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Standard Practice for Use of Process Oriented AOQL and LTPD Sampling Plans[1]

This standard is issued under the fixed designation E1994; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

INTRODUCTION

This standard is an abbreviated compilation of the sampling plans presented by H.F. Dodge and H.G. Romig in their classic development of sampling plans for use with the process associated with a continuing supply of products. The so called AOQL plans provide a means for disposition of product whether or not the process is in control as well as incentives for process improvement in terms of reduced sample size as the process average percent defective is lowered. In addition, so called LTPD plans are provided for use with individual lots of product, not necessarily associated with a process stream.

The sampling plans and parts of the text given here are taken from the Wiley Classics Library Edition of the Dodge-Romig tables (copyright 1998). Additional tables and detailed discussion of the plans, OC curves, and their derivation will be found in that text.[2] The theoretical development of the Dodge-Roming plans will be found in Volumes 8 and 20 of the Bell System Technical Journal[3,4] and an amplification of the plans is given in *Acceptance Sampling in Quality Control.*[5]

1. Scope

1.1 This practice is primarily a statement of principals for the guidance of ASTM technical committees and others in the use of Average Outgoing Quality Limit, AOQL, and Lot Tolerance Percent Defective, LTPD, sampling plans for determining acceptable of lots of product.

2. Referenced Documents

2.1 *ASTM Standards:*[6]

E178 Practice for Dealing With Outlying Observations

E456 Terminology Relating to Quality and Statistics

3. Terminology

3.1 *Definitions*—Terminology E456 provides a more extensive list of terms in E11 standards.

3.2 *lot tolerance percent defective (LTPD)*—the percentage of defective units in a batch or lot for which, for purposes of acceptance sampling, the consumer wishes the probability of acceptance to be restricted to a specified low value, specifically 10 % for this practice. This is also referred to by the more general term *limiting quality* taken at 10 % consumer risk.

3.3 *average outgoing quality (AOQ)*—the average percent defective of outgoing product including all accepted lots or batches, after any defective units found in them are replaced by acceptable units, plus all lots or batches which are not accepted after such lots or batches have been effectively 100 % inspected and all defective units replaced by acceptable units.

3.4 *average outgoing quality limit (AOQL)*—the maximum of the AOQs for all possible incoming percentages defective for the process, for a given acceptance sampling plan.

3.5 *lot quality protection*—a type of protection in which there is prescribed some chosen value of limiting percent defective in a lot (lot tolerance percent defective, (LTPD)) and also some chosen value for the probability (called the consumer's risk) of accepting a submitted lot that has a percent defective equal to the lot tolerance percent defective.

3.6 *average quality protection*—a type of protection in which there is prescribed some chosen value of average percent defective in the product after inspection (average outgoing

[1] This practice is under the jurisdiction of ASTM Committee E11 on Quality and Statistics and is the direct responsibility of Subcommittee E11.30 on Statistical Quality Control.

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[2] Available from John Wiley and Sons, Inc., 605 Third Ave., New York, NY 10158.

[3] Dodge, H. F. and Romig, H. G., "A Method of Sampling Inspection," *The Bell System Technical Journal*, Vol 8, No. 10, 1924, pp. 613–631.

[4] Dodge, H. F. and Romig, H. G., "Single Sampling and Double Sampling Inspection Tables," *The Bell System Technical Journal*, Vol 20, No. 1, 1941, pp. 1–61.

[5] Schilling, E. G., *Acceptance Sampling in Quality Control*, Marcel Dekker Inc., NY, 1982, pp. 372–399.

[6] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

quality limit (AOQL), that shall not be exceeded in the long run no matter what may be the level of percent defective in the product submitted to the inspector.

3.7 *consumer's risk*—the probability that a lot whose percentage defective is equal to the LTPD will be accepted by the plan.

4. Significance and Use

4.1 Two general types of tables (Note 1) are given, one based on the concept of lot tolerance, LTPD, and the other on AOQL. The broad conditions under which the different types have been found best adapted are indicated below.

4.1.1 For each of the types, tables are provided both for single sampling and for double sampling. Each of the individual tables constitutes a collection of solutions to the problem of minimizing the over-all amount of inspection. Because each line in the tables covers a range of lot sizes, the AOQL values in the LTPD tables and the LTPD values in the AOQL tables are often conservative.

NOTE 1—Tables in Annex A1-Annex A4 and parts of the text are reproduced by permission of John R. Wiley and Sons. More extensive tables and discussion of the methods will be found in that text.

4.2 The sampling tables based on lot quality protection (LTPD) (the tables in Annex A1 and Annex A2) are perhaps best adapted to conditions where interest centers on each lot separately, for example, where the individual lot tends to retain its identity either from a shipment or a service standpoint. These tables have been found particularly useful in inspections made by the ultimate consumer or a purchasing agent for lots or shipments purchased more or less intermittently.

4.3 The sampling tables based on average quality protection (AOQL) (the tables in Annex A3 and Annex A4) are especially adapted for use where interest centers on the average quality of product after inspection rather than on the quality of each individual lot and where inspection is, therefore, intended to serve, if necessary, as a partial screen for defective pieces. The latter point of view has been found particularly helpful, for example, in consumer inspections of continuing purchases of large quantities of a product and in manufacturing process inspections of parts where the inspection lots tend to lose their identity by merger in a common storeroom from which quantities are withdrawn on order as needed.

4.4 The plans based on average quality protection (AOQL) consider the degree to which the entire inspection procedure screens out defectives in the product submitted to the inspector. Lots accepted by sample undergo a partial screening through the elimination of defectives found in samples. Lots that fail to be accepted by sample are completely cleared of defectives. Obviously, this requires a nondestructive test. The over-all result is some average percent defective in the product as it leaves the inspector, termed the *average outgoing quality,* which depends on the level of percent defective for incoming product and the proportion of total defectives that are screened out.

