ADV MATH SCI JOURNAL

Advances in Mathematics: Scientific Journal 8 (2019), no.3, 736–745
(Special issue on ICRAPAM)
ISSN 1857-8365 printed version
ISSN 1857-8438 electronic version

Economic Design of Sampling System

***Dr K Ramya and **Dr G Uma**

Assistant Professor, Department of Mathematics, Sri Ramakrishna College of Arts and Science (Autonomous), Nava India, Coimbatore 641006, India.

Assistant Professor, Department of Statistics, PSG College of Arts & Science, Civil Aerodrome post, Coimbatore 641014, India.

Abstract-In this paper, an Economic and Mathematical model has been proposed to determine an optimal sampling system - Quick Switching Sampling System (QSSS) to minimize the total cost of the producer under the condition that both the producer's and the consumer's quality and risk requirements are satisfied. Procedures and tables have been constructed to determine the system. Numerical examples have been illustrated, for the selection of the Quick Switching Sampling System. Based on the above model, the various costs like inspection cost, internal failure cost and post-sale failure cost that may have an effect on the optimal sampling system has been studied.

Keywords: Acceptance Sampling Plan, Single Sampling Plan, Binomial distribution, Quick Switching System, Acceptance number tightening, Economic Design.

Introduction

Acceptance Sampling is used for inspecting the unproduced products, the products that are in process or the produced products. Inspection is done to accept or reject a product based on adherence to a standard. This type of inspection procedure is called as acceptance sampling. The main objective of sampling inspection is to reduce the cost of inspection and also satisfying the customer with an adequate level of quality in the items that are being inspected. Sampling plans may be categorized as single, double, multiple or sequential sampling plans.

In a single sampling plan, the inspector is forced to make a decision concerning acceptability of a lot or batch on the basis of inspection of units in one sample taken from that lot. A single-sampling is defined by the three entities namely lot size 'N', sample size 'n' and acceptance number 'c'. Thus for a lot size of 'N' a random sample of 'n' units are inspected and the number of nonconforming items 'd' is observed. If the number of nonconforming items 'd' is less than or equal to acceptance number c, the lot will be accepted. On the other hand, if 'd' is greater than c, then the lot will be rejected, which is the most user friendly in the shop floor situations.

A double sampling involves the possibility of postponing the decision until a second sample is taken. In the single sampling plan the decision is based on one sample only. However, in the double sampling plan, if the first sample is neither good nor bad, the decision is made on the basis of first and second samples combined. Double sampling plans generally involve less total inspection than the single sampling plan. They also have the advantage of a second chance given to doubtful lots. As an advancement of double sampling plan, multiple and sequential sampling plans may be used where smaller sample sizes are required.

Earlier, the sampling plan was considered without concentrating on economic criteria, only with the motive to satisfy the quality and the risk requirements of both the producer and the consumer.

Wetherill and Chiu (1975) reviewed some major principles of acceptance schemes with emphasis on the economic aspect. Their research showed that for designing an economic sampling plan, some of the major approaches are to be included. The approaches are as follows:

- **The Bayesian Method**

  This method evaluates the costs and losses included when a sampling plan is operated and it attempts to diminish the total cost. The expected cost per batch consists of the sampling cost and the loss happened due to wrong decisions, which is a function of the process quality *'p'*. The optimal single sampling plan is attained by minimizing the expected cost with regard to the two variables *(n, c)*.

- **The Minimax Method**

  The aim of this approach is also to minimize the costs but without considering the process quality *'p'*. Thus the average cost per batch *C(p)* is a function of *'p'*. For any given sampling plan, *C(p)* will go through a maximum when *'p'* varies from 0 to 1. The minimax principle selects the plan that minimizes this maximum.

- **Semieconomic Method**

  Here a point is specified on the OC curve. The specified point on the OC curve is the producer's risk point, or the consumer's risk point, or the indifference quality point. The point defines the association between '*c*' and '*n*'. The plan which minimizes the average amount of inspection at the process average quality is selected.

Tagaras (1994) had developed an economic model which can be used in the selection of minimum cost for acceptance sampling plans by variables. The quadratic Taguchi loss function is applied to model the cost of the items that is being accepted with quality characteristics that has been deviated from the target value. Ferrell and Chhoker (2002) have suggested an economic model for designing Acceptance Sampling plans by adopting the Taguchi approach.Jia-Tzer Hsu (2009) developed the mathematical model that the product inspection, internal failure and post-sale failure costs also have an effect on the optimal sampling plan. Lie-Fern Hsu and Jia-Tzer Hsu (2012) developed the mathematical model that the product inspection, internal failure and post-sale failure costs also have an effect on the choice of the economic sampling plan in a Two-Stage supply chain.

