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Selection Of Quick Switching System with Single Sampling Plans through Relative Slopes (QSS-2 (n, kn, c_0))

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Abstract

This article is the contribution to the study on Quick Switching Systems with reference to Single Sampling Plan (QSS) - Acceptance Number Tightening, using QSS - (n; kn, c_0). Tables are constructed for designing the system indexed by various combinations of parameters.

Keywords: Quick Switching System, Single sampling plan, Acceptable Quality Level, Limiting Quality Level, Relative slopes.

Subject Classification: 62P30 / 62D05

Introduction:

Quick switching systems (QSSs) increase the likelihood of identifying defective products while reducing the number of units to be inspected. QSSs for acceptance sampling consist of two sampling procedures plus a set of rules for switching between them. The first sampling procedure is reduced inspection. It requires a relatively low sample size and is used during periods of good quality. The second sampling procedure is tightened inspection. It uses a higher sample size when defects are encountered. The efficiency of QSSs is in the use of higher sample sizes only when needed, namely during problem periods. In the simplest example, one could start with tightened inspection. Next, decide whether to accept or reject the first lot.

This decision affects the switch number, which then indicates whether or not to switch to reduced inspection. The result is that a subsequent lot is more likely to be rejected if previous lots have been rejected and more likely to be accepted if previous lots have been accepted. Switching rules for QSSs involve the switch number, sample size, and acceptance level of lots. QSSs are similar to chain sampling plans, and are nearly equivalent when the reduced and tightened sample sizes are equal. QSSs can replace the switching systems of Military Standard Mil-Std-105E, because the QSSs are more responsive, easier to use, and can reduce sampling costs by 80 percent.

Romboski (1969) has introduced the concept of QSS-1 (n, C_N, C_T) is a system which considers single sampling plan (n, C_N) and (n, C_T) which are the normal tightened plans with C_N & C_T and introduced another type denoted as QSS-1 (n, kn, C_0) which is QSS-1 with single sampling as reference plan. Under this system the single sampling plan with (n, C_0) and (kn, C_0), k>1 are considered as normal and tightened plan respectively. Devaraj Arumainayagam (1991) has studied the construction to the study of Quick Switching system (QSS) and its applications. Suresh (1993) has studied the QSS-1 with single sampling plan using acceptable and limiting quality levels through incentive and filter effects.

Conditions for Application:

1. The production is steady so that results on current and preceding lots are broadly indicative of a continuing process and submitted lots are accepted to be essentially of the same quality.
2. Lots are submitted substantially in the order of production.
3. Inspection is by attributes with quality defined as fraction nonconforming.

Operating Procedure for QSS-2 (n, kn, c_0) system:

Step1:- From the lot, take a random sample of size ‘n’ at the normal level, count the number of defectives‘d’

a. If $d \leq c_0$ accept the lot and repeat step1.

b. If $d > c_0$ reject the lot and go to step2.

Step:-2 From the next lot , take a random sample of size ‘n’ at the tightened level. Count the number of defectives ’D’.

a. If $D \leq c_0$ accept the lot and continue inspection until two lots in succession are accepted. If so go to step-1 otherwise repeat step2.

b. If $D > c_0$ reject the lot and repeat step2.

Romboski (1969) has derived the OC function for QSS-2 (n, kn, c_0) as

$$Pa(p) = \frac{P_N P_T^2 + P_T(1 - P_N)(1 + P_T)}{P_T^2 + (1 - P_N)(1 + P_T)}$$

Where,

P_N = Proportion of lots expected to be accepted when using single sampling plan Normal plan (n,c_0)

P_T = Proportion of lots expected to be accepted when using single sampling tightened plan (kn, c_0).

Selection of QSS with SSP through Relative slopes (QSS-2 (n, kn, c_0)):

QSS-2 (n, kn, c_0) which is QSS-2 with single sampling as reference plan. Under this system the single sampling plan with (n, c_0) and (kn, c_0), k>1 is considered as normal and tightened plan respectively. The conditions for application of this system are similar to that of QSS-2 (n, c_N, c_T) system.