4.5 Given a specific problem of replacing a 100 % screening inspection by a sampling inspection, the first step is to decide on the type of protection desired, to select the desired limit of percent defective lot tolerance (LTPD) or AOQL value for that type of protection, and to choose between single and double sampling. This results in the selection of one of the appended tables. The second step is to determine whether the quality of product is good enough to warrant the introduction of sampling. The economies of sampling will be realized, of course, only insofar as the percent defective in submitted product is such that the acceptance criteria of the selected sampling plan will be met. A statistical analysis of past inspection results should first be made, therefore, in order to determine existing levels and fluctuations in the percent defective for the characteristic or the group of characteristics under consideration. This provides information with respect to the degree of control as well as the usual level of percent defective to be expected under existing conditions. Determine a value from this and other information for the *process average* percent defective that should be used in applying the selected sampling table, if sampling is to be introduced.

5. Procedure

5.1 Two distinct methods of inspection are employed, single sampling and double sampling. In single sampling only one sample is permitted before a decision is reached regarding the disposition of the lot, and the acceptance criterion is expressed as an acceptance number, c. In double sampling, a second sample is permitted and two acceptance numbers are used; the first, c_1, applying to the observed number of defectives for the first sample alone and the second, c_2, applying to the observed number of defectives for the first and second samples combined. The specific procedures assumed in the development of the tables are as follows:

5.1.1 *Single Sampling Inspection Procedure*:

5.1.1.1 Inspect a sample of n pieces.

5.1.1.2 If the number of defectives found in the sample does not exceed c, the acceptance number, accept the lot.

5.1.1.3 If the number of defectives found in the sample exceeds c, inspect all the pieces in the remainder of the lot.

5.1.1.4 Regardless of whether or not the lot was accepted, correct or replace all defective pieces found in the sample as well as in any subsequent inspection of the remainder of the lot.

5.1.2 *Double Sampling Inspection Procedure*:

5.1.2.1 Inspect a first sample of n_1 pieces.

5.1.2.2 If the number of defectives found in the first sample does not exceed c_1, the acceptance number for the first sample, accept the lot.

5.1.2.3 If the number of defectives found in the first sample exceeds c_2, the acceptance number for the combined first and second samples, inspect all the pieces in the remainder of the lot.

5.1.2.4 If the number of defectives found in the first sample exceeds c_1, but does not exceed c_2, inspect a second sample of n_2 pieces.

5.1.2.5 If the total number of defectives found in the first and second samples combined does not exceed c_2, accept the lot.

5.1.2.6 If the total number of defectives found in the first and second samples combined exceeds c_2, inspect all the pieces in the remainder of the lot.

5.1.2.7 Regardless of whether or not the lot was accepted, correct or replace all defective pieces found in either sample as well as any in subsequent inspection or the remainder of the lot.

5.2 In choosing a sampling plan for a particular application, a number of decisions must be made which depend on the conditions under which the plan is to be used. The accompanying *Sequence of Steps* gives an outline of a typical procedure. These steps are shown in the following numbered paragraphs.

5.3 *Sequence of Steps*:

5.3.1 Decide what characteristics will be included in the inspection.

5.3.1.1 If advantageous, use a separate sampling plan for a single characteristic or selected group of characteristics of like importance. Sampling need not wait until all characteristics have good quality.

5.3.1.2 If one or two characteristics give an outstandingly high number of defective units, treat them separately (using 100 percent inspection; also, if possible, concentrate on correcting the causes of trouble) and include the rest collectively in the sampling inspection.

5.3.1.3 If all characteristics have satisfactory quality, include all of them collectively in the sampling inspection.

5.3.1.4 In general, combine at one inspection station characteristics subject to essentially similar inspection operations, for example, all visual inspection items together, all gauging, or all testing. Visual and gauging inspection operations often combine well.

5.3.1.5 Include in any group characteristics of essentially the same degree of seriousness. If two degrees of seriousness are involved, say major and minor, keep all majors together in one group and all minors in a second group.

5.3.1.6 Consider these plans applicable to all basic types of inspection for manufactured products receiving, process, and final and to the inspection of administrative and clerical products as in *paper-work quality control*.

5.3.2 Decide what is to constitute a lot for purposes of sampling inspection.

5.3.2.1 So far as practicable, require that individual lots presented for acceptance comprise essentially homogeneous material from a common source.

5.3.2.2 If presented material comes from two or more direct sources not under a common system of control, arrange to have each presented lot comprise material from only one of those sources; otherwise have source identification information furnished with each lot.

5.3.2.3 To minimize the amount of inspection, make the lots as large as practicable, considering the limitations of available storage space, delays in shipment, difficulty in handling large rejected lots, etc.

5.3.3 Choose between lot quality (LTPD) and average outgoing quality (AOQL) protection.

5.3.3.1 Choose AOQL if interest centers on the general level of quality of product after inspection. AOQL plans have been found generally more useful than LTPD plans in inspections of a continuing supply of product, especially in consumer's acceptance inspections and in producer's receiving, process, and final inspections.

5.3.3.2 Choose AOQL for a percent defective that will almost always be safely met by the running average quality of product after inspection.

5.3.3.3 Choose LTPD for a percent defective that will almost always be met by each lot. (This will be a much more pessimistic figure than the AOQL value of the plan).

5.3.3.4 As a manufacturer trying to meet a consumer's stated AQL (Note 2), use for final inspection an AOQL plan with an AOQL value equal to the specified AQL value, in order to provide good assurance that outgoing quality will be found acceptable by the consumer (or set the AOQL at one and one third times the AQL for reasonably good assurance).