Devaraj Arumainayagam (1991) has studied Quick Switching System with sampling plans like Single Sampling Plan, Double Sampling Plan for acceptance number tightening and sample size tightening. The tables are constructed for various parameters. Arumainayagam and Soundararajan (1995) constructed tables for Quick Switching System with Double Sampling Plan as a reference plan for Sample size tightening and the system is also compared with the existing plans.

Devaraj Arumainayagam S and Uma G (2013) have designed the construction and selection of Quick Switching System using weighted Poisson distribution-sample size tightening. Uma and Komaladevi (2012) have undertaken a work on Quick Switching System with Fuzzy Parameter using Poisson Distribution. Uma and Nandhini Devi (2015) have studied Quick Switching System by attributes under Fuzzy Poisson Distribution

The purpose of this paper is to design an economic model to determine the optimal sampling system that minimizes the producer's total cost by satisfying both the producer's and consumer's quality and risk requirements.

Quick Switching System

Quick Switching System (QSS) was introduced by Dodge (1967) and further QSS was extensively studied by Romboski (1969). In this system, when a rejection occurs in normal inspection, an immediate switching to tightened inspection will be made.

Quick switching system requires normal plan when the quality is good and tightened plan when the quality is bad. Dodge (1967) proposed a new sampling system consisting of pairs of normal and tightened plans with the switching rules constituting a sampling system. The application of system is as follows.

- Adopt a pair of sampling plans, a normal plan *(N)* and tightened plan *(T)* the plan to *T* to be tighter 'OC' wiser than plan *N*.
- Use plan *N* for the first lot.
- For each lot inspected: if the lot is accepted, use plan *N* for the next lot; and if the lot is rejected, use plan *T* for the next lot.

Quick Switching System with Single Sampling Plan as a reference plan is designated as Quick Switching Single Sampling System – *QSSS* $(n;c_N, c_T)$, where n, c_N *and* c_T are the parameters of the single sampling system.

Conditions of Application

The conditions for application under which the Quick Switching System can be applied and the operation procedures are as follows:

- The produced lots are expected to be of same quality.
- The production is stable so that results on current and preceding lots are broadly indicative of a continuous process.
- Lots are submitted substantially in the order of production.
- Inspection is by attributes, with quality defined as fraction nonconforming.

Operating Procedure for QSS (n; c_N; c_T)

From a lot, take a sample of size *'n'* at the normal level. Count the number of defectives *'d'*.

Step 1: (i) If $d \le c_N$ accept the lot.

(ii) If $d > c_N$ reject the lot and go to step - 2

From the next lot, take a sample of size *n* at the tightened level; count the number of defectives *'d'*.

Step 2: (i) If $d \le c_T$ accept the lot and repeat step - 1.

(ii) If $d > c_T$ reject the lot and go to step - 2.

Performance Measure

The OC function of *QSSS* $(n;c_N, c_T)$, is given by Romboski as

$$P_a(p) = \frac{P_T}{1-P_N+P_T} \tag{1}$$

where

P_N is the proportion of lots expected to be accepted using the normal single sampling plans.

$$P_N = \sum_{x=0}^{c_N} \binom{n}{X} p^x (1-p)^{n-x} \tag{2}$$

P_T is the proportion of lots expected to be accepted using the tightened single sampling plans.

$$P_T = \sum_{x=0}^{c_T} \binom{n}{X} p^x (1-p)^{n-x} \tag{3}$$

Economic Design of Acceptance Sampling System

Mc William et al. (2001) have given a method for finding exact designs of acceptance sampling plans. The design problem is to find the parameters *n* and *c* where

$$P_a(AQL) = P(d \le c|n, AQL) = 1 - \alpha \tag{4}$$

and

$$P_a(LTPD) = P(d \le c|n, LTPD) = \beta \tag{5}$$

$$AOQ = \frac{p.P_a(p)(N-n)}{N} \tag{6}$$

$$ATI = n + (1 - P_a(p))(N - n) \tag{7}$$

Let D_d denote the defective items detected and D_n denote the defective items not detected, then

$$D_d = np + (1 - P_a(p))(N - n)p \tag{8}$$

$$D_n = P_a(p)(N - n)p \tag{9}$$

If the inspection is 100% true, for the *n* sampled items, then it is sure that the expected defective items *np* will be detected. If the lot is rejected (with probability $1 - P_a(p)$), then there will be 100% inspection and the remaining $(N - n)p$ defective items will be detected. On the other hand, if the lot is accepted (with probability $P_a(p)$), the $(N - n)p$ defective items will not be detected.

