270 FOR S=Low TO Sample+10
7280 IF S>Maxn THEN 7420
7290 P=Ltpd
7300 X=0
7310 GOSUB 2600
7320 Crisk=Prob
7330 P=Aq1
7340 X=0
7350 GOSUB 2600
7360 Prisk=1-Prob
7370 IF (ABS(Prisk-Alpha)<=Atol) AND (ABS(Crisk-Beta)<=Btol) THEN PRINT USING 6
270;S,C,Prisk*100,Crisk*100
7380 IF (ABS(Prisk-Alpha)<=Atol) AND (ABS(Crisk-Beta)<=Btol) THEN PRINT USING 6
240
7390 IF (ABS(Prisk-Alpha)<=Atol) AND (ABS(Crisk-Beta)<=Btol) THEN Print=Print+1
7400 IF Prisk>Alpha+Atol+.004 THEN 7420
7410 NEXT S
7420 FOR C=1 TO 50
7430 BEEP
7440 Sample=C+1
7450 IF Sample>Maxn THEN 7900
7460 Pap=1/EXP(Sample*Ltpd)
7470 Cum=Pap
7480 FOR Pass=1 TO C
7490 Pap=Pap*Sample*Ltpd/Pass
7500 Cum=Cum+Pap
7510 IF Cum>1 THEN Cum=1
7520 NEXT Pass
7530 Crisk=Cum
7540 Ck=Crisk
7550 IF Ck<Ck2 THEN 7590
7560 Sample=Sample+1
7570 IF Sample>Maxn THEN 7900
7580 GOTO 7460
7590 IF Sample<25 THEN Low=C+1
7600 IF Sample>25 THEN Low=Sample-25
7610 FOR S=Low TO Sample+1000
7620 IF S>Maxn THEN 7830
7630 P=Ltpd
7640 FOR X=0 TO C

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7650 GOSUB 2600
7660 IF X=0 THEN Crisk=Prob
7670 IF X<>0 THEN Crisk=Prob+Crisk
7680 IF Crisk>I THEN Crisk=I
7690 NEXT X
7700 P=Aq1
7710 FOR X=0 TO C
7720 GOSUB 2600
7730 IF X=0 THEN Prisk=Prob
7740 IF X<>0 THEN Prisk=Prob+Prisk
7750 IF Prisk>I THEN Prisk=I
7760 NEXT X
7770 Prisk=I-Prisk
7780 IF (ABS(Prisk-Alpha)<=Atol) AND (ABS(Crisk-Beta)<=Btol) THEN PRINT USING 6
270;S,C,Prisk*100,Crisk*100
7790 IF (ABS(Prisk-Alpha)<=Atol) AND (ABS(Crisk-Beta)<=Btol) THEN PRINT USING 6
240
7800 IF (ABS(Prisk-Alpha)<=Atol) AND (ABS(Crisk-Beta)<=Btol) THEN Print=Print+1
7810 IF Prisk>Alpha+Atol+.004 THEN 7830
7820 NEXT S
7830 DISP
7840 DISP " WHILE HOLDING BETA TO WITHIN ";Btol*100;"% OF THE SPECIFI
CATION,"
7850 DISP "DO YOU WANT TO EXAMINE PLANS WITH AN ACCEPTANCE NUMBER EQUAL TO";C+1
7860 DISP
7870 BEEP
7880 INPUT R$
7890 IF R$="NO" THEN 7910
7900 NEXT C
7910 IF Print=0 THEN PRINT LIN(2);"No plans were found that satisfied the state
d design tolerances.";LIN(4)
7920 IF Print=0 THEN DISP
7930 IF Print=0 THEN DISP "YOU CAN LOOSEN THE TOLERANCES ON ALPHA & BETA AND TR
Y AGAIN, IF YOU WANT TO"
7940 IF Print=0 THEN DISP
7950 BEEP
7960 FOR I=1 TO 5
7660 IF X=0 THEN Crisk=Prob
7670 IF X<>0 THEN Crisk=Prob+Crisk
7680 IF Crisk>I THEN Crisk=I
7690 NEXT X
7700 P=Aq1
7710 FOR X=0 TO C
7720 GOSUB 2600
7730 IF X=0 THEN Prisk=Prob
7740 IF X<>0 THEN Prisk=Prob+Prisk
7750 IF Prisk>I THEN Prisk=I
7760 NEXT X
7770 Prisk=I-Prisk
7780 IF (ABS(Prisk-Alpha)<=Atol) AND (ABS(Crisk-Beta)<=Btol) THEN PRINT USING 6
270;S,C,Prisk*100,Crisk*100
7790 IF (ABS(Prisk-Alpha)<=Atol) AND (ABS(Crisk-Beta)<=Btol) THEN PRINT USING 6
240
7800 IF (ABS(Prisk-Alpha)<=Atol) AND (ABS(Crisk-Beta)<=Btol) THEN Print=Print+1
7810 IF Prisk>Alpha+Atol+.004 THEN 7830
7820 NEXT S
7830 DISP
7840 DISP " WHILE HOLDING BETA TO WITHIN ";Btol*100;"% OF THE SPECIFI
CATION,"
7850 DISP "DO YOU WANT TO EXAMINE PLANS WITH AN ACCEPTANCE NUMBER EQUAL TO";C+1
7860 DISP
7870 BEEP
7880 INPUT R$
7890 IF R$="NO" THEN 7910
7900 NEXT C
7910 IF Print=0 THEN PRINT LIN(2);"No plans were found that satisfied the state
d design tolerances.";LIN(4)
7920 IF Print=0 THEN DISP
7930 IF Print=0 THEN DISP "YOU CAN LOOSEN THE TOLERANCES ON ALPHA & BETA AND TR
Y AGAIN, IF YOU WANT TO"
7940 IF Print=0 THEN DISP
7950 BEEP
7960 FOR I=1 TO 5
7970 WAIT 200-I*20
7980 BEEP
7990 NEXT I
8000 GOTO 2010

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0010 IF Sc<>5 THEN 2010
0020 FOR I=1 TO 6
0030 IF I=1 THEN DISP "   ENTER THE ACCEPTABLE QUALITY LEVEL   "
0040 IF I=2 THEN DISP "   ENTER THE LOT TOLERANCE PERCENT DEFECTIVE "
0050 IF I=3 THEN DISP "   ENTER THE PRODUCER'S RISK   "
0060 IF I=4 THEN DISP "   ENTER THE CONSUMER'S RISK   "
0070 IF I=5 THEN DISP "   ENTER THE PRODUCER'S RISK TOLERANCE LIMIT "
0080 IF I=6 THEN DISP "   ENTER THE CONSUMER'S RISK TOLERANCE LIMIT "
0090 DISP "   THE ENTRY MUST BE STATED AS A PERCENT!   "
0100 BEEP
0110 BEEP
0120 IF I=1 THEN INPUT Aq1
0130 IF I=2 THEN INPUT Ltpd
0140 IF I=3 THEN INPUT Alpha
0150 IF I=4 THEN INPUT Beta
0160 IF I=5 THEN INPUT Ato1
0170 IF I=6 THEN INPUT Bto1
0180 NEXT I
0190 Aq1=Aq1/100
0200 Ltpd=Ltpd/100
0210 DISP
0220 Maxsam=1000000
0230 DISP "   IS THERE A CONSTRAINT ON THE MAXIMUM SAMPLE SIZE?"
0240 BEEP
0250 BEEP
0260 INPUT Resp
0270 IF Resp="NO" THEN 0320
0280 DISP "   Enter the maximum Sample Size   "
0290 BEEP
0300 BEEP
0310 INPUT Maxsam
0320 DISP
0330 DISP "   IS THERE A FINITE LOT SIZE?   "
0340 BEEP
0350 BEEP
0360 INPUT Resp
0370 IF Resp="NO" THEN Dist="BINOMIAL"
0380 IF Resp="NO" THEN 0460
0390 DISP
0400 DISP "   ENTER THE NUMBER OF UNITS COMPRISING THE FINITE LOT SIZE
"
0410 DISP
0420 BEEP
0430 INPUT Lsize
0440 IF Maxsam>Lsize THEN Maxsam=Lsize
0450 Dist="HYPER"
0460 Print=0
0470 FOR I=1 TO 15
0480 FOR J=1 TO 17
0490 IF $105c(I)>=$105c(J) THEN 9350
0500 IF $105c(J)>Maxsam THEN 9360
0510 IF Dist="HYPER" THEN 0690
0520 S=$105c(J)
0530 C=$105c(I)
0540 P=Aq1
0550 FOR X=0 TO C
0560 GOSUB 2600
0570 IF X=0 THEN Pa(1,1)=Prob
0580 IF X<>0 THEN Pa(1,1)=Pa(1,1)+Prob
0590 NEXT X
0600 P=Ltpd
0610 FOR X=0 TO C
0620 GOSUB 2600
0630 IF X=0 THEN Pa(2,1)=Prob
0640 IF X<>0 THEN Pa(2,1)=Pa(2,1)+Prob
0650 NEXT X
0660 Riskp=(1-Pa(1,1))*100
0670 Riskc=Pa(2,1)*100
0680 GOTO 9050
0690 N=Lsize
0700 M=$105c(J)
0710 C=$105c(I)
0720 K=Aq1*Lsize
0730 IF K=INT(K) THEN 0020
0740 DISP

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0750 DISP "The product of AQL and Lot Size is equal to ";K;". This is the n
umber of "
0760 DISP "defectives er lot which must be an integer, so enter the number of d
effectives"
0770 DISP "per lot that corresponds to AQL!"
0780 DISP
0790 BEEP
0800 INPUT K
0810 GOTO 0730
0820 FOR X=0 TO C
0830 GOSUB 3400
0840 IF X=0 THEN Pa(1,1)=Prob
0850 IF X<>0 THEN Pa(1,1)=Pa(1,1)+Prob
0860 REM
0870 NEXT X
0880 K=Ltpd*Lsize
0890 IF K=INT(K) THEN 0900
0900 DISP
0910 DISP "The product of LTPD and Lot Size is equal to ";K;". This is the
number of "
0920 DISP "defectives er lot which must be an integer, so enter the number of d
effectives"
0930 DISP "per lot that corresponds to LTPD!"
0940 DISP
0950 BEEP
0960 INPUT K
0970 GOTO 0890
0980 FOR X=0 TO C
0990 GOSUB 3400
1000 IF X=0 THEN Pa(2,1)=Prob
1010 IF X<>0 THEN Pa(2,1)=Pa(2,1)+Prob
1020 REM
1030 NEXT X
1040 GOTO 0660
1050 IMAGE SX,"Optional Single Sampling Plans Via MIL-STD-105D"
1060 BEEP
1070 IMAGE SX,"
1080 IMAGE SX,"|Sample|Acceptance|Producer's|Consumer's|
1090 IMAGE +,SX,"| Size | Number | Risk | Risk |"
1100 IMAGE 10X,"For AQL = ",3D.2D,"% & LTPD = ",3D.2D,"%"
1110 IMAGE SX,"That meet Producer's Risk = ",3D.2D,"%",3D.2D,"%"
1120 IMAGE SX,"And meet Consumer's Risk = ",3D.2D,"%",3D.2D,"%"
1130 IF (ABS(Riskp-Alpha)<=Ato1) AND (ABS(Riskc-Beta)<=Bto1) THEN 9150
1140 GOTO 9350
9150 IF Print<>0 THEN 9320
9160 PRINT LIN(4)
9170 PRINT USING 9050
9180 PRINT USING 9100;Aql=100,Ltpd=100
9190 PRINT USING 9110;Alpha,Ato1
9200 PRINT USING 9120;Beta,Bto1
9210 IF Dist="BINOMIAL" THEN 9250
9220 PRINT SPA(24);"Lot Size = ";Lsize
9230 PRINT SPA(15);"Hypergeometric Probabilities"
9240 GOTO 9260
9250 PRINT SPA(10);"Binomial Probabilities"
9260 IF Maxsam<1000000 THEN PRINT SPA(0);"Maximum Sample Size Constraint:";Maxs
am
9270 Print=5
9280 PRINT USING 9070
9290 PRINT USING 9080
9300 PRINT USING 9090
9310 PRINT USING 9070
9320 IMAGE +,SX,"|",5D,"|",2X,6D,2X,"|",6D.2D,"x|",6D.2D,"%|"
9330 PRINT USING 9320;S105s(J),S105c(I),Riskp,Riskc
9340 PRINT USING 9070
9350 NEXT J
9360 NEXT I
9370 IF Print<>0 THEN PRINT LIN(1);"A complete OC Curve for any of these plans
can be obtained by exercising";LIN(1);"Option 1 of this program segment."
9380 IF Print=0 THEN PRINT LIN(6);"No Plans, simultaneously meeting the design
tolerances on Producer's and"

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9400 IF Print=0 THEN PRINT "re-running this option will increase your chances o  
f obtaining optional plans."  
9410 GOTO 2610
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**APPENDIX C**  
**DOUBLE SAMPLING DESIGN AND ASSESSMENT SOURCE CODE**