NOTE 2—AQL = Acceptable Quality Level, as used to index certain systems of sampling plans, signifying what the consumer feels to be the maximum percent defective that, for sampling purposes, can be considered satisfactory as a process average.

5.3.3.5 When producer and consumer of a product are two departments of the same company, use AOQL plans with the provision that the producer perform the 100 percent inspection of rejected lots. Close interchange of quality findings will expedite good process control of quality.

5.3.3.6 Wherever practicable, make arrangements for the producer to perform the 100 percent inspection of rejected lots under procedures acceptable to the consumer and to provide suitable certifications of work performed.

5.3.4 Choose a suitable figure of quality (LTPD or AOQL) for the sampling plan

5.3.4.1 For LTPD, choose the value of percent defective for lot acceptance not more than 10 % of the time (that is, reject at least 90 % of the time).

5.3.4.2 For AOQL, choose the value of average percent defective in product after inspection that should not be exceeded.

5.3.4.3 In choosing a value of LTPD (or AOQL), consider and compare the cost of inspection with the economic loss that would ensue if quality as bad as the LTPD were accepted often (or if the average level of percent defective were greater than the AOQL). Even though the evaluation of economic loss may be difficult, relative values for different levels of percent defective may often be determined.

5.3.5 Choose between single sampling and double sampling.

5.3.5.1 In general, for economy in overall inspection effort, use double sampling rather than single sampling.

5.3.5.2 In general, for minimum variation in the inspector's workload, use single sampling.

5.3.5.3 Consider adopting double sampling as the normal standard for sampling plans in a given plant, with a view to effecting overall economies.

5.3.5.4 In a particular case, for a given AOQL and given process average, compare the OC curves of the two sampling plans (single sampling and double sampling) as an aid in making a choice. (Note 3)

NOTE 3—See the Dodge-Romig text for OC curves.

5.3.6 Select the proper sampling table in Annex A1-Annex A4, on the basis of the above choices.

5.3.7 Obtain an estimate of process average percent defective.

5.3.7.1 Use recent data to estimate the process average.

5.3.7.2 Use rough estimates at the start, if little or no actual data are available; a poor estimate merely prevents getting the most economical plan but keeps the same (LTPD or AOQL) protection.

5.3.7.3 As more data are collected, make improved estimates of process average.

5.3.7.4 Omit wild and obviously nonrepresentative sets of data in making estimates and adopt some suitable rule for discarding data. (see Practice E178)

5.3.8 Choose a sampling plan for the given lot size and the estimated process average.

5.3.8.1 If the estimated process average percent defective, PA, falls within the range of PA values in the selected table, choose the sampling plan corresponding to the PA value and to the given lot size.

5.3.8.2 If the PA is unknown or is estimated to be larger than the largest PA value given in the table, choose the sampling plan corresponding to the largest PA in the table (last column) and to the given lot size.

5.3.8.3 Under 5.3.8.2, obtain revised estimates of the PA from the lot-by-lot data and use a sampling plan with a smaller sample size as soon as a revised estimate of the PA permits.

5.3.8.4 If, for single sampling, the sampling plan given by the table has $c = 0$, consider whether it would be preferable to use a plan with $c = 1$ to avoid making rejections on finding a single defective. There is no such problem for double sampling, since c_2 always equals *1* or more.

5.3.8.5 If inspection includes two classes of defects, major and minor, with two AOQL values, choose the two sampling plans from the appropriate tables in the Annexes and use them simultaneously.

5.3.9 Check the OC curve of the chosen plan(s). (Note 4)

NOTE 4—See the Dodge–Romig text for OC Curves.

5.3.10 From the lot, select sample units by means of a random procedure.

5.3.10.1 Consider the use of random numbers as the preferred way of selecting sample units *at random.* Each unit in the lot is assigned a serial number usually on paper, and then those units whose serial numbers correspond to the numbers in some section of a listing of random numbers are included in the sample.

5.3.10.2 If a double sampling plan has been chosen, consider selecting sample units for both samples at the same time.

5.3.11 Follow the sampling inspection procedure for single sampling or double sampling, whichever was chosen.

5.3.11.1 Inspect each unit in the sample for all the characteristics decided on in Section 5.3.

5.3.11.2 If single sampling is being used, inspect all units in the sample even though the acceptance number is exceeded before all units have been inspected. This facilitates estimation of the process average.

5.3.11.3 If double sampling is being used, inspect all units in the first sample; if desired, discontinue inspection of the second sample when the acceptance number, c_2, is exceeded.

5.3.12 Keep a running check on the process average and change the sampling plan if the process average changes sufficiently.

5.3.12.1 Adopt a definite plan for making periodic estimates of the process average, every 20 or 50 lots or every month, quarter, or six months, depending on the production rate and the quality history.

5.3.12.2 Keep the producing organization informed of the running quality of presented product, preferably in control chart form, and furnish prompt information regarding any sudden adverse shifts in quality.

5.3.12.3 Change from one sampling plan to another within a sampling table, as the process average changes from one general level to another. This provides a general basis for tightened and reduced inspection while holding to a given AOQL or LTPD. If, with stable quality at an excellent level, it is desired to reduce inspection even further, use a larger AOQL or LTPD value, twice as large as the basic AOQL or LTPD.

6. Precision and Bias

The use of this standard assumes that test methods are used with sufficient precision and accuracy that test results can be safely translated into attribute (go-no go) results.

7. Keywords

7.1 average outgoing quality limit; lot tolerance percent defective; sampling; sampling plans

ANNEXES

(Mandatory Information)

A1. SINGLE SAMPLING TABLES FOR STATED VALUES OF LOT TOLERANCE PERCENT DEFECTIVE (LTPD) WITH CONSUMER'S RISK OF 0.10, 0.5 % LTPD, 1.0 % LTP, 2.0 % LTP, 5.0 % LTPD, 10.0 % LTPD

A1.1 Tables A1.1-A1.5 illustrate single sampling stated values of lot tolerance percent.