To derive the total quality cost per lot for a given sampling system, the following cost parameters are defined.

C_i - Inspection cost per item.

C_f - Internal failure cost; i.e., the cost of rework, repair or replacement for a defective item which is not released to the market as a finished product or not released to production for an incoming raw material.

C_0 - The cost of an outgoing defective item, i.e., the post-sale failure cost. For a finished product, this is the cost of replacement and loss of good will for a defective item which is released to the market. For an incoming raw material, this will be the attendant cost when a defective item is released for production use.

The economic sampling system can be determined by the following mathematical model.

Minimize $TC = C_i.ATI + C_f.D_d + C_0.D_n$

Subject to

$$1 - P_a(AQL) \leq \alpha \quad (10)$$

$$P_a(LTPD) \leq \beta \quad (11)$$

Example

The input parameters are given as follows: N = 1,000, AQL = 0.02, $LTPD$ = 0.07, α = 0.05, β = 0.10, p = 0.03, C_i = 1.0, C_f = 2.0, C_0 = 10. Performance measurements are indicated as follows: Table 1 lists part of the Quick Switching Sampling System for *n* up to 100. From Table 1, we can see that both the producer's risk *(1-Pa(AQL))* and average total inspection *(ATI)* increase, and the consumer's risk *Pa(LTPD)* decreases as *n* increases and *c* remains unchanged; on the contrary, both the producer 's risk and average total inspection decrease, and the consumer's risk increases as *'c'* increases and '*n*' remains unchanged. Based on the above input parameters, the optimal sampling system is n = 100, c_N = 5 and c_T = 3 with the minimum total cost TC = 451.942.

Table 2 explains the sensitivity analysis of the optimal single sampling system with different levels of p. For $p \geq 0.13$, the optimal sampling system will have a near zero probability of accepting the lot, resulting in a 100% inspection of the entire lot. As a result, all the defective products will be detected and replaced (ATI = 1000 and AOQ = 0).

Table 3 explains the sensitivity analysis of the inspection cost C_i. If $C_i \leq 0.2$, the inspection cost is relatively low compared to the failure costs (C_f and C_0). Therefore, the optimal sampling system is to have a 100% inspection of the entire lot.For $0.3 \leq C_i \leq 10$, the optimal sampling systems remain at n = 100, c_N = 5 and c_T = 3.

Table 4(a) shows that the internal failure cost C_f is relatively inspective to the optimal sampling system. Therefore, when the inspection cost C_i is small, i.e., $C_i = 0.2$(from Table 4(b)), the internal failure cost C_f affects the optimal sampling system.

Table 5 explains the sensitivity analysis of the post-sale failure cost C_0. If $C_0 \leq 35$, the optimal sampling systems will be n = 100, c_N = 5 and c_T = 3. When $C_0 \geq 40$, the optimal sampling system will change to 100% inspection of the entire lot.

Figure 1 shows the AOQ curve for various '*p*' values. Figure 2hows the OC curve for optimal sample size with different values of '*p*'. As '*p*' value increases, the probability value decreases. According to this curve, both producer and consumer have equal risk requirements.

Comparison of Economic Design for Single Sampling Plan and Quick Switching Sampling System

According to Jia-Tzer-Hsu in Economic Design of Single Sample Acceptance Sampling Plans, the optimal sampling plan is n = 201 and c = 9 with minimum total cost TC = 503.07. But in this study, the optimal sampling system is n = 100, c_N = 5 and c_T = 3 with the minimum total cost TC = 451.942. From the above example, we can see that the optimal sample size is two times lesser in the system when compared with the plan. The OC curve for sampling system is similar to that of the ideal OC curve and indicates that both producer and consumer have an equal chance of risk.