## APPENDIX C DOUBLE SAMPLING DESIGN AND ASSESSMENT SOURCE CODE

```

2000  REM          **** DOUBLE SAMPLE DESIGN AND/OR RISK ASSESSMENT ****
2010  DISP "
2020  DISP "          ) Double Sampling Plan Option Menu (
"
2030  DISP "      Option Description                                Select Code
"
2040  DISP " >Double Sample Operating Characteristic
"
2050  DISP "      Curve Construction And Risk Assessment.....1
"
2060  DISP " >Double Sampling Plan Derivation, Via Poisson
"
2070  DISP "      Approximation of ALPHA = 5% AND Beta = 10% for
"
2080  DISP "      Given Specifications of AQL & LTPD.....2
"
2090  DISP " >Double Sampling Plan Derivation from MIL-STD-105D
"
2100  DISP "      Acceptance/Rejection Numbers and all Stated Sample
"
2110  DISP "      Sizes. This option provides a Binomial or Hyper-
"
2120  DISP "      geometric Assessment of Alpha and Beta for Stated
"
2130  DISP "      AQL & LTPD values. The assessments are limited to
"
2140  DISP "      the feasible combinations of sample size and accept
"
2150  DISP "      reject numbers specified in MIL-STD-105D.....3
"
2160  DISP " >EXIT this Selected Option.....4
"
2170  DISP "
2180  DISP "ENTER THE SELECT CODE OF THE DESIRED OPTION."
2190  DISP
2200  BEEP
2210  INPUT Sc
2220  IF Sc=4 THEN RETURN
2230  IF Sc<>1 THEN 7140
2240  FOR I=1 TO 6
2250  IF I=1 THEN DISP " Enter the First Sample's Size...."
2260  IF I=2 THEN DISP " Enter the Second Sample's Size...."
2270  IF I=3 THEN DISP " Enter the First Sample's Acceptance Number...."
2280  IF I=4 THEN DISP " Enter the Second Sample's Acceptance Number...."
2290  IF I=5 THEN DISP " Enter the First Sample's Rejection Number...."
2300  IF I=6 THEN DISP " Enter the Second Sample's Rejection Number...."
2310  DISP
2320  BEEP
2330  IF I=1 THEN INPUT Dss1
2340  IF I=2 THEN INPUT Dss2
2350  IF I=3 THEN INPUT Dap1
2360  IF I=4 THEN INPUT Dap2
2370  IF I=5 THEN INPUT Dre1
2380  IF I=6 THEN INPUT Dre2
2390  NEXT I
2400  Sample=Dss1+Dss2
2410  DISP "          DO YOU HAVE A FINITE LOT SIZE?"
2420  DISP
2430  BEEP
2440  INPUT Resz
2450  IF Resz="NO" THEN Distz="BINOMIAL"
2460  IF Resz="NO" THEN 2620
2470  DISP "          ENTER THE FINITE LOT SIZE "
2480  DISP
2490  BEEP
2500  INPUT Lsize
2510  Ratio=Sample/Lsize
2520  IF Ratio>=.1 THEN Distz="HYPER"
2530  IF Ratio>=.1 THEN 4020
2540  DISP "Since the ratio of total possible sample size to lot size is less-th
an 10%."
2550  DISP "it maybe acceptable to use a Binomial Approximation to the Hypergeom
etric."
2560  DISP "DO YOU WISH TO USE THIS APPROXIMATION?"
2570  DISP
2580  BEEP

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2590 INPUT Res$
2600 IF Res="NO" THEN Dist$="HYPER"
2610 IF Res="YES" THEN Dist$="BINOMIAL"
2620 IF Dist$="HYPER" THEN 4820
2630 IF Dist$="BINOMIAL" THEN 3100
2640 REM BINOMIAL SUBROUTINE
2650 IF (S-X<0) OR (X<0) THEN Prob=0
2660 IF (S-X<0) OR (X<0) THEN RETURN
2670 IF (S-X=0) OR (X=0) THEN Prob=P^X*(1-P)^(S-X)
2680 IF (S-X=0) OR (X=0) THEN RETURN
2690 Prob=1
2700 FOR Is=1 TO X
2710 Prob=Prob*P
2720 NEXT Is
2730 FOR Is=1 TO S-X
2740 Prob=Prob*((X+Is)/Is)*(1-P)
2750 NEXT Is
2760 RETURN
2770 REM HYPERGEOMETRIC DISTRIBUTION
2780 IF X<0 THEN Prob=0
2790 IF X<0 THEN RETURN
2800 IF X>K THEN Prob=0
2810 IF X>K THEN RETURN
2820 IF X>N THEN Prob=0
2830 IF X>N THEN RETURN
2840 Prob=1
2850 F(1)=K
2860 F(2)=N-K
2870 F(3)=N
2880 F(4)=N-N
2890 F(5)=X
2900 F(6)=K-X
2910 F(7)=N-X
2920 F(8)=N-K-M*X
2930 F(9)=N
2940 FOR Is=1 TO 9
2950 IF F(Is)<1 THEN F(Is)=1
2960 NEXT Is
2970 Prob=Prob*(F(1)*F(2)*F(3)*F(4))/(F(5)*F(6)*F(7)*F(8)*F(9))
2980 FOR Is=1 TO 9
2990 F(Is)=F(Is)-1
3000 IF F(Is)<1 THEN F(Is)=1
3010 NEXT Is
3020 Ck=0
3030 FOR Is=1 TO 9
3040 IF F(Is)=1 THEN 3060
3050 Ck=1
3060 NEXT Is
3070 IF Ck=0 THEN RETURN
3080 GOTO 2970
3090 RETURN
3100 REM BINOMIAL EVALUATION
3110 P=.01
3120 S=Dss1
3130 C=Dsp1
3140 FOR X=0 TO C
3150 GOSUB 2640
3160 IF X=0 THEN Pa(1,1)=Prob
3170 IF X<0 THEN Pa(1,1)=Prob+Pa(1,1)
3180 NEXT X
3190 Cont(1)=0
3200 FOR X=C+1 TO Dre1-1
3210 Con(X)=X
3220 GOSUB 2640
3230 Comp(X)=Prob
3240 Cont(1)=Cont(1)+Comp(X)
3250 NEXT X
3260 An(1)=Dss1+Cont(1)+Dss2
3270 S=Dss2
3280 Pa(2,1)=0
3290 FOR I=C+1 TO Dre2-1
3300 FOR X=0 TO Dre2-1-Con(I)
3310 GOSUB 2640

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3320 Pa(2,1)=Pa(2,1)+Conp(I)*Prob
3330 NEXT X
3340 NEXT I
3350 Pa(3,1)=Pa(1,1)+Pa(2,1)
3360 Pr(1,1)=1-Pa(1,1)-Cont(1)
3370 Pr(2,1)=1-Pa(3,1)
3380 IF Pa(3,1)<.02 THEN 3440
3390 IF (Pa(3,1)<.9) AND (Pa(3,1))>=.25 THEN P=P+.01
3400 IF Pa(3,1))>=.9 THEN P=P+.05
3410 IF Pa(3,1)<.25 THEN P=P+.01
3420 DISP P
3430 GOTO 3120
3440 DISP "The probability of acceptance is";Pa(3,1)*100;"% at percent defectiv
e "
3450 DISP "equal to";P*100;"%."
3460 DISP " WHAT RANGE DO YOU WANT TO INCLUDE ON THE OC CURVE'S PERCENT DEFE
CTIVE AXIS? "
3470 DISP " The entry must be stated as a percent(i.e., fifty percent is 50
). "
3480 DISP
3490 BEEP
3500 INPUT Maxx
3510 Maxx=Maxx+1
3520 DISP "ENTER THE DESIRED LABELING INTERVAL ON THE PERCENT DEFECTIVE AXIS."
3530 DISP " The entry must be stated as a percent(i.e., one percent is 1).
"
3540 DISP
3550 BEEP
3560 INPUT Xint
3570 Inc=Maxx/100
3580 FOR I=1 TO 100
3590 Pd(I)=I*Inc
3600 DISP
3610 DISP Pd(I)
3620 P=Pd(I)/100
3630 S=Dss1
3640 C=Dap1
3650 FOR K=0 TO C
3660 GOSUB 2640
3670 IF K=0 THEN Pa(1,I)=Prob
3680 IF K<>0 THEN Pa(1,I)=Prob+Pa(1,I)
3690 NEXT K
3700 Cont(I)=0
3710 FOR X=C+1 TO Dre1-1
3720 Con(X)=X
3730 GOSUB 2640
3740 Conp(X)=Prob
3750 Cont(I)=Cont(I)+Conp(X)
3760 NEXT X
3770 An(I)=Dss1+Cont(I)*Dss2
3780 S=Dss2
3790 Pa(2,I)=0
3800 FOR J=C+1 TO Dre2-1
3810 FOR X=0 TO Dre2-1-Con(J)
3820 GOSUB 2640
3830 Pa(2,I)=Pa(2,I)+Conp(J)*Prob
3840 NEXT X
3850 NEXT J
3860 Pa(3,I)=Pa(1,I)+Pa(2,I)
3870 Pr(1,I)=1-Pa(1,I)-Cont(I)
3880 Pr(2,I)=1-Pa(3,I)
3890 NEXT I
3900 Lin=100
3910 GOSUB 4510
3920 DISP "DO YOU WANT ANY SPECIFIC POINTS PRINTED?"
3930 DISP
3940 BEEP
3950 INPUT Res
3960 IF Res="NO" THEN 2010
3970 PRINT LIN(4);SPR(10);"Risk Evaluation For the Double Sampling Plan"
3980 PRINT SPR(10);"First Sample: n = ";Dss1;" Accept on ";Dap1;" Reject on "
;Dre1
3990 PRINT SPR(10);"Second Sample: n = ";Dss2;" Accept on ";Dap2;" Reject on "
;Dre2
4000 PRINT SPR(17);"(Binomial Distribution Probabilities)";LIN(1)
4010 PRINT USING 4060
4020 PRINT USING 4070

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4030 PRINT USING 4000
4040 PRINT USING 4090
4050 PRINT USING 4100
4060 IMAGE = "
4070 IMAGE = "
          |-----|-----|-----|-----|-----|-----|-----|-----|
          |Average|   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
4080 IMAGE = |Percent|Acceptance|Continue|Rejection|Acceptance|Rejecti
on|Sample|   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
4090 IMAGE = |Defective|Probability|Probability|Probability|Probability|Probab
ility|Number|   |   |   |   |   |   |   |   |   |   |   |   |   |   |
4100 IMAGE = "
          |-----|-----|-----|-----|-----|-----|-----|-----|

4110 IMAGE +, " |, 4D.4D, " |, 5(6D.4D, " |), 4D.2D, " |"
4120 DISP "ENTER THE PERCENT DEFECTIVE....."
4130 DISP
4140 BEEP
4150 INPUT P
4160 P=P/100
4170 S=Dss1
4180 C=Dap1
4190 FOR K=0 TO C
4200 GOSUB 2640
4210 IF K=0 THEN Pa(1,1)=Prob
4220 IF K(>0) THEN Pa(1,1)=Prob+Pa(1,1)
4230 NEXT K
4240 Cont(1)=0
4250 FOR X=C+1 TO Dre1-1
4260 Con(X)=X
4270 GOSUB 2640
4280 Conp(X)=Prob
4290 Cont(1)=Cont(1)+Conp(X)
4300 NEXT X
4310 Rsn(1)=Dss1+Cont(1)+Dss2
4320 S=Dss2
4330 Pa(2,1)=0
4340 FOR J=C+1 TO Dre2-1
4350 FOR K=0 TO Dre2-1-Con(J)
4360 GOSUB 2640
4370 Pa(2,1)=Pa(2,1)+Conp(J)*Prob
4380 NEXT K
4390 NEXT J
4400 Pa(3,1)=Pa(1,1)+Pa(2,1)
4410 Pr(1,1)=1-Pa(1,1)-Cont(1)
4420 Pr(2,1)=1-Pa(3,1)
4430 PRINT USING 4110;P=100,Pa(1,1)=100,Cont(1)=100,Pr(1,1)=100,Pa(3,1)=100,Pr(
2,1)=100,Rsn(1)
4440 PRINT USING 4100
4450 DISP " DO YOU WANT ANYMORE? "
4460 DISP
4470 BEEP
4480 INPUT Res
4490 IF Res="NO" THEN 2010
4500 GOTO 4120
4510 REM OC CURVE
4520 PLOTTER IS "9872A"
4530 PLOTTER 7,5 IS ON
4540 LOCATE 10,100,10,100
4550 SCALE 0,Maxx,0,104
4560 CSIZE 2
4570 LAXES Xint,5,0,0,-1,1
4580 MOVE S=Xint,101
4590 LABEL " Operating Characteristic Curve"
4600 LABEL "First Sample: n=";Dss1;" C1=";Dap1;" R1=";Dre1
4610 LABEL "Second Sample: n=";Dss2;" C2=";Dap2;" R2=";Dre2
4620 LABEL " Binomial Probabilities"
4630 MOVE 0,100
4640 FOR Pass=1 TO 2
4650 MOVE 0,100
4660 IF Pass=1 THEN PEN 2
4670 IF Pass=2 THEN PEN 3
4680 IF Pass=1 THEN 0=1
4690 IF Pass=2 THEN 0=3
4700 FOR I=1 TO Lim
4710 DRAW Pd(I),Pa(0,1)=100
4720 NEXT I

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4730 NEXT Pass
4740 PEN 1
4750 MOVE SxInt,-5
4760 LABEL "PERCENT DEFECTIVE"
4770 MOVE Xint/4,101
4780 LABEL "Pa(x)"
4790 MOVE 120,120
4800 GOSUB 6790
4810 RETURN
4820 REM HYPERGEOMETRIC EVALUATION
4830 K=Dap2
4840 N=Lsize
4850 M=Das1
4860 Bad=K
4870 C=Dap1
4880 FOR X=0 TO C
4890 GOSUB 2770
4900 IF X=0 THEN Pa(1,1)=Prob
4910 IF X<>0 THEN Pa(1,1)=Prob+Pa(1,1)
4920 NEXT X
4930 Cont(1)=0
4940 FOR X=C+1 TO Dre1-1
4950 Cont(X)=X
4960 GOSUB 2770
4970 Comp(X)=Prob
4980 Cont(1)=Cont(1)+Comp(X)
4990 NEXT X
5000 An(1)=Das1+Cont(1)+Das2
5010 M=Das2
5020 N=Lsize-Das1
5030 Pa(2,1)=0
5040 FOR I=C+1 TO Dre2-1
5050 K=Bad-I
5060 FOR X=0 TO Dre2-1-Con(1)
5070 GOSUB 2770
5080 Pa(2,1)=Pa(2,1)+Comp(1)+Prob
5090 NEXT X
5100 NEXT I
5110 K=Bad
5120 Pa(3,1)=Pa(1,1)+Pa(2,1)
5130 Pr(1,1)=1-Pa(1,1)-Cont(1)
5140 Pr(2,1)=1-Pa(3,1)
5150 DISP "For ";K;" defectives per lot, the Pa for the plan is";Pa(3,1)
5160 DISP
5170 IF Pa(3,1)<.82 THEN S210
5180 IF Pa(3,1)>=.1 THEN K=K+5
5190 IF Pa(3,1)<.1 THEN K=K+1
5200 GOTO 4850
5210 DISP
5220 DISP "The probability of acceptance is";Pa(3,1)*100;"% at";K;" defectives
per Lot."
5230 DISP
5240 DISP " WHAT RANGE DO YOU WANT TO INCLUDE ON THE OC CURVE'S DEFECTIVES PER
LOT AXIS? "
5250 DISP " The entry must be stated as an integer. "
5260 DISP
5270 BEEP
5280 INPUT Maxx
5290 Maxx=Maxx+1
5300 DISP
5310 DISP "ENTER THE DESIRED LABELING INTERVAL ON THE DEFECTIVES PER LOT AXIS."
5320 DISP " The entry must be stated as an integer. "
5330 DISP
5340 BEEP
5350 INPUT Xint
5360 IF Maxx<=100 THEN Lim=Maxx
5370 IF Maxx>100 THEN Lim=100
5380 IF Maxx<=100 THEN Inc=1
5390 IF (Maxx<=200) AND (Maxx>100) THEN Inc=2
5400 IF (Maxx<=400) AND (Maxx>200) THEN Inc=4
5410 IF (Maxx<=500) AND (Maxx>400) THEN Inc=5
5420 IF (Maxx<=600) AND (Maxx>500) THEN Inc=6
5430 IF (Maxx<=1000) AND (Maxx>600) THEN Inc=10
5440 FOR I=1 TO Lim
5450 Pd(I)=Dap2+(I-1)*Inc
5460 DISP

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5470 DISP Pd(I)
5480 K=Pd(I)
5490 Bad=K
5500 N=Lsize
5510 M=Dss1
5520 C=Dap1
5530 FOR X=0 TO C
5540 GOSUB 2770
5550 IF X=0 THEN Pa(1,I)=Prob
5560 IF X<>0 THEN Pa(1,I)=Prob+Pa(1,I)
5570 NEXT X
5580 Cont(I)=0
5590 FOR X=C+1 TO Dre1-1
5600 Con(X)=X
5610 GOSUB 2770
5620 Comp(X)=Prob
5630 Cont(I)=Cont(I)+Comp(X)
5640 NEXT X
5650 Asn(I)=Dss1+Cont(I)+Dss2
5660 M=Dss2
5670 N=Lsize-Dss1
5680 Pa(2,I)=0
5690 FOR J=C+1 TO Dre2-1
5700 K=Bad-J
5710 FOR X=0 TO Dre2-1-Con(J)
5720 GOSUB 2770
5730 Pa(2,I)=Pa(2,I)+Comp(J)*Prob
5740 NEXT X
5750 NEXT J
5760 Pa(3,I)=Pa(1,I)+Pa(2,I)
5770 Pr(1,I)=-Pa(1,I)-Cont(I)
5780 Pr(2,I)=1-Pa(3,I)
5790 BEEP
5800 DISP "K=";Pd(I); " Pa[1st]=";Pa(1,I); " Pa(Plan)=";Pa(3,I)
5810 NEXT I
5820 GOSUB 6460
5830 DISP "DO YOU WANT ANY SPECIFIC POINTS PRINTED?"
5840 DISP
5850 BEEP
5860 INPUT Res
5870 IF Res="NO" THEN 2010
5880 PRINT LIN(4);SPA(10);"Risk Evaluation For the Double Sampling Plan"
5890 PRINT SPA(10);"First Sample: n = ";Dss1;" Accept on ";Dap1;" Reject on "
;Dre1
5900 PRINT SPA(10);"Second Sample: n = ";Dss2;" Accept on ";Dap2;" Reject on "
;Dre2;LIN(1);SPA(25);"Lot Size = ";Lsize
5910 PRINT SPA(17);"(Hypergeometric Distribution Probabilities)";LIN(1)
5920 PRINT USING 5970
5930 PRINT USING 5980
5940 PRINT USING 5990
5950 PRINT USING 6000
5960 PRINT USING 6010
5970 IMAGE "
5980 IMAGE "
          | First Sample Risks | Plan Risks |
          |-----|-----|
          |Average|
5990 IMAGE |Defective|Acceptance |Continue | Rejection |Acceptance |Rejecti
on |Sample |
6000 IMAGE +, | Per Lot |Probability|Probability|Probability|Probability|Probab
ility|Number |
6010 IMAGE "
          |-----|-----|
6020 IMAGE +, |",2X,3D,2X,"|",5(6D,4D,"|"),4D,2D,"|
6030 DISP "ENTER THE NUMBER OF DEFECTIVES PER LOT...."
6040 DISP
6050 BEEP
6060 INPUT K
6070 M=Dss1
6080 N=Lsize
6090 C=Dap1
6100 Bad=K
6110 FOR X=0 TO C
6120 GOSUB 2770
6130 IF X=0 THEN Pa(1,1)=Prob
6140 IF X<>0 THEN Pa(1,1)=Prob+Pa(1,1)
6150 NEXT X
6160 Cont(1)=0

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6170 FOR K=C+1 TO Dre1-1
6180 Con(K)=X
6190 GOSUB 2770
6200 Conp(X)=Prob
6210 Cont(1)=Cont(1)+Conp(X)
6220 NEXT K
6230 Rsn(1)=Dss1+Cont(1)+Dss2
6240 N=Lsize-Dss1
6250 M=Dss2
6260 Pa(2,1)=0
6270 FOR J=C+1 TO Dre
6280 K=Bad-J
6290 FOR X=0 TO Dre2-1-Con(J)
6300 GOSUB 2770
6310 Pa(2,1)=Pa(2,1)+Conp(J)+Prob
6320 NEXT X
6330 NEXT J
6340 K=Bad
6350 Pa(3,1)=Pa(1,1)+Pa(2,1)
6360 Pr(1,1)=1-Pa(1,1)-Cont(1)
6370 Pr(2,1)=1-Pa(3,1)
6380 PRINT USING 6020;K,Pa(1,1)*100,Cont(1)*100,Pr(1,1)*100,Pa(3,1)*100,Pr(2,1)
        *100,Rsn(1)
6390 PRINT USING 6010
6400 DISP " DO YOU WANT ANYMORE? "
6410 DISP
6420 BEEP
6430 INPUT Res
6440 IF Res="NO" THEN 2010
6450 GOTO 6030
6460 REM OC CURVE
6470 PLOTTER IS "9072A"
6480 PLOTTER 7,5 IS ON
6490 LOCATE 10,100,10,100
6500 SCALE 0,Maxx,0,104
6510 CBIZE 2
6520 LAXES Xint,5,0,0,-1,1
6530 MOVE SxInt,101
6540 LABEL " Operating Characteristic Curve"
6550 LABEL "First Sample: n=";Dss1;" C1=";Dap1;" R1=";Dre1
6560 LABEL "Second Sample: n=";Dss2;" C2=";Dap2;" R2=";Dre2
6570 LABEL " Lot Size = ";Lsize
6580 LABEL " Hypergeometric Probabilities"
6590 MOVE 0,100
6600 FOR Pass=1 TO 2
6610 MOVE 0,100
6620 IF Pass=1 THEN PEN 2
6630 IF Pass=2 THEN PEN 3
6640 IF Pass=1 THEN Q=1
6650 IF Pass=2 THEN Q=3
6660 FOR I=1 TO Lim
6670 DRAW Pd(I),Pa(Q,I)*100
6680 NEXT I
6690 NEXT Pass
6700 PEN 1
6710 MOVE SxInt,-5
6720 LABEL "DEFECTIVES PER LOT"
6730 MOVE Xint/4,101
6740 LABEL "Pa(x)"
6750 MOVE 120,120
6760 GOSUB 6790
6770 REM
6780 RETURN
6790 DISP
6800 DISP " RELOAD THE PLOTTER. WHEN DONE, ENTER GO! "
6810 DISP
6820 BEEP
6830 INPUT Rs
6840 PLOTTER IS "9072A"
6850 PLOTTER 7,5 IS ON
6860 Big=-10
6870 FOR I=1 TO Lim
6880 IF Rsn(I)>Big THEN Big=Rsn(I)
6890 NEXT I
6900 Maxy=INT(Big)+3
6910 LOCATE 10,100,10,100
6920 SCALE 0,Maxx,0,Maxy+3

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6930 CSIZE 2
6940 Yint=INT(Maxy/20)
6950 IF Yint<1 THEN Yint=1
6960 LAKES Xint,Yint,0,0,-1,1
6970 MOVE S0Xint,Maxy
6980 LABEL "      Average Sample Number Curve"
6990 LABEL "First Sample: n=";Dss1;" C1=";Dap1;" R1=";Dre1
7000 LABEL "Second Sample: n=";Dss2;" C2=";Dap2;" R2=";Dre2
7010 IF Dist="HYPER" THEN LABEL "      Lot Size =";Lsize
7020 IF Dist="HYPER" THEN LABEL "      Hypergeometric Probabilities"
7030 IF Dist<>"HYPER" THEN LABEL "      Binomial Probabilities"
7040 MOVE Xint/5,Maxy
7050 LABEL "ASN"
7060 MOVE 4*Xint,Yint
7070 IF Dist="BINOMIAL" THEN LABEL "PERCENT DEFECTIVE"
7080 IF Dist<>"BINOMIAL" THEN LABEL "DEFECTIVES PER LOT"
7090 MOVE 0,Dss1
7100 FOR I=1 TO Lim
7110 DRAW Pd(I),Asn(I)
7120 NEXT I
7130 RETURN
7140 IF Sc<>2 THEN 7050
7150 DISP "The Double Sampling plans addressed herein are of two types. The fir
st type"
7160 DISP "specifies that the second sample's size is twice that of the first w
hile the "
7170 DISP "second type specifies that both samples are of equal size."
7180 DISP
7190 DISP "      IF YOU WANT OPTIONAL PLANS IN WHICH n2 = 2(n1), ENTER A 1.
"
7200 DISP "      IF YOU WANT OPTIONAL PLANS IN WHICH n2 = n1, ENTER A 2. "
7210 DISP
7220 BEEP
7230 INPUT Sel
7240 FOR I=1 TO 2
7250 IF I=1 THEN DISP " ENTER THE ACCEPTABLE QUALITY LEVEL, STATED IN PERCENT
FORM. "
7260 IF I=2 THEN DISP " ENTER THE LOT TOLERANCE PERCENT DEFECTIVE, STATED IN P
ERCENT FORM. "
7290 DISP
7300 BEEP
7310 IF I=1 THEN INPUT Aq1
7320 IF I=2 THEN INPUT Ltpd
7350 NEXT I
7360 Aq1=Aq1/100
7370 Ltpd=Ltpd/100
7380 Alpha=Alpha/100
7390 Beta=Beta/100
7400 IF Sel=1 THEN Lim=16
7410 IF Sel=2 THEN Lim=17
7420 FOR J=1 TO Lim
7430 Dss1=INT(Ccea(Sel,J,5)/Aq1)+1
7440 Pr(1,J)=Dss1
7450 IF Sel=1 THEN Pr(2,J)=2*Dss1
7460 IF Sel=2 THEN Pr(2,J)=Dss1
7470 Pa(1,J)=Aq1
7480 Pa(2,J)=Ccea(Sel,J,6)/Dss1
7490 Pa(3,J)=Ccea(Sel,J,7)/Dss1
7500 Pa(4,J)=Ccea(Sel,J,8)/Dss1
7510 Dss1=INT(Ccea(Sel,J,7)/Ltpd)+1
7520 Pr(3,J)=Dss1
7530 IF Sel=1 THEN Pr(4,J)=2*Dss1
7540 IF Sel=2 THEN Pr(4,J)=Dss1
7550 Pa(5,J)=Ccea(Sel,J,5)/Dss1
7560 Pa(6,J)=Ccea(Sel,J,6)/Dss1
7570 Pa(7,J)=Ltpd
7580 Pa(8,J)=Ccea(Sel,J,8)/Dss1
7590 NEXT J
7600 IMAGE "
"
7610 IMAGE " _____|Sampling Plan Specification| Percent Defective at |Aver
age|"

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7620 IMAGE " | Plan | Sample Size | Acceptance On | Which the P(Acceptance) | Samp
le | "
7630 IMAGE " | Option | First | Second | First | Second | Is Approximately Equal | Numb
er | "
7640 IMAGE +, " | Number | Sample | Sample | Sample | Sample | 95% | 50% | 10% | Pa=95
% | "
7650 IMAGE " _____
7660 IMAGE +, " | ", 1X, 4D, " | ", 4(6D, " | ", 3(2D, 4D, " | ", 4D, 2D, " | "
7670 PRINT USING 7600
7680 PRINT USING 7610
7690 PRINT USING 7620
7700 PRINT USING 7630
7710 PRINT USING 7640
7720 PRINT USING 7650
7730 Count=0
7740 FOR J=1 TO Lim
7750 Count=Count+1
7760 PRINT USING 7660; Count, Pr(1, J), Pr(2, J), Ccea(Del, J, 3), Ccea(Sel, J, 4), Pa(1, J)
+100, Pa(2, J)+100, Pa(3, J)+100, Pa(4, J)
7770 PRINT USING 7650
7780 Count=Count+1
7790 PRINT USING 7660; Count, Pr(3, J), Pr(4, J), Ccea(Del, J, 3), Ccea(Sel, J, 4), Pa(5, J)
+100, Pa(6, J)+100, Pa(7, J)+100, Pa(8, J)
7800 PRINT USING 7650
7810 NEXT J
7820 PRINT LIN(2); "Exact risk assessments are available for any selected plan b
y"
7830 PRINT LIN(2); "exercising selection number 1 of the Double Sampling Menu. ";
LIN(1)
7840 GOTO 2010
7850 IF Sc(>) THEN 2010
7860 FOR I=1 TO 6
7870 DISP
7880 IF I=1 THEN DISP " ENTER THE ACCEPTABLE QUALITY LEVEL, STATED AS A PERCENT
T. "
7890 IF I=2 THEN DISP " ENTER THE LOT TOLERANCE PERCENT DEFECTIVE, STATED AS A
PERCENT. "
7900 IF I=3 THEN DISP " ENTER THE PRODUCER'S RISK, STATED AS A PERCENT. "
7910 IF I=4 THEN DISP " ENTER THE CONSUMER'S RISK, STATED AS A PERCENT. "
7920 IF I=5 THEN DISP " ENTER THE DESIGN TOLERANCE ON PRODUCER'S RISK, STATED
AS A PERCENT. "
7930 IF I=6 THEN DISP " ENTER THE DESIGN TOLERANCE ON CONSUMER'S RISK, STATED
AS A PERCENT. "
7940 DISP
7950 BEEP
7960 IF I=1 THEN INPUT Aq1
7970 IF I=2 THEN INPUT Ltpd
7980 IF I=3 THEN INPUT Alpha
7990 IF I=4 THEN INPUT Beta
8000 IF I=5 THEN INPUT Ato1
8010 IF I=6 THEN INPUT Bto1
8020 NEXT I
8030 Aq1=Aq1/100
8040 Ltpd=Ltpd/100
8050 DISP
8060 DISP "IS THERE A CONSTRAINT ON THE NUMBER OF UNITS THAT CAN BE SAMPLED?"
8070 DISP
8080 INPUT Resc
8090 IF Resc="NO" THEN Maxsam=1000000
8100 IF Resc="NO" THEN 8160
8110 DISP
8120 DISP "ENTER THE MAXIMUM NUMBER OF UNITS THAT MAY BE SAMPLED."
8130 DISP
8140 BEEP
8150 INPUT Maxsam
8160 DISP " DO YOU HAVE A FINITE LOT SIZE?"
8170 DISP
8180 BEEP
8190 INPUT Res
8200 IF Res="NO" THEN Dist="BINOMIAL"
8210 IF Res="YES" THEN Dist="HYPER"
8220 IF Res="NO" THEN 8270
8230 DISP " ENTER THE LOT SIZE."
8240 DISP
8250 BEEP
8260 INPUT Lsize