TABLE A1.1 Single Sampling Table for Lot Tolerance Percent Defective (LTPD) = 0.5 %

NOTE 1—*n* = sample size; *c* = acceptance number; AOQL = average outgoing quality limit; "all" indicates that each piece in the lot is to be inspcted.

Lot Size	Process Average 0 to 0.005 %			Process Average 0.006 to 0.050 %			Process Average 0.051 to 0.100 %			Process Average 0.101 to 0.150 %			Process Average 0.151 to 0.200 %			Process Average 0.201 to 0.250 %		
	n	*c*	AOQL %	*n*	*c*	AOQL %	*n*	*c*	AOQL %	*n*	*c*	AOQL %	*n*	*c*	AOQL %	*n*	*c*	AOQL %
1–180	all	0	0	all	0	0	all	0	0	all	0	0	all	0	0	all	0	0
181–210	180	0	0.02	180	0	0.02	180	0	0.02	180	0	0.02	180	0	0.02	180	0	0.02
211–250	210	0	0.03	210	0	0.03	210	0	0.03	210	0	0.03	210	0	0.03	210	0	0.03
251–300	240	0	0.03	240	0	0.03	240	0	0.03	240	0	0.03	240	0	0.03	240	0	0.03
301–400	275	0	0.04	275	0	0.04	275	0	0.04	275	0	0.04	275	0	0.04	275	0	0.04
401–500	300	0	0.05	300	0	0.05	300	0	0.05	300	0	0.05	300	0	0.05	300	0	0.05
501–600	320	0	0.05	320	0	0.05	320	0	0.05	320	0	0.05	320	0	0.05	320	0	0.05
601–800	350	0	0.06	350	0	0.06	350	0	0.06	350	0	0.06	350	0	0.06	350	0	0.06
801–1000	365	0	0.06	365	0	0.06	365	0	0.06	365	0	0.06	365	0	0.06	365	0	0.06
1001–2000	410	0	0.07	410	0	0.07	410	0	0.07	670	1	0.08	670	1	0.08	670	1	0.08
2001–3000	430	0	0.07	430	0	0.07	705	1	0.09	705	1	0.09	955	2	0.10	955	2	0.10
3001–4000	440	0	0.07	440	0	0.07	730	1	0.09	985	2	0.10	1230	3	0.11	1230	3	0.11
4001–5000	445	0	0.08	740	1	0.10	1000	2	0.11	1000	2	0.11	1250	3	0.12	1480	4	0.12
5001–7000	450	0	0.08	750	1	0.10	1020	2	0.12	1280	3	0.12	1510	4	0.13	1760	5	0.14
7001–10 000	455	0	0.08	760	1	0.10	1040	2	0.12	1530	4	0.14	1790	5	0.14	2240	7	0.16
10 001–20 000	460	0	0.08	775	1	0.10	1330	3	0.14	1820	5	0.16	2300	7	0.17	2780	9	0.18
20 001–50 000	775	1	0.11	1050	2	0.13	1600	4	0.15	2080	5	0.18	3060	10	0.20	4200	15	0.22
50 001–100 000	780	1	0.11	1060	2	0.13	1840	5	0.17	2590	8	0.19	3780	13	0.22	5140	19	0.24

TABLE A1.2 Single Sampling Table for Lot Tolerance Percent Defective (LTPD) = 1.0 %

NOTE—*n* = sample size; *c* = acceptance number; AOQL = average outgoing quality limit; "all" indicates that each piece in the lot is to be inspcted.

Lot Size	Process Average 0 to 0.010 %			Process Average 0.011 to 0.10 %			Process Average 0.11 to 0.20 %			Process Average 0.21 to 0.30 %			Process Average 0.31 to 0.40 %			Process Average 0.41 to 0.50 %		
	n	*c*	AOQL %	*n*	*c*	AOQL %	*n*	*c*	AOQL %	*n*	*c*	AOQL %	*n*	*c*	AOQL %	*n*	*c*	AOQL %
1–120	all	0	0	all	0	0	all	0	0	all	0	0	all	0	0	all	0	0
121–150	120	0	0.06	120	0	0.06	120	0	0.06	120	0	0.06	120	0	0.06	120	0	0.06
151–200	140	0	0.08	140	0	0.08	140	0	0.08	140	0	0.08	140	0	0.08	140	0	0.08
201–300	165	0	0.10	165	0	0.10	165	0	0.10	165	0	0.10	165	0	0.10	165	0	0.10
301–400	175	0	0.12	175	0	0.12	175	0	0.12	175	0	0.12	175	0	0.12	175	0	0.12
401–500	180	0	0.13	180	0	0.13	180	0	0.13	180	0	0.13	180	0	0.13	180	0	0.13
501–600	190	0	0.13	190	0	0.13	190	0	0.13	190	0	0.13	190	0	0.13	305	1	0.14
601–800	200	0	0.14	200	0	0.14	200	0	0.14	330	1	0.15	330	1	0.15	330	1	0.15
801–1000	205	0	0.14	205	0	0.14	205	0	0.14	335	1	0.17	335	1	0.17	335	1	0.17
1001–2000	220	0	0.15	220	0	0.15	360	1	0.19	490	2	0.21	490	2	0.21	610	3	0.22
2001–3000	220	0	0.15	375	1	0.20	505	2	0.23	630	3	0.24	745	4	0.26	870	5	0.26
3001–4000	225	0	0.15	380	1	0.20	510	2	0.24	645	3	0.25	880	5	0.28	1000	6	0.29
4001–5000	225	0	0.16	380	1	0.20	520	2	0.24	770	4	0.28	895	5	0.29	1120	7	0.31
5001–7000	230	0	0.15	385	1	0.21	655	3	0.27	780	4	0.29	1020	6	0.32	1260	8	0.34
7001–10 000	230	0	0.16	520	2	0.25	660	3	0.28	910	5	0.32	1150	7	0.34	1500	10	0.37
10 001–20 000	390	1	0.21	525	2	0.26	785	4	0.31	1040	6	0.35	1400	9	0.39	1980	14	0.43
20 001–50 000	390	1	0.21	530	2	0.26	920	5	0.34	1300	8	0.39	1890	13	0.44	2570	19	0.48
50 001–100 000	390	1	0.21	670	3	0.29	1040	6	0.36	1420	9	0.41	2120	15	0.47	3150	23	0.50