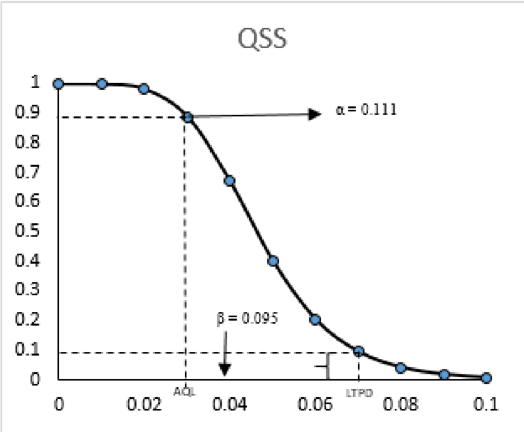

Figure 1. OC curve

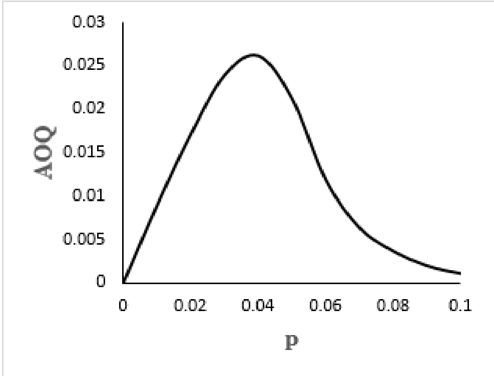

Figure 2. AOQ curve

Table 1: Quick Switching Sampling System satisfying the conditions AQL = 0.02, LTPD = 0.07, α = 0.05, β = 0.1, with n ≤ 120

n	c_N	c_T	QSS	AOQ	ATI	D_d	D_n	1-Pa(AQL)	Pa(LTPD)	TC
96	4	3	0.8061	0.0218	271.25	8.13	21.86	0.0479	0.0995	506.15
97	5	2	0.8593	0.0232	224.018	6.72	23.27	0.0190	0.0427	470.25
97	5	1	0.7429	0.0201	329.09	9.87	20.12	0.0311	0.0105	550.10
98	5	2	0.8525	0.0230	230.96	6.92	23.07	0.0201	0.0400	475.53
98	5	1	0.7310	0.0197	340.59	10.21	19.78	0.0329	0.0098	558.84
99	5	2	0.8456	0.0228	238.06	7.14	22.85	0.0212	0.0374	480.92
99	5	1	0.7189	0.0194	352.27	10.56	19.43	0.0349	0.0090	567.72
100	5	3	0.8889	0.024	199.92	5.99	24.00	0.0177	0.0950	451.94
100	5	2	0.8385	0.0226	245.32	7.35	22.64	0.0223	0.0351	486.45
100	5	1	0.7065	0.0190	364.11	10.92	19.07	0.0369	0.0084	576.72
101	5	3	0.8842	0.0238	205.10	6.15	23.84	0.0185	0.0900	455.88
101	5	2	0.8312	0.0224	252.75	7.58	22.41	0.0235	0.0328	492.09
101	5	1	0.6939	0.0187	376.11	11.28	18.71	0.0391	0.0078	585.84
102	5	3	0.8792	0.0236	210.39	6.31	23.68	0.0194	0.0853	459.89
102	5	2	0.8236	0.0221	260.33	7.80	22.19	0.0247	0.0308	497.85
102	5	1	0.6812	0.0183	388.24	11.64	18.35	0.0413	0.0072	595.06
103	5	3	0.8742	0.0235	215.78	6.47	23.52	0.0204	0.0808	463.95
103	5	2	0.8159	0.0219	268.06	8.04	21.95	0.0260	0.0288	503.76
103	5	1	0.6683	0.0179	400.49	12.01	17.98	0.0436	0.0067	604.37
104	5	3	0.8691	0.0233	221.27	6.63	23.36	0.0213	0.0765	468.16
104	5	2	0.8081	0.0217	275.94	8.27	21.72	0.0273	0.0270	509.71
104	5	1	0.6553	0.0176	412.84	12.38	17.61	0.0460	0.0062	613.76
105	5	3	0.8638	0.0231	226.86	6.80	23.19	0.0223	0.0725	472.42
105	5	2	0.8000	0.0214	283.96	8.51	21.48	0.0287	0.0253	515.81
105	5	1	0.6421	0.0172	425.27	12.75	17.24	0.0485	0.0057	623.20
106	5	3	0.8584	0.0230	232.56	6.97	23.02	0.0234	0.0686	476.74
106	5	2	0.7918	0.0212	292.13	8.76	21.23	0.0302	0.0237	522.01
107	5	3	0.8529	0.0228	238.35	7.15	22.84	0.0244	0.0650	481.15
107	5	2	0.7833	0.0209	300.43	9.01	20.98	0.0317	0.0222	528.32