```

```

0270 Print=0
0280 FOR I=1 TO 16
0290 DISP
0300 DISP I
0310 Check=0
0320 FOR J=1 TO 16
0330 IF 2*Mils(J)>Maxsam THEN 9960
0340 IF Mils(J)<=Mils(I,1) THEN 9950
0350 IF 2*Mils(J)<=Mils(I,2) THEN 9950
0360 DISP TAB(J);J
0370 IF Dist="HYPER" THEN 0910
0380 P=Aq1
0390 S=Mils(J)
0400 C=Mils(I,1)
0410 FOR X=0 TO C
0420 GOSUB 2640
0430 IF X=0 THEN Pa(1,1)=Prob
0440 IF X>0 THEN Pa(1,1)=Pa(1,1)+Prob
0450 NEXT X
0460 Cont(1)=0
0470 FOR X=C+1 TO Mils(I,1)-1
0480 Con(X)=X
0490 GOSUB 2640
0500 Comp(X)=Prob
0510 Cont(1)=Cont(1)+Comp(X)
0520 NEXT X
0530 Ran(1)=Mils(J)*(1+Cont(1))
0540 Pa(2,1)=0
0550 FOR Ji=C+1 TO Mils(I,2)-1
0560 FOR X=0 TO Mils(I,2)-1-Con(Ji)
0570 GOSUB 2640
0580 Pa(2,1)=Pa(2,1)+Comp(Ji)*Prob
0590 NEXT X
0600 NEXT Ji
0610 Pa(3,1)=(Pa(1,1)+Pa(2,1))*100
0620 IF Pa(3,1)>100 THEN Pa(3,1)=100
0630 Pr(2,1)=100-Pa(3,1)
0640 Cont(1)=Cont(1)+100
0650 P=Lcpd
0660 FOR X=0 TO C
0670 GOSUB 2640
0680 IF X=0 THEN Pa(1,2)=Prob
0690 IF X>0 THEN Pa(1,2)=Pa(1,2)+Prob
0700 NEXT X
0710 Cont(2)=0
0720 FOR X=C+1 TO Mils(I,1)-1
0730 Con(X)=X
0740 GOSUB 2640
0750 Comp(X)=Prob
0760 Cont(2)=Cont(2)+Comp(X)
0770 NEXT X
0780 Ran(2)=Mils(J)*(1+Cont(2))
0790 Pa(2,2)=0
0800 FOR Ji=C+1 TO Mils(I,2)-1
0810 FOR X=0 TO Mils(I,2)-1-Con(Ji)
0820 GOSUB 2640
0830 Pa(2,2)=Pa(2,2)+Comp(Ji)*Prob
0840 NEXT X
0850 NEXT Ji
0860 Pa(3,2)=(Pa(1,2)+Pa(2,2))*100
0870 IF Pa(3,2)>100 THEN Pa(3,2)=100
0880 Cont(2)=Cont(2)+100
0890 Pr(2,2)=100-Pa(3,2)
0900 GOTO 9690
0910 K=Aq1*Lsize
0920 IF K=INT(K) THEN 9000
0930 DISP
0940 DISP "THE PRODUCT OF ACCEPTABLE QUALITY LEVEL & LOT SIZE IS ";K
0950 DISP "TO USE THE HYPERGEOMETRIC DISTRIBUTION, THIS PARAMETER MUST BE AN I
NTEGER."
0960 DISP " ENTER THE NUMBER OF DEFECTIVES PER LOT THAT IS CONSIDERED TO BE AC
CEPTABLE. "
0970 DISP
0980 BEEP
0990 INPUT K
9000 N=Lsize