Designing Plans for QSS-2 (n, kn, c_0) given (p_1,h_1):

Designing plans for given values of p_1 and h_1 use the Table 1 for finding the parameters of QSS-2 (n, kn, c_0) plan . For given h_1, scan the column headed h_1 using Table 1 which is equal to or just greater than the desired value which locates the corresponding values for k, c_0 and np_1.

Example: For given p_1=0.2 and h_1=0.5, from Table 1 under column headed h_1, locate the equal to or just greater than specified h_1 which is 0.5229, corresponding to this h_1, the k, C_0 and np_1values associated are 4, 2.75, 1.5154 respectively. From this one can obtain the sample size n=8. Thus the selected parameters for QSS-2 plan are n=8, kn=14, c_0=4.

Designing Plans for QSS-2 (n, kn, c_0) given (p_2, h_2):

Designing plans for given values of p_2 and h_2 use the Table 1 for finding the parameters of QSS-2 (n, kn, c_N) plan. For given h_2, scan the column headed h_2 using Table 1 which is equal to or just greater than the desired value which locates the corresponding values for k, c_0 and np_1.

Example: Given p_2=0.4 and h_2=3.5, from Table 1 under column headed h_2, locate the equal to or just greater than specified h_2 which is 3.6588, corresponding to this h_2, the k, c_0 and np_1values associated are 2, 2.75, 2.0051 respectively. From this one can obtain the sample size n=5. Thus the selected parameters for QSS-2 plan are n=5, kn= 13.75, c_0=2.

Designing Plans through the ratio of relative slopes (n, kn, c_0):

Design plans for specified AQL (or LQL) with the ratio of relative slopes h_2/h_1. By using Table 1 under the column headed h_2/h_1, one can locate the values which is equal to or just greater than the desired ratio, corresponding to this located value one can find n, kn, c_0 and np_1 values.

Column3 and 7 of Table 1 are used to design plans for specified AQL (or LQL) with the ratio of relative slopes h_2/h_1. For example given p_1= 0.05 h_1=0.15 and h_2=2.0 one can obtain the ratio h_2/h_1=13.3333. By using Table 1 under the column headed h_2/h_1, one can locate the values which are equal to or just greater than the desired ratio, which is 13.0520 Corresponding to this located value one can find c_0, k and np_1 values 5, 2.75, 1.9776 respectively. From this one can obtain the sample size n= 39.

Thus the selected parameters for the plan are n=39, kn= 107.25, c_0=5.

Construction of Tables:

The expression for $P_a(p)$ of QSS-2 (n, kn, c_0) with single sampling plan with parameters for k, c_0 and n has been derived by Romboski(1969)

$$Pa(p) = \frac{P_N P_T^2 + P_T(1-P_N)(1+P_T)}{P_T^2 + (1-P_N)(1+P_T)}$$

This is the OC function for QSS-2 with single sampling plan as reference plan having parameter k and c_0 under the Conditions for application of Poisson model for OC Curve. For given values of k, c_0 and $P_a(p)$ above equation can be solved for the values of np using method of iterations. The entries in the columns np_1, np_2 under Table 1 are such np values with $P_a(p)$= 0.95and 0.10 respectively.