108	5	3	0.8472	0.0226	244.24	7.32	22.67	0.0255	0.0615	485.62
108	5	2	0.7748	0.0207	308.86	9.26	20.73	0.0332	0.0208	534.73
109	5	3	0.8414	0.0224	250.23	7.50	22.49	0.0267	0.0583	490.18
109	5	2	0.7660	0.0204	317.42	9.52	20.47	0.0348	0.0195	541.24
110	5	3	0.8355	0.0223	256.32	7.68	22.31	0.0279	0.0552	494.80
110	5	2	0.7571	0.0202	326.10	9.78	20.21	0.0365	0.0183	547.84
111	5	3	0.8295	0.0221	262.50	7.87	22.12	0.0291	0.0523	499.50
111	5	2	0.7481	0.0199	334.90	10.04	19.95	0.0382	0.0172	554.52
112	5	3	0.8234	0.0219	268.77	8.06	21.93	0.0303	0.0495	504.26
112	5	2	0.7389	0.0196	343.81	10.31	19.68	0.0400	0.0161	561.29
113	5	3	0.8172	0.0217	275.13	8.25	21.74	0.0316	0.0468	509.10
113	5	2	0.7296	0.0194	352.81	10.58	19.41	0.0418	0.0151	568.14
114	5	3	0.8108	0.0215	281.58	8.44	21.55	0.0330	0.0443	514.00
114	5	2	0.7201	0.0191	361.92	10.85	19.14	0.0437	0.0141	575.06
115	5	4	0.8472	0.0224	250.18	7.50	22.49	0.0301	0.0973	490.13
115	5	3	0.8043	0.0213	288.11	8.64	21.35	0.0343	0.0420	518.97
115	5	2	0.7106	0.0188	371.11	11.13	18.86	0.0457	0.0133	582.04
116	5	4	0.8424	0.0223	255.30	7.65	22.34	0.0312	0.0930	494.03
116	5	3	0.7978	0.0211	294.73	8.84	21.15	0.0358	0.0397	524
116	5	2	0.7009	0.0185	380.38	11.41	18.58	0.0477	0.0124	589.09
117	5	4	0.8375	0.0221	260.49	7.81	22.18	0.0324	0.0889	497.97
117	5	3	0.7911	0.0209	301.43	9.04	20.95	0.0372	0.0376	529.09
117	5	2	0.6911	0.0183	389.73	11.69	18.30	0.0498	0.0117	596.19
118	5	4	0.8325	0.0220	265.72	7.97	22.02	0.0337	0.0849	501.95
118	5	3	0.7843	0.0207	308.21	9.24	20.75	0.0387	0.0356	534.24
119	5	4	0.8274	0.0218	271.02	8.13	21.86	0.0349	0.0812	505.97
119	5	3	0.7774	0.0205	315.06	9.45	20.54	0.0403	0.0337	539.45
120	5	4	0.822	0.0217	276.37	8.29	21.70	0.0362	0.0775	510.04
120	5	3	0.7704	0.0203	321.99	9.65	20.34	0.0418	0.0319	544.71

Table 2: Optimal Single Sampling System which is a function of the product quality p (other input parameters are given as the base set)

n	p	c_N	c_T	QSS	AOQ	ATI	D_d	D_n	1-Pa(AQL)	Pa(LTPD)	TC
96	0.01	4	3	0.9971	0.009	98.64	0.99	9.01	0.048	0.0995	190.747
96	0.02	4	3	0.952	0.0172	139.4	2.79	17.2	0.048	0.0995	317.055
100	0.03	5	3	0.889	0.024	199.9	6	24	0.0177	0.095	451.942
192	0.04	10	8	0.8103	0.0262	345.2	13.8	26.2	0.0019	0.0852	634.764
262	0.05	14	12	0.5744	0.0212	576.1	28.8	21.2	0.0003	0.081	845.641
225	0.06	12	10	0.2542	0.0118	803	48.2	11.8	0.0007	0.0896	1017.55
96	0.07	4	3	0.0995	0.0063	910	63.7	6.3	0.048	0.0995	1100.4
96	0.08	4	3	0.0491	0.0036	955.6	76.4	3.55	0.048	0.0995	1144.01
96	0.09	4	3	0.0235	0.0019	978.8	88.1	1.91	0.048	0.0995	1174.06
96	0.1	4	3	0.0109	0.001	990.1	99	0.99	0.048	0.0995	1198.03