```

```

9810 Bad=K
9820 N=Mils(J)
9830 C=Mils(I,1)
9840 FOR X=0 TO C
9850 GOSUB 2770
9860 IF X=0 THEN Pa(1,1)=Prob
9870 IF X<>0 THEN Pa(1,1)=Pa(1,1)+Prob
9880 NEXT X
9890 Cont(1)=0
9900 FOR X=C+1 TO Mlr(I,1)-1
9910 Con(X)=X
9920 GOSUB 2770
9930 Comp(X)=Prob
9940 Cont(1)=Cont(1)+Comp(X)
9950 NEXT X
9960 An(1)=Mils(J)*(1+Cont(1))
9970 N=Lsize-Mils(J)
9980 Pa(2,1)=0
9990 FOR It=C+1 TO Mlr(I,1)-1
9995 K=Bad-It
9998 FOR X=0 TO Mlr(I,2)-1-Con(It)
9999 GOSUB 2770
9999 Pa(2,1)=Pa(2,1)+Comp(It)*Prob
9999 NEXT X
9999 NEXT It
9999 Cont(1)=100*Cont(1)
9999 Pa(3,1)=100*(Pa(1,1)+Pa(2,1))
9999 IF Pa(3,1)>100 THEN Pa(3,1)=100
9999 Pr(2,1)=100-Pa(3,1)
9999 K=Ltpd*Lsize
9999 IF K=INT(K) THEN 9300
9999 DISP "THE PRODUCT OF LOT TOLERANCE PERCENT DEFECTIVE & LOT SIZE IS ";K
9999 DISP "TO USE THE HYPERGEOMETRIC DISTRIBUTION, THIS PARAMETER MUST BE AN I
9999 NTEGER."
9999 DISP " ENTER THE NUMBER OF DEFECTIVES PER LOT THAT IS CONSIDERED TO BE MA
9999 RCINAL."
9999 DISP
9999 DEEP
9999 INPUT K
9999 N=Lsize
9999 Bad=K
9999 N=Mils(J)
9999 C=Mils(I,1)
9999 FOR X=0 TO C
9999 GOSUB 2770
9999 IF X=0 THEN Pa(1,2)=Prob
9999 IF X<>0 THEN Pa(1,2)=Prob+Pa(1,2)
9999 NEXT X
9999 Cont(2)=0
9999 FOR X=C+1 TO Mlr(I,1)-1
9999 Con(X)=X
9999 GOSUB 2770
9999 Comp(X)=Prob
9999 Cont(2)=Cont(2)+Comp(X)
9999 NEXT X
9999 An(2)=Mils(J)*(1+Cont(2))
9999 N=Mils(J)
9999 N=Lsize-Mils(J)
9999 Pa(2,2)=0
9999 FOR It=C+1 TO Mlr(I,2)-1
9999 K=Bad-It
9999 FOR X=0 TO Mlr(I,2)-1-Con(It)
9999 GOSUB 2770
9999 Pa(2,2)=Pa(2,2)+Comp(It)*Prob
9999 NEXT X
9999 NEXT It
9999 Pa(3,2)=100*(Pa(2,2)+Pa(1,2))
9999 IF Pa(3,2)>100 THEN Pa(3,2)=100
9999 Pr(2,2)=100-Pa(3,2)
9999 Cont(2)=100*Cont(2)
9999 IF (ABS(Pr(2,1)-Alpha)<=Ato1) AND (ABS(Pa(3,2)-Beta)<=Bto1) THEN Check=1
9999 IF (ABS(Pr(2,1)-Alpha)<=Ato1) AND (ABS(Pa(3,2)-Beta)<=Bto1) THEN 9800
9999 IF Check=1 THEN 9960
9999 GOTO 9950
9999 IMAGE 1X,"
9999 IMAGE 1X,"

```

Accept/Reject

```

9750 IMAGE IX," | Sample | Criteria | Risk & Sampling Burden At Desired S
pecifications|"
9760 IMAGE IX," | Size | First |Second |Acceptable Quality Level| Tolerance
% Defective |"
9770 IMAGE IX," | 1st |2nd|Acc|Rej|Acc|Rej| Pa | Fc |Alpha| ASN |Beta | Pc
Pr | ASN |"
9780 IMAGE IX,"
9790 IMAGE +,IX,"|",2(4D,"|"),4(3D,"|"),2(3(3D.1D,"|"),4D.1D,"|")
9800 IF Print<>0 THEN 9930
9810 IF Dist="HYPER" THEN PRINT LIN(4);SPA(20);"Hypergeometric Probability Eva
luation"
9820 IF Dist="BINOMIAL" THEN PRINT LIN(4);SPA(20);"Binomial Probability Evalua
tion"
9830 PRINT SPA(22);"Optional MIL-STD-105D Sampling Plans";LIN(1);SPA(38);"AQL="
;Aql*100;"% and LTPD=";Ltpd*100;"%"
9840 PRINT SPA(10);"Producer's Risk = ";Alpha;"α";Ato1;"% and Consumer's Risk
= ";Beta;"β";Bto1;"%"
9850 IF Maxsam<1000000 THEN PRINT SPA(20);"Maximum Total Sample Constraint:";Ma
xsam
9860 IF Dist="HYPER" THEN PRINT SPA(32);"Lot Size = ";Lsize
9870 Print=S
9880 PRINT USING 9730
9890 PRINT USING 9740
9900 PRINT USING 9750
9910 PRINT USING 9760
9920 PRINT USING 9770
9930 PRINT USING 9790;Mils(J),Mils(J),Mila(I,1),Mila(I,1),Mila(I,2),Mila(I,2),P
a(3,1),Cont(1),Pr(2,1),Asn(1),Pa(3,2),Cont(2),Pr(2,2),Asn(2)
9940 PRINT USING 9780
9950 NEXT J
9960 NEXT I
9970 IF Print=0 THEN PRINT "No plans were found which met the design specificat
ions at the specified";LIN(1);"Tolerances. Lower the tolerances & try again!"
9980 IF Print=0 THEN 2010
9990 PRINT LIN(2);"A complete assessment of whether these plans is obtainable b
y exercising";LIN(1);"Option 01 of this software segment.";LIN(4)
10000 GOTO 2010