TABLE A1.3 Single Sampling Table for Lot Tolerance Percent Defective (LTPD) = 2.0 %

NOTE—*n* = sample size; *c* = acceptance number; AOQL = average outgoing quality limit; "all" indicates that each piece in the lot is to be inspcted.

Lot Size	Process Average 0 to 0.02 %			Process Average 0.03 to 0.20 %			Process Average 0.21 to 0.40 %			Process Average 0.41 to 0.60 %			Process Average 0.61 to 0.80 %			Process Average 0.81 to 1.00 %		
	n	*c*	AOQL %	*n*	*c*	AOQL %	*n*	*c*	AOQL %	*n*	*c*	AOQL %	*n*	*c*	AOQL %	*n*	*c*	AOQL %
1–75	all	0	0	all	0	0	all	0	0	all	0	0	all	0	0	all	0	0
76–100	70	0	0.16	70	0	0.16	70	0	0.16	70	0	0.16	70	0	0.16	70	0	0.16
101–200	85	0	0.25	85	0	0.25	85	0	0.25	85	0	0.25	85	0	0.25	85	0	0.25
201–300	95	0	0.26	95	0	0.26	95	0	0.26	95	0	0.26	95	0	0.26	95	0	0.26
301–400	100	0	0.28	100	0	0.28	100	0	0.28	160	1	0.32	160	1	0.32	160	1	0.32
401–500	105	0	0.28	105	0	0.28	105	0	0.28	165	1	0.34	165	1	0.34	165	1	0.34
501–600	105	0	0.29	105	0	0.29	175	1	0.34	175	1	0.34	175	1	0.34	235	2	0.36
601–800	110	0	0.29	110	0	0.29	180	1	0.36	240	2	0.40	240	2	0.40	300	3	0.41
801–1000	115	0	0.28	115	0	0.28	185	1	0.37	245	2	0.42	305	3	0.44	305	3	0.44
1001–2000	115	0	0.30	190	1	0.40	255	2	0.47	325	3	0.50	380	4	0.54	440	5	0.56
2001–3000	115	0	0.31	190	1	0.41	260	2	0.48	385	4	0.58	450	5	0.60	565	7	0.64
3001–4000	115	0	0.31	195	1	0.41	330	3	0.54	450	5	0.63	510	6	0.65	690	9	0.70
4001–5000	195	1	0.41	260	2	0.50	335	3	0.54	455	5	0.63	575	7	0.69	750	10	0.74
5001–7000	195	1	0.42	265	2	0.50	335	3	0.55	515	6	0.69	640	8	0.73	870	12	0.80
7001–10 000	195	1	0.42	265	2	0.50	395	4	0.62	520	6	0.69	760	10	0.79	1050	15	0.86
10 001–20 000	200	1	0.42	265	2	0.51	460	5	0.67	650	8	0.77	885	12	0.86	1230	18	0.94
20 001–50 000	200	1	0.42	335	3	0.58	520	6	0.73	710	9	0.81	1060	15	0.93	1520	23	1.0
50 001–100 000	200	1	0.42	335	3	0.58	585	7	0.76	770	10	0.84	1180	17	0.97	1690	26	1.1

TABLE A1.4 Single Sampling Table for Lot Tolerance Percent Defective (LTPD) = 5.0 %

NOTE—*n* = sample size; *c* = acceptance number; AOQL = average outgoing quality limit; "all" indicates that each piece in the lot is to be inspcted.

Lot Size	Process Average 0 to 0.05 %			Process Average 0.06 to 0.50 %			Process Average 0.51 to 1.00 %			Process Average 1.01 to 1.50 %			Process Average 1.51 to 2.00 %			Process Average 2.01 to 2.50 %		
	n	*c*	AOQL %	*n*	*c*	AOQL %	*n*	*c*	AOQL %	*n*	*c*	AOQL %	*n*	*c*	AOQL %	*n*	*c*	AOQL %
1–30	all	0	0	all	0	0	all	0	0	all	0	0	all	0	0	all	0	0
31–50	30	0	0.49	30	0	0.49	30	0	0.49	30	0	0.49	30	0	0.49	30	0	0.49
51–100	37	0	0.63	37	0	0.63	37	0	0.63	37	0	0.63	37	0	0.63	37	0	0.63
101–200	40	0	0.74	40	0	0.74	40	0	0.74	40	0	0.74	40	0	0.74	40	0	0.74
201–300	43	0	0.74	43	0	0.74	70	1	0.92	70	1	0.92	95	2	0.99	95	2	0.99
301–400	44	0	0.74	44	0	0.74	70	1	0.99	100	2	1.0	120	3	1.1	145	4	1.1
401–500	45	0	0.75	75	1	0.95	100	2	1.1	100	2	1.1	125	3	1.2	150	4	1.2
501–600	45	0	0.76	75	1	0.98	100	2	1.1	125	3	1.2	150	4	1.3	175	5	1.3
601–800	45	0	0.77	75	1	1.0	100	2	1.2	130	3	1.2	175	5	1.4	200	6	1.4
801–1000	45	0	0.78	75	1	1.0	105	2	1.2	155	4	1.4	180	5	1.4	225	7	1.5
1001–2000	45	0	0.80	75	1	1.0	130	3	1.4	180	5	1.6	230	7	1.7	280	9	1.8
2001–3000	75	1	1.1	105	2	1.3	135	3	1.4	210	6	1.7	280	9	1.9	370	13	2.1
3001–4000	75	1	1.1	105	2	1.3	160	4	1.5	210	6	1.7	305	10	2.0	420	15	2.2
4001–5000	75	1	1.1	105	2	1.3	160	4	1.5	235	7	1.8	330	11	2.0	440	16	2.2
5001–7000	75	1	1.1	105	2	1.3	185	5	1.7	260	8	1.9	350	12	2.2	490	18	2.4
7001–10 000	75	1	1.1	105	2	1.3	185	5	1.7	260	8	1.9	380	13	2.2	535	20	2.5
10 001–20 000	75	1	1.1	135	3	1.4	210	6	1.8	285	9	2.0	425	15	2.3	610	23	2.6
20 001–50 000	75	1	1.1	135	3	1.4	235	7	1.9	305	10	2.1	470	17	2.4	700	27	2.7
50 001–100 000	75	1	1.1	160	4	1.6	235	7	1.9	355	12	2.2	515	19	2.5	770	30	2.8