96	0.11	4	3	0.0049	0.0005	995.5	110	0.49	0.048	0.0995	1219.46
96	0.12	4	3	0.0022	0.0002	998	120	0.24	0.048	0.0995	1239.92
172	0.13	7	4	9E-08	9E-08	1000	130	0	0.0305	0.0065	1260
162	0.14	7	4	7E-08	7E-08	1000	140	0	0.0213	0.0111	1280
142	0.15	6	3	4E-08	4E-08	1000	150	0	0.0349	0.0101	1300
127	0.16	6	3	9E-08	9E-08	1000	160	0	0.0187	0.0242	1320
137	0.17	6	3	5E-09	5E-09	1000	170	0	0.0286	0.0135	1340
131	0.18	6	3	3E-09	3E-09	1000	180	0	0.0223	0.0192	1360
117	0.19	5	4	9E-08	9E-08	1000	190	0	0.0325	0.0889	1380
96	0.2	4	3	2E-07	2E-07	1000	200	0	0.048	0.0995	1400

Table 3: Optimal Single Sampling System which is a function of the inspection cost C_i (other input parameters are given as the base set)

n	C_i	c_N	c_T	QSS	AOQ	ATI	D_d	D_n	1-Pa(AQL)	Pa(LTPD)	TC
1000	0.1	28	26	0.3057	0	1000	30	0	0.0344	5E-10	849.671
1000	0.2	28	26	0.3057	0	1000	30	0	0.0344	5E-10	849.671
100	0.3	5	3	0.889	0.024	199.92	6	24	0.0177	0.095	87.8383
100	0.4	5	3	0.889	0.024	199.92	6	24	0.0177	0.095	87.8383
100	0.5	5	3	0.889	0.024	199.92	6	24	0.0177	0.095	87.8383
100	1	5	3	0.889	0.024	199.92	6	24	0.0177	0.095	87.8383
100	1.5	5	3	0.889	0.024	199.92	6	24	0.0177	0.095	87.8383
100	2	5	3	0.889	0.024	199.92	6	24	0.0177	0.095	87.8383
100	2.5	5	3	0.889	0.024	199.92	6	24	0.0177	0.095	87.8383
100	3	5	3	0.889	0.024	199.92	6	24	0.0177	0.095	87.8383
100	3.5	5	3	0.889	0.024	199.92	6	24	0.0177	0.095	87.8383
100	4	5	3	0.889	0.024	199.92	6	24	0.0177	0.095	87.8383
100	4.5	5	3	0.889	0.024	199.92	6	24	0.0177	0.095	87.8383
100	5	5	3	0.889	0.024	199.92	6	24	0.0177	0.095	87.8383
100	5.5	5	3	0.889	0.024	199.92	6	24	0.0177	0.095	87.8383
100	6	5	3	0.889	0.024	199.92	6	24	0.0177	0.095	87.8383
100	6.5	5	3	0.889	0.024	199.92	6	24	0.0177	0.095	87.8383
100	7	5	3	0.889	0.024	199.92	6	24	0.0177	0.095	87.8383
100	7.5	5	3	0.889	0.024	199.92	6	24	0.0177	0.095	87.8383
100	8	5	3	0.889	0.024	199.92	6	24	0.0177	0.095	87.8383
100	8.5	5	3	0.889	0.024	199.92	6	24	0.0177	0.095	87.8383
100	9	5	3	0.889	0.024	199.92	6	24	0.0177	0.095	87.8383
100	9.5	5	3	0.889	0.024	199.92	6	24	0.0177	0.095	87.8383

100	10	5	3	0.889	0.024	199.92	6	24	0.0177	0.095	87.8383

Table 4(a): Optimal Single Sampling System which is a function of the internal failure cost C_f (other input parametersare given as the base set)