```



**APPENDIX D**  
**SEQUENTIAL SAMPLING SOURCE CODE**

## APPENDIX D SEQUENTIAL SAMPLING SOURCE CODE

```

2000 REM Sequ: Wald's Sequential Sampling Approach
2010 FOR I=1 TO 4
2020 DISP
2030 IF I=1 THEN DISP " ENTER THE ACCEPTABLE QUALITY LEVEL, STATED AS A PERCENT
T "
2040 IF I=2 THEN DISP " ENTER THE LOT TOLERANCE PERCENT DEFECTIVE, STATED AS A
PERCENT "
2050 IF I=3 THEN DISP " ENTER THE PRODUCER'S RISK, STATED AS A PERCENT "
2060 IF I=4 THEN DISP " ENTER THE CONSUMER'S RISK, STATED AS A PERCENT "
2070 DISP
2080 BEEP
2090 IF I=1 THEN INPUT Aq1
2100 IF I=2 THEN INPUT Ltpd
2110 IF I=3 THEN INPUT Alpha
2120 IF I=4 THEN INPUT Beta
2130 NEXT I
2140 Aq1=Aq1/100
2150 Ltpd=Ltpd/100
2160 Alpha=Alpha/100
2170 Beta=Beta/100
2180 Denom=LOG(Ltpd*(1-Aq1)/(Aq1*(1-Ltpd)))
2190 H1=LOG((1-Alpha)/Beta)/Denom
2200 H2=LOG((1-Beta)/Alpha)/Denom
2210 S=LOG((1-Aq1)/(1-Ltpd))/Denom
2220 DISP
2230 DISP " DO YOU WANT A COPY OF THE DERIVED LINES? "
2240 DISP
2250 BEEP
2260 INPUT Res
2270 IF Res="NO" THEN 2420
2280 PRINT LIN(4);SPA(10);"Acceptance Line: X = -(;"H1;" + ";"S;"(n)";LIN(1)
2290 PRINT SPA(10);"Rejection Line: X = ";"H2;" + ";"S;"(n)"
2300 FOR I=1 TO 100
2310 Table(I,1)=1
2320 Table(I,2)=-H1+S*I
2330 Table(I,3)=H2+S*I
2340 IF Table(I,2)<0 THEN 2380
2350 Ck=INT(Table(I,2))
2360 IF Ck=Table(I,2) THEN 2380
2370 Table(I,2)=Ck
2380 Ck=INT(Table(I,3))
2390 IF Ck=Table(I,3) THEN 2410
2400 Table(I,3)=Ck+1
2410 NEXT I
2420 DISP
2430 DISP " DO YOU WANT A TABLE OF THE ACCEPT/REJECT NUMBERS VERSUS NUMBER SA
MPLED? "
2440 DISP
2450 BEEP
2460 INPUT Res
2470 IF Res="NO" THEN 2050
2480 IMAGE " ",4(" ")
2490 IMAGE "T",4("Number | If Total ")
2500 IMAGE " |",4("Of Unit | Defective ")
2510 IMAGE " |",4("Sampled | Acpt | Rejt |")
2520 IMAGE "+",4(1X,5D," |",1X,3A," |",1X,3A," |")
2530 PRINT LIN(4);SPA(24);"Wald's Sequential Sampling Table"
2540 PRINT SPA(24);"AQL=";Aq1*100;"% & LTPD=";Ltpd*100;"%"
2550 PRINT SPA(30);"Producer's Risk= ";Alpha*100;"%"
2560 PRINT SPA(30);"Consumer's Risk= ";Beta*100;"%"
2570 PRINT USING 2400
2580 PRINT USING 2490
2590 PRINT USING 2500
2600 PRINT USING 2510
2610 FOR I=1 TO 25
2620 IF Table(I,2)<0 THEN Tabs(1)=Nums(102)
2630 IF Table(I,2)=0 THEN Tabs(1)=Nums(101)
2640 IF Table(I+25,2)<0 THEN Tabs(3)=Nums(102)
2650 IF Table(I+25,2)=0 THEN Tabs(3)=Nums(101)
2660 IF Table(I+50,2)<0 THEN Tabs(5)=Nums(102)
2670 IF Table(I+50,2)=0 THEN Tabs(5)=Nums(101)
2680 IF Table(I+75,2)<0 THEN Tabs(7)=Nums(102)
2690 IF Table(I+75,2)=0 THEN Tabs(7)=Nums(101)
2700 IF Table(I,2)>0 THEN Tabs(1)=Nums(Table(I,2))
2710 IF Table(I+25,2)>0 THEN Tabs(3)=Nums(Table(I+25,2))
2720 IF Table(I+50,2)>0 THEN Tabs(5)=Nums(Table(I+50,2))

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```

2730 IF Table(I+75,2)>0 THEN Tabs(7)=Nums(Table(I+75,2))
2740 IF (Table(I,3)>Table(I,1)) OR (Table(I,3)<=0) THEN Tabs(2)=Nums(102)
2750 IF Table(I,3)<=Table(I,1) THEN Tabs(2)=Nums(Table(I,3))
2760 IF (Table(I+25,3)>Table(I+25,1)) OR (Table(I+25,3)<=0) THEN Tabs(4)=Nums(1
02)
2770 IF Table(I+25,3)<=Table(I+25,1) THEN Tabs(4)=Nums(Table(I+25,3))
2780 IF (Table(I+50,3)>Table(I+50,1)) OR (Table(I+50,3)<=0) THEN Tabs(6)=Nums(1
02)
2790 IF Table(I+50,3)<=Table(I+50,1) THEN Tabs(6)=Nums(Table(I+50,3))
2800 IF (Table(I+75,3)>Table(I+75,1)) OR (Table(I+75,3)<=0) THEN Tabs(8)=Nums(1
02)
2810 IF Table(I+75,3)<=Table(I+75,1) THEN Tabs(8)=Nums(Table(I+75,3))
2820 PRINT USING 2520;Table(I,1);Tabs(1),Tabs(2),Table(I+25,1),Tabs(3),Tabs(4),
Table(I+50,1),Tabs(5),Tabs(6),Table(I+75,1),Tabs(7),Tabs(8)
2830 PRINT USING 2400
2840 NEXT I
2850 F3s=(1-Beta)/Alpha
2860 F4s=Beta/(1-Alpha)
2870 Nopt=0
2880 Theta=2
2890 Fis=(1-Ltpd)/(1-Aql)
2900 F2s=Ltpd/Aql
2910 Pps=(1-Fis^Theta)/(F2s^Theta-Fis^Theta)
2920 IF (Pps>0) AND (Pps<1) THEN 2960
2930 Theta=Theta*.84
2940 IF Theta=0 THEN 2930
2950 GOTO 2910
2960 Nopt=Nopt+1
2970 Pd(Nopt)=Pps
2980 Pa(1,Nopt)=(F3s^Theta-1)/(F3s^Theta-F4s^Theta)
2990 Asn(Nopt)=Pa(1,Nopt)*LOG(F4s)+(1-Pa(1,Nopt))*LOG(F3s)
3000 Asn(Nopt)=Asn(Nopt)/(Pps*LOG(F2s)+(1-Pps)*LOG(Fis))
3010 BEEP
3020 IF Nopt=100 THEN 3040
3030 GOTO 2930
3040 FOR I=1 TO 99
3050 FOR J=1 TO 100
3060 IF Pd(I)<=Pd(J) THEN 3160
3070 Tem=Pd(I)
3080 Pd(I)=Pd(J)
3090 Pd(J)=Tem
3100 Tem=Pa(1,I)
3110 Pa(1,I)=Pa(1,J)
3120 Pa(1,J)=Tem
3130 Tem=Asn(I)
3140 Asn(I)=Asn(J)
3150 Asn(J)=Tem
3160 NEXT J
3170 BEEP
3180 NEXT I
3190 DISP
3200 DISP " DO YOU WANT A TABLE OF Pa & ASN VERSUS PERCENT DEFECTIVE? "
3210 DISP
3220 BEEP
3230 INPUT Res
3240 IF Res="NO" THEN 3420
3250 PRINT LIN(4)
3260 PRINT SPA(30);"Sequential Sampling"
3270 PRINT " " AQL=";Aql*100;"%, Producer's Risk=";Alpha*100;"%, LTPD=";Ltpd
+100;"% & Consumer's Risk=";Beta*100;"%"
3280 PRINT " Probability of Acceptance and Average Sample Size Versus Percent
Defective"
3290 IMAGE 7X, " ", 2(" ")
3300 IMAGE 7X, " ", 2(" ")
3310 IMAGE 7X, " ", 2(" Percent of Sample ")
3320 IMAGE 7X, " ", 2(" Defective Acceptance Number ")
3330 PRINT USING 3290
3340 PRINT USING 3300
3350 PRINT USING 3310
3360 PRINT USING 3320
3370 IMAGE 4, 7X, " |", 2(6D.2D, " |", 6D.2D, " % |", 4D.2D, " |")
3380 FOR I=1 TO 50
3390 PRINT USING 3370;Pd(I)*100,Pa(1,I)*100,Asn(I),Pd(I+50)*100,Pa(1,I+50)*100,
Asn(I+50)
3400 PRINT USING 3290
3410 NEXT I

```

```

3420 DISP
3430 DISP " DO YOU WANT A PLOT OF THE OC CURVE? "
3440 DISP
3450 BEEP
3460 INPUT Res
3470 IF Res="NO" THEN 3660
3480 PLOTTER IS "9872A"
3490 PLOTTER 7,5 IS ON
3500 LOCATE 10,100,10,100
3510 SCALE 0,INT(Pd(100)*100)+1,0,104
3520 CSIZE 2
3530 IF Pd(100)*100<=20 THEN Inx=1
3540 IF (Pd(100)*100>20) AND (Pd(100)*100<=40) THEN Inx=2
3550 IF (Pd(100)*100>40) AND (Pd(100)*100<=80) THEN Inx=4
3560 LAXES Inx,5,0,0,-1,1
3570 MOVE Inx/2,101
3580 LABEL "Pa(x)"
3590 MOVE 5*Inx,-4
3600 LABEL "PERCENT DEFECTIVE"
3610 MOVE 0,100
3620 PEN 2
3630 FOR I=1 TO 100
3640 DRAW Pd(I)*100,Pa(1,I)*100
3650 NEXT I
3660 DISP
3670 DISP " DO YOU WANT A PLOT OF THE AVERAGE SAMPLE SIZE TO A DECISION? "
3680 DISP
3690 BEEP
3700 INPUT Res
3710 IF Res="NO" THEN RETURN
3720 PLOTTER IS "9872A"
3730 PLOTTER 7,5 IS ON
3740 LOCATE 10,100,10,100
3750 IF Pd(100)*100<=20 THEN Inx=1
3760 IF (Pd(100)*100>20) AND (Pd(100)*100<=40) THEN Inx=2
3770 Sig=-99999
3780 FOR I=1 TO 100
3790 IF Rsn(I)>Sig THEN Sig=Rsn(I)
3800 NEXT I
3810 Maxy=INT(Sig)
3820 Maxy=10*INT(Maxy/10)+13
3830 SCALE 0,INT(Pd(100)*100)+1,0,Maxy
3840 CSIZE 2
3850 IF Maxy<=20 THEN Iny=1
3860 IF (Maxy>20) AND (Maxy<=40) THEN Iny=2
3870 IF (Maxy>40) AND (Maxy<=80) THEN Iny=4
3880 LAXES Inx,Iny,0,0,-1,1
3890 MOVE Inx/2,Maxy-3
3900 LABEL "ASN"
3910 MOVE 5*Inx,-.9*Iny
3920 LABEL "PERCENT DEFECTIVE"
3930 MOVE Pd(I)*100,Rsn(I)
3940 PEN 2
3950 FOR I=2 TO 100
3960 DRAW Pd(I)*100,Rsn(I)
3970 NEXT I
3980 RETURN