TABLE A1.5 Single Sampling Table for Lot Tolerance Percent Defective (LTPD) = 10.0 %

NOTE—*n* = sample size; *c* = acceptance number; AOQL = average outgoing quality limit; "all" indicates that each piece in the lot is to be inspcted.

Lot Size	Process Average 0 to 0.10 %			Process Average 0.11 to 1.00 %			Process Average 1.01 to 2.00 %			Process Average 2.01 to 3.00 %			Process Average 3.01 to 4.00 %			Process Average 4.01 to 5.00 %		
	n	*c*	AOQL %	*n*	*c*	AOQL %	*n*	*c*	AOQL %	*n*	*c*	AOQL %	*n*	*c*	AOQL %	*n*	*c*	AOQL %
1–20	all	0	0	all	0	0	all	0	0	all	0	0	all	0	0	all	0	0
21–50	17	0	1.3	17	0	1.3	17	0	1.3	17	0	1.3	17	0	1.3	17	0	1.3
51–100	20	0	1.5	20	0	1.5	20	0	1.5	33	1	1.7	33	1	1.7	33	1	1.7
101–200	22	0	1.5	22	0	1.5	35	1	2.0	48	2	2.2	48	2	2.2	60	3	2.4
201–300	23	0	1.5	38	1	1.9	50	2	2.3	65	3	2.4	75	4	2.6	85	5	2.7
301–400	23	0	1.5	38	1	2.0	50	2	2.4	65	3	2.5	90	5	2.7	100	6	2.9
401–500	23	0	1.5	38	1	2.0	50	2	2.5	75	4	2.8	90	5	2.9	110	7	3.2
501–600	23	0	1.5	38	1	2.1	65	3	2.7	80	4	3.0	100	6	3.2	125	8	3.3
601–800	23	0	1.6	38	1	2.1	65	3	2.8	90	5	3.1	100	6	3.3	140	9	3.4
801–1000	39	1	2.1	50	2	2.6	65	3	2.8	90	5	3.2	115	7	3.4	150	10	3.7
1001–2000	39	1	2.1	50	2	2.6	80	4	3.1	105	6	3.4	140	9	3.9	195	14	4.4
2001–3000	39	1	2.1	50	2	2.6	80	4	3.1	115	7	3.7	165	11	4.1	230	17	4.7
3001–4000	39	1	2.1	50	2	2.6	90	5	3.4	130	8	3.8	190	13	4.4	255	19	4.8
4001–5000	39	1	2.1	50	2	2.6	90	5	3.5	130	8	3.9	200	14	4.5	270	20	4.9
5001–7000	39	1	2.1	65	3	3.0	105	6	3.6	140	9	4.1	200	14	4.6	295	22	5.0
7001–10 000	39	1	2.2	65	3	3.0	105	6	3.6	150	10	4.2	210	15	4.7	315	24	5.2
10 001-20 000	39	1	2.2	65	3	3.0	120	7	3.7	150	10	4.3	240	17	4.8	340	26	5.4
20 001–50 000	39	1	2.2	80	4	3.2	120	7	3.7	165	11	4.4	260	19	5.0	380	30	5.7
50 001–100 000	39	1	2.2	95	5	3.3	130	8	4.0	180	12	4.4	270	20	5.1	380	30	5.7

A2. DOUBLE SAMPLING TABLES FOR STATED VALUES OF LOT TOLERANCE PERCENT DEFECTIVE (LTPD) WITH CONSUMER RISK OF 0.10, 0.5 % LTPD, 1.0 % LTPD, 2.0 % LTPD, 5.0 % LTPD, 10.0 % LTPD

A2.1 Tables A2.1-A2.5 illustrate double sampling stated values of lot tolerance percent.