n	C_f	c_N	c_T	QSS	AOQ	ATI	D_d	D_n	1-Pa(AQL)	Pa(LTPD)	TC
100	0	5	3	0.889	0.024	199.92	5.998	24	0.0177	0.095	439.947
100	0.5	5	3	0.889	0.024	199.92	5.998	24	0.0177	0.095	442.946
100	1	5	3	0.889	0.024	199.92	5.998	24	0.0177	0.095	445.945
100	1.5	5	3	0.889	0.024	199.92	5.998	24	0.0177	0.095	448.943
100	2	5	3	0.889	0.024	199.92	5.998	24	0.0177	0.095	451.942
100	2.5	5	3	0.889	0.024	199.92	5.998	24	0.0177	0.095	454.941
100	3	5	3	0.889	0.024	199.92	5.998	24	0.0177	0.095	457.94
100	3.5	5	3	0.889	0.024	199.92	5.998	24	0.0177	0.095	460.939
100	4	5	3	0.889	0.024	199.92	5.998	24	0.0177	0.095	463.938
100	4.5	5	3	0.889	0.024	199.92	5.998	24	0.0177	0.095	466.937
100	5	5	3	0.889	0.024	199.92	5.998	24	0.0177	0.095	469.936
100	5.5	5	3	0.889	0.024	199.92	5.998	24	0.0177	0.095	472.934
100	6	5	3	0.889	0.024	199.92	5.998	24	0.0177	0.095	475.933
100	6.5	5	3	0.889	0.024	199.92	5.998	24	0.0177	0.095	478.932
100	7	5	3	0.889	0.024	199.92	5.998	24	0.0177	0.095	481.931
100	7.5	5	3	0.889	0.024	199.92	5.998	24	0.0177	0.095	484.93
100	8	5	3	0.889	0.024	199.92	5.998	24	0.0177	0.095	487.929
100	8.5	5	3	0.889	0.024	199.92	5.998	24	0.0177	0.095	490.928
100	9	5	3	0.889	0.024	199.92	5.998	24	0.0177	0.095	493.926
100	9.5	5	3	0.889	0.024	199.92	5.998	24	0.0177	0.095	496.925
100	10	5	3	0.889	0.024	199.92	5.998	24	0.0177	0.095	499.924

Table 4(b): Optimal Single Sampling System which is a function of the internal failure cost C_f (with $C_i = 0.2$ and other input parameters are given as the base set)

N	C_f	c_N	c_T	QSS	AOQ	ATI	D_d	D_n	1-Pa(AQL)	Pa(LTPD)	TC
1000	0	28	26	0.3057	0	1000	30	0	0.0344	5E-10	200
1000	0.5	28	26	0.3057	0	1000	30	0	0.0344	5E-10	215
1000	1	28	26	0.3057	0	1000	30	0	0.0344	5E-10	230
1000	1.5	28	26	0.3057	0	1000	30	0	0.0344	5E-10	245
1000	2	28	26	0.3057	0	1000	30	0	0.0344	5E-10	260
1000	2.5	28	26	0.3057	0	1000	30	0	0.0344	5E-10	275
1000	3	28	26	0.3057	0	1000	30	0	0.0344	5E-10	290
100	3.5	5	3	0.889	0.024	199.92	5.998	24	0.0177	0.095	301
100	4	5	3	0.889	0.024	199.92	5.998	24	0.0177	0.095	303.998
100	4.5	5	3	0.889	0.024	199.92	5.998	24	0.0177	0.095	306.997
100	5	5	3	0.889	0.024	199.92	5.998	24	0.0177	0.095	309.996
100	5.5	5	3	0.889	0.024	199.92	5.998	24	0.0177	0.095	312.995
100	6	5	3	0.889	0.024	199.92	5.998	24	0.0177	0.095	315.994

100	6.5	5	3	0.889	0.024	199.92	5.998	24	0.0177	0.095	318.993
100	7	5	3	0.889	0.024	199.92	5.998	24	0.0177	0.095	321.992
100	7.5	5	3	0.889	0.024	199.92	5.998	24	0.0177	0.095	324.991
100	8	5	3	0.889	0.024	199.92	5.998	24	0.0177	0.095	327.989
100	8.5	5	3	0.889	0.024	199.92	5.998	24	0.0177	0.095	330.988
100	9	5	3	0.889	0.024	199.92	5.998	24	0.0177	0.095	333.987
100	9.5	5	3	0.889	0.024	199.92	5.998	24	0.0177	0.095	336.986
100	10	5	3	0.889	0.024	199.92	5.998	24	0.0177	0.095	339.985

Table 5: Optimal Single Sampling System which is a function of the post sale failure cost C_0 (other input parameters are given as the base set)