```

**APPENDIX E**  
**MULTIPLE SAMPLING SOURCE CODE**

## APPENDIX E MULTIPLE SAMPLING SOURCE CODE

```

2000 REM ***** Multiple Sampling Plan Design *****
2010 DISP "
-
2020 DISP "           Multiple Sampling Design Options
-
2030 DISP "   Option Description                               Select Code
-
2040 DISP "   >Barnard-Enters-Hanaker's Poisson Approximation
-
2050 DISP "     of Sample Size for Producer's Risk of Five
-
2060 DISP "     Percent & Consumer's Risk of Ten Percent.
-
2070 DISP "     Achieved Risks are Calculated Via the Binomial.....1
-
2080 DISP "   >MIL-STD-105D Alternate Plans For Specified
-
2090 DISP "     AQL, Producer's Risk, LTPD, and Consumer's
-
2100 DISP "     Risk. Achieved risks are Calculated Via the
-
2110 DISP "     Binomial.....2
-
2120 DISP "
-
2130 DISP
2140 DISP "           ENTER THE SELECT CODE OF THE DESIRED OPTION."
2150 DISP
2160 BEEP
2170 INPUT Sc
2180 IF Sc<>1 THEN 4230
2190 GOSUB 2210
2200 GOTO 2360
2210 DISP
2220 DISP "   ENTER THE ACCEPTABLE QUALITY LEVEL, STATED AS A PERCENT: "
2230 DISP
2240 BEEP
2250 INPUT Aql
2260 Aql=Aql/100
2270 DISP
2280 DISP "   ENTER THE LOT TOLERANCE PERCENT DEFECTIVE, STATED AS A PERCENT!
-
2290 DISP
2300 BEEP
2310 INPUT Ltpd
2320 Ltpd=Ltpd/100
2330 Ratio=Ltpd/Aql
2340 Row=1
2350 RETURN
2360 Diff=ABS(Ratio-Ccat(1,2))
2370 FOR I=2 TO 20
2380 Ck=ABS(Ratio-Ccat(I,2))
2390 IF Ck>Diff THEN 2450
2400 Row=I
2410 Tier=?
2420 IF (Row=4) OR (Row=6) OR (Row=9) OR (Row=13) THEN Tier=0
2430 IF Row=5 THEN Tier=9
2440 Diff=Ck
2450 BEEP
2460 NEXT I
2470 FOR J=1 TO 9
2480 Multi(J,2)=Ccat(Row,J+2)
2490 Multi(J,13)=Ccat(Row,J+11)
2500 NEXT J
2510 Ss1=INT(Ccat(Row,21)/Aql)
2520 Ss2=INT(Ccat(Row,23)/Ltpd)
2530 IF Ss1>Ss2 THEN Low=Ss2
2540 IF Ss1<=Ss2 THEN Low=Ss1
2550 IF Ss1>Ss2 THEN High=Ss1+1
2560 IF Ss1<=Ss2 THEN High=Ss2+1
2570 Low=INT(Low)-1
2580 IF Low<1 THEN Low=1
2590 High=INT(High)+2
2600 Plans=0
2610 DISP Low,High
2620 FOR Sample=Low TO High
2630 FOR J=1 TO Tier

```

```

2640 Multi(J,1)=Sample*J
2650 NEXT J
2660 BEEP
2670 P=Aq1
2680 GOSUB 3510
2690 Cal=1-Pac
2700 Expa=En
2710 P=Ltpd
2720 GOSUB 3510
2730 Cbe=Pac
2740 Expb=En
2750 Plans=Plans+1
2760 PRINT LIN(4);SPA(16);"Optional Sampling Plan 0";Plans
2770 PRINT SPA(10);"Which Approximate: Producer's Risk = 5% & Consumer's Risk =
10 %"
2780 PRINT "The Binomial Distribution Point Estimate of Producer's Risk is ";Ca
l*100;"%, "
2790 PRINT SPA(12);"and the Point Estimate of Consumer's Risk is ";Cbe*100;"%, "
2800 IMAGE "

```

2810 IMAGE	Total	Cumulative	
Cumulative			
2820 IMAGE	Number	Acceptance	Cumulative Continuance Numbers
Rejection			
2830 IMAGE	Of Units	Number	
Number			
2840 IMAGE	Sampled	( R )	( C )
( R )			

```

2850 PRINT LIN(4);SPA(26);"Multiple Plan Specification"
2860 PRINT USING 2800
2870 PRINT USING 2810
2880 PRINT USING 2820
2890 PRINT USING 2830
2900 PRINT USING 2840
2910 FOR I=1 TO 9
2920 IF Multi(I,13)=100 THEN Tier=I-1
2930 IF Multi(I,13)=100 THEN 2970
2940 NEXT I
2950 Tier=9
2960 BEEP
2970 FOR I=1 TO Tier
2980 IF Multi(I,2)<0 THEN Start=0
2990 IF Multi(I,2)=0 THEN Start=Multi(I,2)+1
3000 FOR J=1 TO 12
3010 Con(J)=Start+(J-1)
3020 IF Con(J)=Multi(I,13) THEN Pass=J-1
3030 IF Con(J)=Multi(I,13) THEN 3080
3040 NEXT J
3050 DISP
3060 DISP "Sorry! The program is setup to handle only 11 continuation numbers!"

```

```

3070 GOTO 2950
3080 IF Multi(I,2)<0 THEN Tabs(1)=Nums(102)
3090 IF Multi(I,2)=0 THEN Tabs(1)=Nums(101)
3100 IF Multi(I,2)>0 THEN Tabs(1)=Nums(Multi(I,2))
3110 IF Multi(I,2)+1=Multi(I,13) THEN Ncont=0
3120 IF Multi(I,2)+1=Multi(I,13) THEN 3170
3130 FOR J=1 TO Pass
3140 IF Con(J)=0 THEN Tabs(J+1)=Nums(101)
3150 IF Con(J)<>0 THEN Tabs(J+1)=Nums(Con(J))
3160 NEXT J
3170 FOR J=Pass+1 TO 11
3180 Tabs(J+1)="XXX"
3190 NEXT J
3200 IMAGE "+, ",1X,6D,1X,"|",4X,3A,4X,"|X|",11(3A,"|"),1X,8D,1X,"|"
3210 PRINT USING 3200;Multi(I,1),Tabs(1),Tabs(2),Tabs(3),Tabs(4),Tabs(5),Tabs(6),
Tabs(7),Tabs(8),Tabs(9),Tabs(10),Tabs(11),Tabs(12),Multi(I,13)
3220 PRINT USING 2800
3230 NEXT I
3240 PRINT LIN(2);SPA(20);"A complete risk assessment is obtainable by "
3250 PRINT SPA(20);"exercising Option 3 of the Main Menu."
3260 NEXT Sample
3270 IF Plans<0 THEN RETURN
3280 IF Plans=0 THEN PRINT " No plans were found which satisfied the design tol
erances you specified!"
3290 IF Plans=0 THEN PRINT " If you wish, you can widen the design tolerances o
n Producer's and "

```

```

3300 IF Plans=0 THEN PRINT " Consumer's Risk and re-execute this option."
3310 IF Plans=0 THEN PRINT "           IF YOU WANT TO DO THIS, ENTER YES."
3320 IF Plans=0 THEN PRINT "           OTHERWISE, ENTER NO."
3330 DISP
3340 BEEP
3350 INPUT Res
3360 IF Res="NO" THEN RETURN
3370 GOTO 2190
3380 REM BINOMIAL SUBROUTINE
3390 IF (S-X<0) OR (X<0) THEN Prob=0
3400 IF (S-X<0) OR (X<0) THEN RETURN
3410 IF (S-X=0) OR (X=0) THEN Prob=P^X*(1-P)^(S-X)
3420 IF (S-X=0) OR (X=0) THEN RETURN
3430 Prob=1
3440 FOR Is=1 TO X
3450 Prob=Prob*P
3460 NEXT Is
3470 FOR Is=1 TO S-X
3480 Prob=Prob*((X+Is)/Is)*(1-P)
3490 NEXT Is
3500 RETURN
3510 REM PA & EN DRILL
3520 S=Multi(1,1)
3530 Start=1
3540 Pen=0
3550 Pac=0
3560 En=Multi(1,1)
3570 FOR X=0 TO Multi(1,13)-1
3580 GOSUB 3300
3590 Con(X+1)=X
3600 Conp(X+1)=Prob
3610 NEXT X
3620 IF Multi(1,2)>=0 THEN 3670
3630 FOR X=0 TO Multi(1,13)-1
3640 Pen=Pen+Conp(X+1)
3650 NEXT X
3660 GOTO 3750
3670 FOR X=0 TO Multi(1,13)-1
3680 IF Con(X+1)<=Multi(1,2) THEN Pac=Pac+Conp(X+1)
3690 IF Con(X+1)>Multi(1,2) THEN Start=X+1
3700 IF Con(X+1)>Multi(1,2) THEN 3720
3710 NEXT X
3720 FOR X=Start TO Multi(1,13)
3730 Pen=Pen+Conp(X)
3740 NEXT X
3750 En=En+Pen*(Multi(2,1)-Multi(1,1))
3760 Pacer=1
3770 FOR It=Start TO Multi(1,13)
3780 Table(Pacer,1)=Con(It)
3790 Table(Pacer,2)=Conp(It)
3800 Pacer=Pacer+1
3810 NEXT It
3820 Pacer=Pacer-1
3830 FOR I=2 TO Tier
3840 Pen=0
3850 IF Multi(I-1,2)<0 THEN Start=0
3860 IF Multi(I-1,2)>=7 THEN Start=Multi(I-1,2)+1
3870 FOR It=Start TO Multi(I,13)-1
3880 Con(It+1)=It
3890 Conp(It+1)=0
3900 NEXT It
3910 FOR It=1 TO Pacer
3920 X=0
3930 GOSUB 3300
3940 Def=Table(It,1)+X
3950 Prdef=Table(It,2)+Prob
3960 FOR Is=Start TO Multi(I,13)-1
3970 IF Def=Con(Is+1) THEN Conp(Is+1)=Conp(Is+1)+Prdef
3980 IF Def=Con(Is+1) THEN 4060
3990 NEXT Is
4000 IF Def=Multi(I,13)-1 THEN 4030
4010 X=X+1
4020 GOTO 3930
4030 NEXT It
4040 IF Multi(I,2)<0 THEN 4100
4050 FOR It=Start TO Multi(I,13)-1

```



```

4060 IF Con(I+1)<=Multi(I,2) THEN Pac=Pac+Conp(I+1)
4070 IF Con(I+1)<=Multi(I,2) THEN Start=Start+1
4080 NEXT I
4090 IF Multi(I,2)+1=Multi(I,13) THEN 4210
4100 FOR It=Start TO Multi(I,13)-1
4110 Pen=Pen+Conp(I+1)
4120 NEXT It
4130 En=En+Pen*(Multi(I+1,1)-Multi(I,1))
4140 Pacer=1
4150 FOR It=Start TO Multi(I,13)-1
4160 Table(Pacer,1)=Con(I+1)
4170 Table(Pacer,2)=Conp(I+1)
4180 Pacer=Pacer+1
4190 NEXT It
4200 Pacer=Pacer-1
4210 NEXT I
4220 RETURN
4230 GOSUB 2210
4240 D:SP
4250 Tier=7
4260 Ccrit=1
4270 DISP "ENTER THE PRODUCER'S RISK, STATED AS A PERCENT! "
4280 DISP
4290 BEEP
4300 INPUT Alpha
4310 Alpha=Alpha/100
4320 DISP
4330 DISP "ENTER THE CONSUMER'S RISK, STATED AS A PERCENT! "
4340 DISP
4350 BEEP
4360 INPUT Beta
4370 Beta=Beta/100
4380 FOR Plans=1 TO 15
4390 Plans=0
4400 FOR Jt=1 TO 7
4410 Multi(Jt,2)=Hsplan(Plan,Jt,1)
4420 Multi(Jt,13)=Hsplan(Plan,Jt,2)
4430 NEXT Jt
4440 BEEP
4450 FOR Sample=1 TO 21
4460 FOR Pass=1 TO 7
4470 Multi(Pass,1)=Pass*Hsplan(Sample)
4480 NEXT Pass
4490 P=Aq1
4500 GOSUB 3510
4510 Cal=1-Pac
4520 BEEP
4530 Enal=En
4540 P=Ltpd
4550 GOSUB 3510
4560 Cbe=Pac
4570 Crit=((Cal-Alpha)^2+(Cbe-Beta)^2)^.5
4580 IF (Crit>Ccrit) AND (Plans>0) THEN 5070
4590 IF Crit>Ccrit THEN 5020
4600 Ccrit=Crit
4610 PRINT LIN(4);SPA(6);"The sampling plan specified below is the closest examined thusfar"
4620 Plans=Plans+1
4630 PRINT "Which Approximates: Producer's Risk =";Alpha*100;"% & Consumer's Risk =";Beta*100;"%";LIN(1)
4640 PRINT "The Binomial Distribution Point Estimate of Producer's Risk is ";Cal*100;"%,"
4650 PRINT SPA(12);"and the Point Estimate of Consumer's Risk is ";Cbe*100;"%,";LIN(2)
4660 PRINT LIN(4);SPA(26);"Multiple Plan Specification"
4670 PRINT USING 2000
4680 PRINT USING 2010
4690 PRINT USING 2020
4700 PRINT USING 2030
4710 PRINT USING 2040
4720 FOR I=1 TO Tier
4730 IF Multi(I,2)<0 THEN Start=0
4740 IF Multi(I,2)>0 THEN Start=Multi(I,2)+1
4750 FOR J=1 TO 12
4760 Con(J)=Start+(J-1)
4770 IF Con(J)=Multi(I,13) THEN Pass=J-1