TABLE A2.1 Double Sampling Table for Lot Tolerance Percent Defective (LTPD) = .50 %

Lot Size	Process Average 0 to 0.005 %						Process Average 0.006 to 0.050 %						Process Average 0.051 to 0.100 %					
	Trial 1[A]		Trial 2[B]			AOQL[C] in %	Trial 1		Trial 2			AOQL in %	Trial 1		Trial 2			AOQL[C] in %
	n_1	c_1	n_2	n_1+n_2	c_2		n_1	c_1	n_2	n_1+n_2	c_2		n_1	c_1	n_2	n_1+n_2	c_2	
1–180	all[D]	0	...	...	...	0	all	0	...	...	...	0	all	0	...	...	...	0
181–210	180		...	...	...	0.02	180	0	...	...	...	0.02	180	0	...	...	...	0.02
211–250	210	0	...	...	...	0.03	210	0	...	...	...	0.03	210	0	...	...	...	0.03
251–300	240	0	...	...	...	0.03	240	0	...	...	...	0.03	240	0	...	...	...	0.03
301–400	275	0	...	...	...	0.04	275	0	...	...	...	0.04	275	0	...	...	...	0.04
401–450	290	0	...	...	...	0.04	290	0	...	...	...	0.04	290	0	...	...	...	0.04
451–500	340	0	110	450	1	0.04	340	0	110	450	1	0.04	340	0	110	450	1	0.04
501–550	350	0	130	480	1	0.05	350	0	130	480	1	0.05	350	0	130	480	1	0.05
551–600	360	0	150	510	1	0.05	360	0	150	510	1	0.05	360	0	150	510	1	0.05
601–800	400	0	185	585	1	0.06	400	0	185	585	1	0.06	400	0	185	585	1	0.06
801–1000	430	0	200	630	1	0.07	430	0	200	630	1	0.07	430	0	200	630	1	0.07
1001–2000	490	0	265	755	1	0.08	490	0	265	755	1	0.08	490	0	265	755	1	0.08
2001–3000	520	0	290	810	1	0.09	520	0	290	810	1	0.09	520	0	530	1050	2	0.10
3001–4000	530	0	310	840	1	0.09	530	0	570	1100	2	0.11	530	0	570	1100	2	0.11
4001–5000	540	0	305	845	1	0.09	540	0	580	1120	2	0.11	540	0	830	1370	3	0.12
5001–7000	545	0	315	860	1	0.10	545	0	615	1160	2	0.11	545	0	865	1410	3	0.12
7001–10 000	550	0	330	880	1	0.10	550	0	620	1170	2	0.12	550	0	1130	1680	4	0.14
10 001–20 000	555	0	345	900	1	0.10	555	0	925	1480	3	0.13	555	0	1185	1740	4	0.15
20 001–50 000	560	0	650	1210	2	0.12	560	0	940	1500	3	0.14	900	1	1400	2300	6	0.16
50 001–100 000	560	0	650	1210	2	0.12	560	0	1210	1770	4	0.15	905	1	1655	2560	7	0.17

Lot Size	Process Average 0.101 to 0.150 %						Process Average 0.151 to 0.200 %						Process Average 0.201 to 0.250 %					
	Trial 1[A]		Trial 2[B]			AOQL[C] in %	Trial 1		Trial 2			AOQL in %	Trial 1		Trial 2			AOQL in %
	n_1	c_1	n_2	n_1+n_2	c_2		n_1	c_1	n_2	n_1+n_2	c_2		n_1	c_1	n_2	n_1+n_2	c_2	
1–180	all[D]	0	...	...	...	0	all	0	...	...	...	0	all	0	...	...	...	0
181–210	180	0	...	...	...	0.02	180	0	...	...	...	0.02	180	0	...	...	...	0.02
211–250	210	0	...	...	...	0.03	210	0	...	...	...	0.03	210	0	...	...	...	0.03
251–300	240	0	...	...	...	0.03	240	0	...	...	...	0.03	240	0	...	...	...	0.03
301–400	275	0	...	...	...	0.04	275	0	...	...	...	0.04	275	0	...	...	...	0.04
401–450	290	0	...	...	...	0.04	290	0	...	...	...	0.04	290	0	...	...	...	0.04
451–500	340	0	110	450	1	0.04	340	0	110	450	1	0.04	340	0	110	450	1	0.04
501–550	350	0	130	480	1	0.05	350	0	130	480	1	0.05	350	0	130	480	1	0.05
551–600	360	0	150	510	1	0.05	360	0	150	510	1	0.05	360	0	150	510	1	0.05
601–800	400	0	185	585	1	0.06	400	0	185	585	1	0.06	400	0	185	585	1	0.06
801–1000	430	0	200	630	1	0.07	430	0	200	630	1	0.07	430	0	200	630	1	0.07
1001–2000	490	0	500	990	2	0.09	490	0	500	990	2	0.09	490	0	500	990	2	0.09
2001–3000	520	0	530	1050	2	0.10	520	0	760	1280	3	0.11	520	0	980	1500	4	0.11
3001–4000	530	0	810	1340	3	0.11	530	0	1030	1560	4	0.12	840	1	1160	2000	6	0.13
4001–5000	540	0	1060	1600	4	0.13	845	1	1205	2050	6	0.14	845	1	1425	2270	7	0.14
5001–7000	545	0	1105	1650	4	0.13	860	1	1490	2350	7	0.15	860	1	1700	2560	8	0.16
7001–10 000	880	1	1300	2180	6	0.15	880	1	1770	2650	8	0.16	1170	2	2160	3330	11	0.17
10 001–20 000	900	1	1840	2740	8	0.18	1200	2	2250	3450	11	0.19	1740	4	2620	4360	15	0.21
20 001–50 000	1210	2	2330	3540	11	0.20	1500	3	2980	4480	15	0.22	2300	6	4240	6540	24	0.24
50 001–100 000	1210	2	2590	3800	12	0.21	1770	4	3690	5460	19	0.23	2560	7	5420	7980	30	0.26

[A]Trial 1: n_1= first sample size; c_1= acceptance number for first sample.
[B]Trial 2: n_2= second sample size; c_2= acceptance number for first and second samples combined.
[C]AOQL = Average Outgoing Quality Limit.
[D]"*all*" indicates that each piece in the lot is to be inspected.