N	C_0	c_N	c_T	QSS	AOQ	ATI	D_d	D_n	1-Pa(AQL)	Pa(LTPD)	TC
100	5	5	3	0.889	0.024	199.924	5.998	24	0.0177	0.095	331.931
100	10	5	3	0.889	0.024	199.924	5.998	24	0.0177	0.095	451.942
100	15	5	3	0.889	0.024	199.924	5.998	24	0.0177	0.095	571.954
100	20	5	3	0.889	0.024	199.924	5.998	24	0.0177	0.095	691.965
100	25	5	3	0.889	0.024	199.924	5.998	24	0.0177	0.095	811.976
100	30	5	3	0.889	0.024	199.924	5.998	24	0.0177	0.095	931.988
100	35	5	3	0.889	0.024	199.924	5.998	24	0.0177	0.095	1052
1000	40	28	26	0.3057	0	1000	30	0	0.0344	5E-10	1060
1000	45	28	26	0.3057	0	1000	30	0	0.0344	5E-10	1060
1000	50	28	26	0.3057	0	1000	30	0	0.0344	5E-10	1060
1000	55	28	26	0.3057	0	1000	30	0	0.0344	5E-10	1060
1000	60	28	26	0.3057	0	1000	30	0	0.0344	5E-10	1060
1000	65	28	26	0.3057	0	1000	30	0	0.0344	5E-10	1060
1000	70	28	26	0.3057	0	1000	30	0	0.0344	5E-10	1060
1000	75	28	26	0.3057	0	1000	30	0	0.0344	5E-10	1060
1000	80	28	26	0.3057	0	1000	30	0	0.0344	5E-10	1060
1000	85	28	26	0.3057	0	1000	30	0	0.0344	5E-10	1060
1000	90	28	26	0.3057	0	1000	30	0	0.0344	5E-10	1060
1000	95	28	26	0.3057	0	1000	30	0	0.0344	5E-10	1060
1000	100	28	26	0.3057	0	1000	30	0	0.0344	5E-10	1060

Table 6: Proportion defective vs. Probability of acceptance

p	0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09	0.1
Pa(p)	1	0.9994	0.9822	0.8889	0.6699	0.4017	0.2036	0.0950	0.0428	0.0189	0.0082

References

1. ANSI/ASQ Z1.4-2003 (2003), “Sampling Procedures and Tables for Inspection by attributes, American Society for Quality.

2. Dodge H.F and Romig H.G (1998), “Sampling Inspection Tables –Single and Double Sampling”, 2nd Revised and Expanded Edition, John Wiley & Sons, N.Y., U.S.A.
3. Military Standard (MIL-STD-105E) (1989), “Sampling Procedures and Tables for Inspection by Attributes”, U.S. Department of Defense. Washington, DC, U.S.A.
4. Montgomery D.C (2005), “Introduction to Statistical Quality Control, 5th Edition”, John Wiley & Sons, N.Y., U.S.A.
5. Devaraj Arumainayagam and Soundarajan (1995), “Construction and evaluation of matched Quick Switching System”, Journal of Applied Statistics, 22, (2).
6. Devaraj Arumainayagam and Uma (2013), “Construction and selection of quick switching system using weighted Poisson distribution - sample size tightening”, Journal of the Indian Statistical Association, 51 (2), 329 – 344.
7. Ferrell W.G and Chhoker A (2002), “Design of economically optimal acceptance sampling plans with inspection error”, Computers and Operations Research, 29, 10, 1283-1300.
8. Jia-Tzer Hsu (2009), “Economic design of single sample .acceptance sampling plans”.
9. Lie-Fern Hsu and Jia-Tzer Hsu (2012), “Economic design of acceptance sampling plans in a two-stage supply chain”, Advanced in Decision Sciences.
10. Mc Williams T.P, Saniga, E.M and Davis D.J (2001), “On the design of single sample acceptance sampling plans” Economic Quality Control 16, 193-198.
11. Tagaras G (1994), “Economic acceptance sampling plans by variables with quadratic quality cost”, IIE Transactions, 26, 6, 29-36.
12. Uma G and Komaladevi (2014), “Designing Quick Switching System with Fuzzy Parameter”, Proceedings of the UGC sponsored National Conference on Advances in Statistical Theory, Modeling and Applications (NCASTMA) during March 27-28, 2014 organized by the Department of Statistics, Bharathiar University, Coimbatore – 641046.
13. Uma G and Nandhini Devi R (2015), “Determination of Quick Switching System by Attributes under Fuzzy Poisson Distribution”, Coimbatore Institute of Information Technology, Vol.7, No. 7.
14. Wetherill G.B and Chiu W.K (1975), “A review of acceptance sampling schemes with emphasis on the economic aspect”. Int. Stat. Rev., 43, 2, 191-210.