```

```

4780 IF Con(J)=Multi(I,13) THEN 4830
4790 NEXT J
4800 DISP
4810 DISP "Sorry! The program is setup to handle only 11 continuation numbers!"
4820 GOTO 4760
4830 IF Multi(I,2)<0 THEN Tabs(1)=Nums(102)
4840 IF Multi(I,2)=0 THEN Tabs(1)=Nums(101)
4850 IF Multi(I,2)>0 THEN Tabs(1)=Nums(Multi(I,2))
4860 IF Multi(I,2)+1=Multi(I,13) THEN Ncont=0
4870 IF Multi(I,2)+1=Multi(I,13) THEN 4920
4880 FOR J=1 TO Pass
4890 IF Con(J)=0 THEN Tabs(J+1)=Nums(101)
4900 IF Con(J)<>0 THEN Tabs(J+1)=Nums(Con(J))
4910 NEXT J
4920 FOR J=Pass+1 TO 11
4930 Tabs(J+1)="XXX"
4940 NEXT J
4950 IMAGE +, "|", 1X, 6D, 1X, "|", 4X, 3A, 4X, "|X|", 11(3A, "|"), 1X, 8D, 1X, "| "
4960 PRINT USING 4950; Multi(I,1), Tabs(1), Tabs(2), Tabs(3), Tabs(4), Tabs(5), Tabs(6)
, Tabs(7), Tabs(8), Tabs(9), Tabs(10), Tabs(11), Tabs(12), Multi(I,13)
4970 PRINT USING 4980
4980 IMAGE " _____ ", 11( " _____ "), " _____ "
4990 NEXT I
5000 PRINT LIN(2);SPR(20);"A complete risk assessment is obtainable by "
5010 PRINT SPR(20);"exercising Option 5 of the Main Menu."
5020 DISP "Plan 0";Plan;" with incremental sample sizes of ";Multi(I,1)
5030 NEXT Sample
5040 DISP
5050 DISP TAB(Plan+4);"Moving to Plan";Plan
5060 DISP
5070 NEXT Plan
5080 RETURN

```

**APPENDIX F**  
**SPECIAL PURPOSE ASSESSMENT SOURCE CODE**

## APPENDIX F SPECIAL PURPOSE ASSESSMENT SOURCE CODE

```

2000 REM ***** SPECIAL PLAN DC CURVE & ASN ASSESSMENT *****
2010 IMAGE =

```

2020 IMAGE	Total	Cumulative			
Cumulative					
2030 IMAGE	Number	Acceptance		Cumulative Continuance Numbers	
Rejection					
2040 IMAGE	Of Units	Number			
Number					
2050 IMAGE	Sampled	( A )		( C )	
( R )					

```

2060 PRINT LIN(4);SPA(26);"Multiple Plan Specification"
2070 PRINT USING 2010
2080 PRINT USING 2020
2090 PRINT USING 2030
2100 PRINT USING 2040
2110 PRINT USING 2050
2120 FOR I=1 TO 51
2130 Pass=0
2140 Tier=1
2150 DISP
2160 DISP " ENTER THE NUMBER OF UNITS SAMPLED TO DECISION POINT, NUMBER
" ; I
2170 DISP
2180 BEEP
2190 INPUT Multi(I,1)
2200 DISP
2210 DISP "IF THE LOT CAN BE ACCEPTED AT THIS POINT, ENTER THE ACCEPTANCE NUM
BER "
2220 DISP "IF THE LOT CAN NOT BE ACCEPTED AT THIS POINT, ENTER A NEGATIVE N
UMBER. "
2230 DISP
2240 BEEP
2250 INPUT Multi(I,2)
2260 DISP
2270 DISP "IF THE LOT CAN BE REJECTED AT THIS POINT, ENTER THE REJECTION NUMB
ER "
2280 DISP "IF THE LOT CAN NOT BE REJECTED AT THIS POINT, ENTER A NEGATIVE N
UMBER. "
2290 DISP
2300 BEEP
2310 INPUT Multi(I,13)
2320 IF Multi(I,2)<0 THEN 2340
2330 IF Multi(I,2)+1=Multi(I,13) THEN 2440
2340 NEXT I
2350 DISP
2360 DISP " SORRY! THE PROGRAM IS CURRENTLY SETUP TO HANDLE 50 TIERS, SEE
Pat Lavelle"
2370 DISP
2380 BEEP
2390 FOR I=1 TO 25
2400 DISP
2410 BEEP
2420 NEXT I
2430 STOP
2440 FOR I=1 TO Tier
2450 IF Multi(I,2)<0 THEN Start=0
2460 IF Multi(I,2)>0 THEN Start=Multi(I,2)+1
2470 FOR J=1 TO 12
2480 Con(J)=Start+(J-1)
2490 IF Con(J)=Multi(I,13) THEN Pass=J-1
2500 IF Con(J)=Multi(I,13) THEN 2550
2510 NEXT J
2520 DISP
2530 DISP "Sorry! The program is setup to handle only 11 continuation numbers!
"
2540 GOTO 2370
2550 IF Multi(I,2)<0 THEN Tabs(1)=Numb(102)
2560 IF Multi(I,2)=0 THEN Tabs(1)=Numb(101)
2570 IF Multi(I,2)>0 THEN Tabs(1)=Numb(Multi(I,2))
2580 IF Multi(I,2)+1=Multi(I,13) THEN Ncont=0
2590 IF Multi(I,2)+1=Multi(I,13) THEN 2640
2600 FOR J=1 TO Pass
2610 IF Con(J)=0 THEN Tabs(J+1)=Numb(101)
2620 IF Con(J)>0 THEN Tabs(J+1)=Numb(Con(J))
2630 NEXT J

```

```

2640 FOR J=Pass+1 TO 11
2650 Tabs(J+1)="XXX"
2660 NEXT J
2670 IMAGE +,"|",1X,6D,1X,"|",4X,3A,4X,"|X|",11(3A,"|"),1X,8D,1X,"|"-
2680 PRINT USING 2670;Multi(I,1),Tabs(1),Tabs(2),Tabs(3),Tabs(4),Tabs(5),Tabs(6
),Tabs(7),Tabs(8),Tabs(9),Tabs(10),Tabs(11),Tabs(12),Multi(I,13)
2690 PRINT USING 2010
2700 NEXT I
2710 GOTO 3220
2720 REM BINOMIAL SUBROUTINE
2730 IF (S-X<0) OR (X<0) THEN Prob=0
2740 IF (S-X<0) OR (X<0) THEN RETURN
2750 IF (S-X=0) OR (X=0) THEN Prob=P^X*(1-P)^(S-X)
2760 IF (S-X=0) OR (X=0) THEN RETURN
2770 Prob=1
2780 FOR Is=1 TO X
2790 Prob=Prob*P
2800 NEXT Is
2810 FOR Is=1 TO S-X
2820 Prob=Prob*((X+Is)/Is)*(1-P)
2830 NEXT Is
2840 RETURN
2850 REM HYPERGEOMETRIC DISTRIBUTION
2860 IF X<0 THEN Prob=0
2870 IF K<0 THEN Prob=0
2880 IF K<0 THEN RETURN
2890 IF X>K THEN Prob=0
2900 IF X>K THEN RETURN
2910 IF (K=0) AND (X=0) THEN Prob=1
2920 IF (K=0) AND (X=0) THEN RETURN
2930 IF X<0 THEN RETURN
2940 IF X>M THEN Prob=0
2950 IF X>M THEN RETURN
2960 Prob=1
2970 F(1)=K
2980 F(2)=M-K
2990 F(3)=M
3000 F(4)=M-M
3010 F(5)=X
3020 F(6)=K-X
3030 F(7)=M-X
3040 F(8)=M-K-M+X
3050 F(9)=M
3060 FOR Is=1 TO 9
3070 IF F(Is)<1 THEN F(Is)=1
3080 NEXT Is
3090 Prob=Prob*(F(1)*F(2)*F(3)*F(4))/(F(5)*F(6)*F(7)*F(8)*F(9))
3100 FOR Is=1 TO 9
3110 F(Is)=F(Is)-1
3120 IF F(Is)<1 THEN F(Is)=1
3130 NEXT Is
3140 Ck=0
3150 FOR Is=1 TO 9
3160 IF F(Is)=1 THEN 3180
3170 Ck=1
3180 NEXT Is
3190 IF Ck=0 THEN RETURN
3200 GOTO 3090
3210 RETURN
3220 DISP
3230 DISP " DO YOU WANT TO BASE YOUR RISK CALCULATIONS ON A FINITE LOT SIZE?"
.
3240 DISP
3250 BEEP
3260 INPUT Res
3270 IF Res="YES" THEN Dist="HYPER"
3280 IF Res="YES" THEN DISP
3290 IF Res="YES" THEN DISP TAB(20);"ENTER THE LOT SIZE."
3300 IF Res="YES" THEN DISP
3310 IF Res="YES" THEN BEEP
3320 IF Res="YES" THEN INPUT Lsize
3330 REM *****
3340 IF Res="YES" THEN 5240
3350 REM *****
3360 IF Res="NO" THEN Dist="BINOMIAL"
3370 P=.01
3380 REM

```

```

3390 GOSUB 3410
3400 GOTO 4120
3410 S=Multi(I,1)
3420 Start=1
3430 Pen=0
3440 Pac=0
3450 En=Multi(I,1)
3460 FOR X=0 TO Multi(I,13)-1
3470 GOSUB 2720
3480 Con(X+1)=X
3490 Conp(X+1)=Prob
3500 NEXT X
3510 IF Multi(I,2)>=0 THEN 3560
3520 FOR X=0 TO Multi(I,13)-1
3530 Pen=Pen+Conp(X+1)
3540 NEXT X
3550 GOTO 3640
3560 FOR X=0 TO Multi(I,13)-1
3570 IF Con(X+1)<=Multi(I,2) THEN Pac=Pac+Conp(X+1)
3580 IF Con(X+1)>Multi(I,2) THEN Start=X+1
3590 IF Con(X+1)>Multi(I,2) THEN 3610
3600 NEXT X
3610 FOR X=Start TO Multi(I,13)
3620 Pen=Pen+Conp(X)
3630 NEXT X
3640 En=En+Pene(Multi(I,2,1)-Multi(I,1))
3650 Pacer=1
3660 FOR It=Start TO Multi(I,13)
3670 Table(Pacer,1)=Con(It)
3680 Table(Pacer,2)=Conp(It)
3690 Pacer=Pacer+1
3700 NEXT It
3710 Pacer=Pacer-1
3720 FOR I=2 TO Tier
3730 Pen=0
3740 IF Multi(I-1,2)<0 THEN Start=0
3750 IF Multi(I-1,2)=0 THEN Start=Multi(I-1,2)+1
3760 FOR Is=Start TO Multi(I,13)-1
3770 Con(It+1)=It
3780 Conp(It+1)=0
3790 NEXT It
3800 FOR It=1 TO Pacer
3810 X=0
3820 GOSUB 2720
3830 Def=Table(It,1)*X
3840 Prdef=Table(It,2)*Prob
3850 FOR Is=Start TO Multi(I,13)-1
3860 IF Def=Con(Is+1) THEN Conp(Is+1)=Conp(Is+1)*Prdef
3870 IF Def=Con(Is+1) THEN 3890
3880 NEXT Is
3890 IF Def=Multi(I,13)-1 THEN 3920
3900 X=X+1
3910 GOTO 3820
3920 NEXT It
3930 IF Multi(I,2)<0 THEN 3990
3940 FOR It=Start TO Multi(I,13)-1
3950 IF Con(It+1)<=Multi(I,2) THEN Pac=Pad+Conp(It+1)
3960 IF Con(It+1)<=Multi(I,2) THEN Start=Start+1
3970 NEXT It
3980 IF Multi(I,2)+1=Multi(I,13) THEN 4100
3990 FOR It=Start TO Multi(I,13)-1
4000 Pen=Pen+Conp(It+1)
4010 NEXT It
4020 En=En+Pene(Multi(I+1,1)-Multi(I,1))
4030 Pacer=1
4040 FOR It=Start TO Multi(I,13)-1
4050 Table(Pacer,1)=Con(It+1)
4060 Table(Pacer,2)=Conp(It+1)
4070 Pacer=Pacer+1
4080 NEXT It
4090 Pacer=Pacer-1
4100 NEXT I
4110 RETURN
4120 IF Pac<.02 THEN 4160
4130 BEEP
4140 P=P*.01
4150 GOTO 3390