The value of the column np_1 are such values of np which are obtained through equating first derivative of $P_a(p)$ to 0 for given values of k, c_0 and $P_a(p)$. The entries under the column h_1, h_2 are calculated through the expression

$$h = -\frac{p}{Pa(p)}\frac{dP_a(p)}{dp} \qquad \text{for } p = p_1, p_2$$

Table 1: Certain Parametric Values for QSS-2 with Single Sampling Plan

c_0	k	np_1	np_2	h_1	h_2	h_2/h_1
1	1.2500	0.3465	3.1208	0.0876	2.3131	26.4072
1	1.5000	0.3373	2.6098	0.0916	2.2221	24.2707
1	1.7500	0.3281	2.2458	0.0960	2.1967	22.8792
1	2.0000	0.3192	1.9734	0.1007	2.2061	21.9015
1	2.2500	0.3105	1.7619	0.1056	2.2351	21.1690
1	2.5000	0.3022	1.5930	0.1105	2.2753	20.5945
1	2.7500	0.2942	1.4549	0.1153	2.3219	20.1296
1	3.0000	0.2867	1.3400	0.1201	2.3721	19.7457
2	1.2500	0.7962	4.2709	0.1222	2.8371	23.2203
2	1.5000	0.7726	3.5735	0.1326	2.8423	21.4370
2	1.7500	0.7483	3.0776	0.1455	2.9404	20.2154
2	2.0000	0.7241	2.7073	0.1600	3.0887	19.3006

c_0	k	np_1	np_2	h_1	h_2	h_2/h_1
2	2.2500	0.7007	2.4204	0.1757	3.2652	18.5842
2	2.5000	0.6782	2.1917	0.1920	3.4577	18.0067
2	2.7500	0.6567	2.0051	0.2086	3.6588	17.5418
3	1.2500	1.3289	5.3619	0.1535	3.3012	21.5021
3	1.5000	1.2861	4.4884	0.1737	3.4377	19.7861
3	1.7500	1.2410	3.8686	0.2004	3.7086	18.5032
3	2.0000	1.1960	3.4069	0.2319	4.0581	17.4996
3	2.2500	1.1524	3.0499	0.2666	4.4562	16.7139
3	2.5000	1.1108	2.7659	0.3034	4.8848	16.0981
3	3.0000	1.0347	2.3427	0.3802	5.7898	15.2291
4	1.2500	1.9144	6.4164	0.1830	3.7310	20.3858
4	1.7500	1.7779	4.6352	0.2631	4.5224	17.1905
4	2.0000	1.7076	4.0864	0.3195	5.1394	16.0871
4	2.2500	1.6398	3.6632	0.3829	5.8415	15.2549
4	2.5000	1.5756	3.3272	0.4513	6.6026	14.6316
4	2.7500	1.5154	3.0541	0.5229	7.4044	14.1602
4	3.0000	1.4593	2.8278	0.5968	8.2334	13.7962
5	1.2500	2.5369	7.4456	0.2114	4.1387	19.5761
5	1.5000	2.4439	6.2382	0.2620	4.6300	17.6707
5	2.2500	2.1503	4.2664	0.5284	7.4482	14.0965
5	2.5000	2.0609	3.8811	0.6412	8.6527	13.4937
5	2.7500	1.9776	3.5684	0.7613	9.9362	13.0520
6	1.5000	3.0642	7.0879	0.3107	5.2442	16.8779
6	1.7500	2.9323	6.1235	0.4168	6.3319	15.1922
7	1.2500	3.8589	9.4519	0.2667	4.9141	18.4242
7	1.5000	3.7034	7.9258	0.3631	5.8771	16.1849
7	2.0000	3.3714	6.0615	0.6984	9.2171	13.1975
8	1.2500	4.5483	10.4357	0.2942	5.2894	17.9802
8	1.5000	4.3577	8.7545	0.4196	6.5318	15.5666
9	1.2500	5.2521	11.4097	0.3218	5.6598	17.5901
9	1.5000	5.0243	9.5756	0.4805	7.2111	15.0085
10	1.2500	5.9682	12.3753	0.3496	6.0268	17.2398
10	1.5000	5.7010	10.3903	0.5460	7.9172	14.5010
11	1.2500	6.6947	13.3338	0.3778	6.3918	16.9198
11	1.5000	6.3863	11.1997	0.6163	8.6518	14.0375

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