TABLE A2.2 Double Sampling Table for Lot Tolerance Percent Defective (LTPD) = 1.0 %

Lot Size	Process Average 0 to 0.010 %						Process Average 0.011 to 0.10 %						Process Average 0.11 to 0.20 %					
	Trial 1[A]		Trial 2[B]			AOQL[C] in %	Trial 1		Trial 2			AOQL in %	Trial 1		Trial 2			AOQL in %
	n_1	c_1	n_2	n_1+n_2	c_2		n_1	c_1	n_2	n_1+n_2	c_2		n_1	c_1	n_2	n_1+n_2	c_2	
1–120	all[D]	0	...	...	...	0	all	0	...	...	...	0	all	0	...	...	...	0
121–150	120	0	...	...	...	0.06	120	0	...	...	...	0.06	120	0	...	...	...	0.06
151–200	140	0	...	...	...	0.08	140	0	...	...	...	0.08	140	0	...	...	...	0.08
201–260	165	0	...	...	...	0.10	165	0	...	...	...	0.10	165	0	...	...	...	0.10
261–300	180	0	75	255	1	0.10	180	0	75	255	1	0.10	180	0	75	255	1	0.10
301–400	200	0	90	290	1	0.12	200	0	90	290	1	0.12	200	0	90	290	1	0.12
401–500	215	0	100	315	1	0.14	215	0	100	315	1	0.14	215	0	100	315	1	0.14
501–600	225	0	115	340	1	0.15	225	0	115	340	1	0.15	225	0	115	340	1	0.15
601–800	235	0	125	360	1	0.16	235	0	125	360	1	0.16	235	0	125	360	1	0.16
801–1000	245	0	135	380	1	0.17	245	0	135	380	1	0.17	245	0	250	495	2	0.19
1001–2000	265	0	155	420	1	0.18	265	0	155	420	1	0.18	265	0	285	550	2	0.21
2001–3000	270	0	160	430	1	0.19	270	0	300	570	2	0.22	270	0	420	690	3	0.25
3001–4000	275	0	160	435	1	0.19	275	0	305	580	2	0.22	275	0	435	710	3	0.25
4001–5000	275	0	165	440	1	0.19	275	0	310	585	2	0.23	275	0	565	840	4	0.28
5001–7000	275	0	170	445	1	0.20	275	0	315	590	2	0.23	275	0	580	855	4	0.29
7001–10 000	280	0	320	600	2	0.24	280	0	460	740	3	0.26	280	0	590	870	4	0.30
10 001–20 000	280	0	325	605	2	0.24	280	0	465	745	3	0.27	450	1	700	1150	6	0.33
20 001–50 000	280	0	325	605	2	0.25	280	0	605	885	4	0.30	450	1	830	1280	7	0.36
50 001–100 000	280	0	325	605	2	0.25	280	0	605	885	4	0.30	450	1	960	1410	8	0.38

Lot Size	Process Average 0.21 to 0.30 %						Process Average 0.31 to 0.40 %						Process Average 0.41 to 0.50 %					
	Trial 1[A]		Trial 2[B]			AOQL[C] in %	Trial 1		Trial 2			AOQL in %	Trial 1		Trial 2			AOQL in %
	n_1	c_1	n_2	n_1+n_2	c_2		n_1	c_1	n_2	n_1+n_2	c_2		n_1	c_1	n_2	n_1+n_2	c_2	
1–120	all[D]	0	...	...	...	0	all	0	...	...	...	0	all	0	...	...	...	0
121–150	120	0	...	...	...	0.06	120	0	...	...	...	0.06	120	0	...	...	...	0.06
151–200	140	0	...	...	...	0.08	140	0	...	...	...	0.08	140	0	...	...	...	0.08
201–260	165	0	...	...	...	0.10	165	0	...	...	...	0.10	165	0	...	...	...	0.10
261–300	180	0	75	255	1	0.10	180	0	75	255	1	0.10	180	0	75	255	1	0.10
301–400	200	0	90	290	1	0.12	200	0	90	290	1	0.12	200	0	90	290	1	0.12
401–500	215	0	100	315	1	0.14	215	0	100	315	1	0.14	215	0	100	315	1	0.14
501–600	225	0	115	340	1	0.15	225	0	115	340	1	0.15	225	0	205	430	2	0.16
601–800	235	0	230	465	2	0.18	235	0	230	465	2	0.18	235	0	230	465	2	0.18
801–1000	245	0	250	495	2	0.19	245	0	250	495	2	0.19	245	0	250	495	2	0.19
1001–2000	265	0	405	670	3	0.23	265	0	515	780	4	0.24	265	0	515	780	4	0.24
2001–3000	270	0	545	815	4	0.26	430	1	620	1050	6	0.28	430	1	830	1260	8	0.30
3001–4000	435	1	645	1080	6	0.29	435	1	865	1300	8	0.30	580	2	940	1520	10	0.33
4001–5000	440	1	660	1100	6	0.30	440	1	1000	1440	9	0.33	585	2	1075	1660	11	0.35
5001–7000	445	1	785	1230	7	0.33	590	2	990	1580	10	0.36	730	3	1190	1920	13	0.38
7001–10 000	450	1	920	1370	8	0.35	600	2	1240	1840	12	0.39	870	4	1540	2410	17	0.41
10 001–20 000	605	2	1035	1640	10	0.39	745	3	1485	2230	15	0.43	1150	6	1990	3140	23	0.44
20 001–50 000	605	2	1295	1900	12	0.42	885	4	1845	2730	19	0.47	1280	7	2600	3880	29	0.52
50 001–100 000	605	2	1545	2150	14	0.44	885	4	2085	2970	21	0.49	1410	8	3280	4690	36	0.55

[A] Trial 1: n_1= first sample size; c_1= acceptance number for first sample.
[B] Trial 2: n_2= second sample size; c_2= acceptance number for first and second samples combined.
[C] AOQL = Average Outgoing Quality Limit.
[D] "*all*" indicates that each piece in the lot is to be inspected.