```

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4160 DISP
4170 DISP "THE PROBABILITY OF ACCEPTANCE IS ";Pac;" FOR A PERCENT DEFECTIVE OF
";P*100
4180 DISP " THE EXPECTED SAMPLE NUMBER IS ";En;" AT THIS PERCENT DEFECTIVE."
4190 DISP " ENTER THE MAXIMUM VALUE OF PERCENT DEFECTIVE YOU WISH TO BE "
4200 DISP " SHOWN ON THE OC CURVE. THIS ENTRY MUST BE MADE AS A PERCENT!
"
4210 DISP
4220 BEEP
4230 INPUT Pmax
4240 Maxx=10*(INT(Pmax/10)+1)+1
4250 FOR If=1 TO 100
4260 Pd(If)=If*Pmax/100
4270 P=Pd(If)/100
4280 GOSUB 3410
4290 Pa(1,If)=Pac
4300 DISP Pa(1,If)
4310 Asn(If)=En
4320 NEXT If
4330 BEEP
4340 PLOTTER IS "9872A"
4350 PLOTTER 7,5 IS ON
4360 LOCATE 10,100,10,100
4370 SCALE 0,Maxx,0,100
4380 IF Maxx<=20 THEN Inx=1
4390 IF (Maxx>20) AND (Maxx<=40) THEN Inx=2
4400 IF (Maxx>40) AND (Maxx<=80) THEN Inx=4
4410 IF Maxx>80 THEN Inx=5
4420 CSIZE 2
4430 LAKES Inx,5,0,0,-1,1
4440 MOVE 4*Inx,-4.95
4450 LABEL "PERCENT DEFECTIVE"
4460 MOVE Inx/3,101
4470 LABEL "Pa(%)"
4480 MOVE 0,100
4490 PEN 2
4500 FOR I=1 TO 100
4510 DRAW Pd(I),Pa(1,I)*100
4520 NEXT I
4530 MOVE 120,200
4540 DISP
4550 DISP " DO YOU WANT ANY OF THESE POINTS PRINTED? "
4560 DISP
4570 BEEP
4580 INPUT Res
4590 IF Res="NO" THEN 4850
4600 IMAGE 12X,"
4610 IMAGE 12X,"
4620 IMAGE 12X," Percent Acceptance Sample
4630 IMAGE 12X," Defective Probability Number
4640 PRINT USING 4600
4650 PRINT USING 4610
4660 PRINT USING 4620
4670 PRINT USING 4630
4680 IMAGE 4,12X,"|",5D.2D,"%|",7D.2D,"%|",5D.1D"| "
4690 IMAGE 12X,"
4700 DISP
4710 DISP " ENTER THE PERCENT DEFECTIVE, STATED AS A PERCENT. "
4720 DISP
4730 BEEP
4740 INPUT Perd
4750 P=Perd/100
4760 GOSUB 3410
4770 PRINT USING 4680;Perd,Pac*100,En
4780 PRINT USING 4690
4790 DISP
4800 DISP TAB(25);" DO YOU WANT ANYMORE? "
4810 DISP
4820 BEEP
4830 INPUT Res
4840 IF Res="YES" THEN 4700
4850 DISP
4860 DISP "DO YOU WANT A PLOT OF THE ASN CURVE?"
4870 DISP

```

```

4880 BEEP
4890 INPUT Res
4900 IF Res="NO" THEN RETURN
4910 PLOTTER IS "9872A"
4920 PLOTTER 7,5 IS ON
4930 Big=9999
4940 FOR I=1 TO 100
4950 IF Asn(I)>Big THEN Big=Asn(I)
4960 NEXT I
4970 DISP
4980 DISP " THE LARGEST ASN IS ";Big
4990 DISP " ENTER THE MAXIMUM ASN YOU WANT SHOWN ON THE PLOT. "
5000 DISP
5010 BEEP
5020 INPUT Maxy
5030 LOCATE 10,100,10,100
5040 SCALE 0,Maxx,0,Maxy
5050 DISP
5060 DISP " WHAT LABELING INTERVAL DO YOU WANT ON THE Y axis?"
5070 DISP
5080 BEEP
5090 INPUT Iny
5100 CSIZE 2
5110 LAXES Inx,Iny,0,0,-1,1
5120 MOVE Inx/3,Maxy-3
5130 LABEL "ASN"
5140 MOVE 4*Inx,-Maxy/20
5150 LABEL "PERCENT DEFECTIVE"
5160 MOVE 0,Multi(1,1)
5170 PEN 2
5180 FOR I=1 TO 100
5190 IF I=1 THEN MOVE Pd(I),Asn(I)
5200 DRAW Pd(I),Asn(I)
5210 NEXT I
5220 MOVE 500,500
5230 RETURN
5240 DISP
5250 DISP " YOU MAY START THE SEARCH PROCEDURE BY ENTERING THE INITIAL NUMBE
R OF "
5260 DISP " DEFECTIVES PER LOT. A RECOMMENDATION IS MADE THAT THIS VALUE BE
10% "
5270 DISP " OF THE LOT SIZE. REMEMBER, THIS ENTRY MUST BE AN INTEGER!
"
5280 DISP
5290 BEEP
5300 INPUT K
5310 Bad=K
5320 GOSUB 5340
5330 GOTO 6040
5340 REM HYPERGEOMETRIC EVALUATION OF SPECIAL PLAN
5350 N=LotSize
5360 Start=0
5370 M=Multi(1,1)
5380 FOR X=0 TO Multi(1,13)-1
5390 GOSUB 2050
5400 Table(X+1,1)=X
5410 Table(X+1,2)=Prob
5420 NEXT X
5430 Pac=0
5440 En=Multi(1,1)
5450 Pen=0
5460 IF Multi(1,2)<0 THEN Start=0
5470 IF Multi(1,2)>0 THEN Start=Multi(1,2)+1
5480 Contin=Multi(1,13)-1
5490 Connus=Contin-Start+1
5500 FOR It=1 TO Connus
5510 Con(It)=Start+It-1
5520 NEXT It
5530 FOR Is=1 TO Multi(1,13)
5540 IF Table(It,1)<=Multi(1,2) THEN Pac=Pac+Table(It,2)
5550 IF Table(It,1)<=Multi(1,2) THEN 5600
5560 FOR Is=1 TO Connus
5570 IF Table(It,1)=Con(Is) THEN Conp(Is)=Table(It,2)
5580 IF Table(It,1)=Con(Is) THEN 5600
5590 NEXT Is
5600 NEXT It
5610 FOR Is=1 TO Connus

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```

5620 Pen=Pen+Conp(Is)
5630 NEXT Is
5640 En=En+Pene(Multi(2,1)-Multi(1,1))
5650 FOR I=2 TO Tier
5660 N=Lsize-Multi(I-1,1)
5670 M=Multi(I,1)-Multi(I-1,1)
5680 Start=0
5690 FOR It=1 TO Connum
5700 K=Bad-Con(It)
5710 Lima(It)=Multi(I,13)-Con(It)-1
5720 FOR X=0 TO Lima(It)
5730 GOSUB 2050
5740 Fig(It,X+1)=Prob*Conp(It)
5750 Fig(It,X+1)=X+Con(It)
5760 NEXT X
5770 NEXT It
5780 IF Multi(I,2)>=0 THEN Start=Multi(I,2)+1
5790 Contin=Multi(I,13)-1
5800 Lim=Contin-Start+1
5810 FOR It=1 TO Lim
5820 Con(It)=Start+It-1
5830 Conp(It)=0
5840 NEXT It
5850 Pen=0
5860 FOR It=1 TO Connum
5870 FOR X=0 TO Lima(It)
5880 IF Fig(It,X+1)<=Multi(I,2) THEN Pac=Pac+Fig(It,X+1)
5890 IF Fig(It,X+1)<=Multi(I,2) THEN 5960
5900 IF Multi(I,2)+1=Multi(I,13) THEN 5960
5910 FOR Jt=1 TO Lim
5920 IF Fig(It,X+1)=Con(Jt) THEN Conp(Jt)=Conp(Jt)+Fig(It,X+1)
5930 IF Fig(It,X+1)=Con(Jt) THEN Pene=Pene+Fig(It,X+1)
5940 IF Fig(It,X+1)=Con(Jt) THEN 5960
5950 NEXT Jt
5960 REN
5970 NEXT X
5980 NEXT It
5990 Connum=Lim
6000 En=En+Pene(Multi(I+1,1)-Multi(I,1))
6010 BEEP
6020 NEXT I
6030 RETURN
6040 IF Pac<.02 THEN 6140
6050 DISP
6060 DISP "When";Bad;" defectives are present in the lot, Pa is";Pac*100;"%."
6070 DISP "      HOLD ON I AM INCREASING THE DEFECTIVES TO SCOPE OUT THE OC CUR
VE!"
6080 DISP
6090 Ck=10*INT(Bad/10)
6100 Bad=Ck+10
6110 K=Bad
6120 BEEP
6130 GOTO 5310
6140 DISP
6150 DISP "  IF THE SUBMITTED LOT CONTAINS ";Bad;"DEFECTIVES, THE PROBABILITY
OF"
6160 DISP "  ACCEPTANCE IS ";Pac;"."
6170 DISP "  ENTER THE MAXIMUM NUMBER OF DEFECTIVES PER LOT, YOU WANT SHOWN
"
6180 DISP "  ON THE OC CURVE. THIS ENTRY MUST BE AN INTEGER!"
6190 DISP
6200 BEEP
6210 INPUT Maxx
6220 IF Maxx<=100 THEN Incx=1
6230 IF Maxx<=100 THEN Lim=Maxx
6240 IF Maxx<=100 THEN 6320
6250 DISP
6260 DISP "WHAT INTERVAL DO YOU WANT BETWEEN SUCCESSIVE DEFECTIVES PER LOT? "
6270 DISP
6280 Lim=100
6290 Maxx=Maxx+3
6300 BEEP
6310 INPUT Incx
6320 FOR If=1 TO Lim
6330 K=If+Incx

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6340 Bad=K
6350 COSUB 5340
6360 Pa(1,If)=Pac
6370 Pd(If)=Bad
6380 DISP
6390 DISP "0 ";Bad;" defectives/lot: Pa=";Pac*100;"% & ASN=";En
6400 DISP
6410 BEEP
6420 Asn(If)=En
6430 DISP
6440 NEXT If
6450 PLOTTER IS "9072A"
6460 PLOTTER 7,5 IS ON
6470 LOCATE 10,100,10,100
6480 SCALE 0,Maxx,0,100
6490 DISP
6500 DISP "THE RECOMMENDED LABELING INTERVAL FOR DEFECTIVES/LOT IS ";INT(Maxx/1
5)
6510 DISP "          ENTER THE LABELING INTERVAL YOU WANT SHOWN"
6520 DISP
6530 BEEP
6540 INPUT Inx
6550 CSIZE 2
6560 LINES Inx,5,0,0,-1,1
6570 MOVE Inx/3,100
6580 LABEL "Pa(%)"
6590 MOVE 4*Inx,-4.95
6600 LABEL "DEFECTIVES PER LOT, Lot Size = ";Lsize;"Units"
6610 Lim=100
6620 IF Maxx<3<100 THEN Lim=Maxx-3
6630 MOVE 0,100
6640 FOR If=1 TO Lim
6650 DRAW Pd(If),100*Pa(1,If)
6660 DISP Pd(If),100*Pa(1,If)
6670 NEXT If
6680 MOVE 500,500
6690 FOR J=1 TO 11
6700 IF J<>6 THEN DISP
6710 IF J=6 THEN DISP "          DO YOU WANT ANY OF THESE POINTS PRINTED?"
6720 NEXT J
6730 BEEP
6740 INPUT Res
6750 IF Res="NO" THEN 7000
6760 PRINT LIN(4)
6770 PRINT USING 6000
6780 PRINT USING 6010
6790 PRINT USING 6020
6800 IMAGE 12X,"
6810 IMAGE 12X," Defectives Acceptance Sample
6820 IMAGE 12X," Per Lot Probability Number
6830 IMAGE 12X," |",90," |",70.20,"%|",50.10"
6840 DISP
6850 DISP "          ENTER THE NUMBER OF DEFECTIVES PER LOT"
6860 DISP
6870 BEEP
6880 INPUT K
6890 Bad=K
6900 COSUB 5340
6910 PRINT USING 6030;Bad;Pac*100,En
6920 PRINT USING 6000
6930 DISP
6940 DISP "DO YOU WANT ANOTHER ONE?"
6950 DISP
6960 BEEP
6970 INPUT Res
6980 IF Res="YES" THEN 6040
6990 PRINT LIN(4)
7000 DISP
7010 DISP "          DO YOU WANT AN ASN PLOT?"
7020 DISP
7030 BEEP
7040 INPUT Res
7050 IF Res="NO" THEN RETURN
7060 Lim=100
7070 IF Maxx<3<100 THEN Lim=Maxx-3
7080 Sig=99999
7090 FOR If=1 TO Lim

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7100 IF Asn(Ij)>Big THEN Big=Asn(Ij)
7110 NEXT Ij
7120 DISP
7130 DISP "          THE LARGEST ASN IS ";Big
7140 DISP " ENTER THE MAXIMUM ASN YOU WANT SHOWN ON THE PLOT. "
7150 DISP
7160 BEEP
7170 INPUT Maxy
7180 PLOTTER IS "9872A"
7190 PLOTTER 7,5 IS ON
7200 LOCATE 10,100,10,100
7210 SCALE 0,Maxx,0,Maxy
7220 DISP
7230 DISP " WHAT LABELING INTERVAL DO YOU WANT ON THE Y axis?"
7240 DISP
7250 BEEP
7260 INPUT Iny
7270 CSIZE 2
7280 LAXES Inx,Iny,0,0,-1,1
7290 MOVE Inx/3,Maxy*.95
7300 LABEL "ASN"
7310 MOVE 4*Inx,-Maxy/20
7320 LABEL "DEFECTIVES PER LOT, Lot Size = ";Lsize;"units"
7330 FOR Ij=1 TO Lim
7340 IF Ij=1 THEN MOVE Pd(Ij),Asn(Ij)
7350 IF (Pd(Ij)=0) AND (Asn(Ij)=0) THEN 7380
7360 DRAW Pd(Ij),Asn(Ij)
7370 NEXT Ij
7380 RETURN

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