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Quick Switching System with Special Type Double Sampling Plan-2(QSSTDS-2)

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Abstract: *This paper mainly proposes the study on Quick Switching STDS System-2 of QSS (n, kn; c_0) indexed through its OC Curve, Acceptable Quality Level, Limiting Quality Level, Indifference Quality Level and Operating Ratio with suitable illustrations are given for the readymade selection of plan parameters.*

Keywords: *Quick Switching System, Special Type Double Sampling, Acceptable Quality Level, Limiting Quality Level, Indifference Quality Level*

Introduction

Statistical quality control is the application of statistical techniques to measure and evaluate the quality of product, service or process. Quality is defined in many ways from satisfying customer requirements to fitness for use to conformance for the requirements. Acceptance sampling is the process of randomly inspecting a sample of goods and deciding whether to accept the entire lot based on the sample results. Acceptance sampling is an inspection procedure used to determine whether to accept or reject a specific quantity of material.

Quick Switching System

Romboski (1969) has presented extensively a system of immediate switching to tightened inspection when the rejection comes under normal inspection. Quick switching systems (QSS) increase the likelihood of identifying defective products while reducing the number of units to be inspected. QSS for acceptance sampling consist of two sampling procedures plus a set of rules for switching between them. Due to instantaneous switching between normal and tightened plan, this system is referred as "Quick Switching System". Using the concept of Markov chain, the OC function of QSS-1 is derived by Romboski (1969) as

$$P_a(P) = \left(\frac{P_T}{1 - P_N + P_T} \right)$$

Romboski (1969) introduced QSS-1 ***(n; c_N, c_T)*** which is a QSS-1 with single sampling plan as a reference plan [***(n ,c_N)***and ***(n, c_T)*** are respectively the normal and tightened single sampling plans with ***$c_T < c_N$***].

The condition for application of Quick Switching System

(a) A production is steady so that results on current and preceding lots are broadly indicative of a continuing process and submitted lots are expected to be essentially of the same quality.

(b) Lots are submitted substantially in their order of production.

(c) Inspection by attributes is considered with quality defined as fraction non-conforming.

Special Type Double Sampling Plan

In Special Type Double Sampling Plan in which acceptance is not allowed in the first stage of sampling when sampling plans are set for product characteristics that involve costly or destructive testing by attributes, it is usual practice to use a Single Sampling Plan with acceptance number with Ac=0 and Ac=1. But the OC curve for a Single Sampling Plans with Ac=0 and Ac=1 lead to conflict interest between the producer and consumer. Such conflict can be overcome if one is able to design a suitable plan having an OC curve lying between the OC curves of Ac=0 and Ac=1 plans. Govindaraju (1984) has proposed the Special Type Double of Sampling plan procedure. It is valid under general conditions for applications of attributes sampling inspection. However, this plan will specially be useful to product characteristics involving costly or destructive testing.

QUICK SWITCHING SPECIAL TYPE DOUBLE SAMPLING SYSTEM (QSSTDSS) – 2

Quick Switching System (QSS)-2 with Special Type Double Sampling (STDS) plan as reference plan studied through various quality levels and this plan is called as Quick Switching Special Type Double Sampling System (QSSTDSS)-2. Performance measures are indicated for Acceptable Quality Level (AQL), Limiting Quality Level (LQL), Indifference Quality Level (IQL) and Operating Ratio. Under the assumption of Poisson model procedures is constructed, necessary tables and procedure are given for designing the system for various entry parameters. Under this system the special type double sampling plan with (n,c_0) and(kn,c_0), $k>1$ is considered as normal and tightened plan respectively.

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QSSTDSS-2(n, kn; c_0) refers to Quick Switching Special Type Double Sampling System-1 where the normal STDS plan has a sample of size n and tightened STDS plan has a sample of size kn with the acceptance number c0.
The QSS-2 (n, kn; c_0) refers to a Quick Switching System (QSS) where the normal and tightened sampling plans have the same acceptance number but on tightened inspection is a multiple of k ($k \geq 1$) of the sample size on normal inspection.

Advantages of QSS

1. The composite OC curve of QSS-1 is possessive better shape (close to z shape) than the corresponding normal and tightened OC curves.
2. As the tightened becomes severe the composite OC curve approaches to the ideal form.
3. The system result in reduction of sample size then the corresponding reference plan.
4. Confidence in the supplier, normally lots is expected to be essentially of the same quality.
5. The QSS-2 plan has two consecutive tightened inspection hence it has more advantage than the QSS-1 plan.

Operating procedure for QSS-2 ((n, kn; c_0) system

Step 1

From the lot, take a random sample of size '*n*' at the normal inspection level using the STDS plan and count the number of defectives 'd'

If $d \leq C_0$ accept the lot and repeat step 1.
If $d > C_0$ reject the lot and go to step 2.

Step 2

From the next lot, take a random sample of size 'kn' at the tightened inspection level using the STDS plan and count the number of defectives'd'.

1. If $d \leq c_0$ accept the lot and continue the tightened inspection until two consecutive lots are to be accepted then go to step-1 otherwise continue step 2.
2. If $d > c_0$ reject the lot and repeat step 2.

Romboski (1969) has also made certain modification and studied the merits and demerits of switching rules of QSS when it is compared with two-plan system (m,d). The rule of QSS is retained at m=1 where as tightened rule is made when d>1.

Operating Characteristic Function

Govindaraju (1984), based on Romboski (1969) has derived the expression for OC function of QSSTDSS-2 of (n, k_n, c_o) is given by

$$P_a(P) = \frac{P_N P_T^2 + p_T(1-p_N)(1+P_T)}{P_T^2 + (1-P_N)(1+P_T)} \qquad (1)$$

Where,

$$P_N = \frac{P_r(X \leq u_1)}{\left[1 - p_r(X \leq u_2) + P_r(X \leq u_1)\right]} \qquad (2)$$

$$P_T = \frac{P_r(X \leq v_1)}{\left[1 - p_r(X \leq v_2) + P_r(X \leq v_1)\right]} \qquad (3)$$

Measures of performance of QSSTDSS-2(n.kn;c_0)

The OC function is given by where the values of PN and PT are defined below:
P_N: Proportion of lots expected to be accepted when using normal Special Type Double Sampling plan(n;c0)
P_T: Proportion of lots expected to be accepted when using tightened Special Type Double Sampling plan(kn,c0)Plotting the OC curve
The following figure shows the OC curve for the Quick Switching Special Type Double Sampling System (QSSTDSS)-2

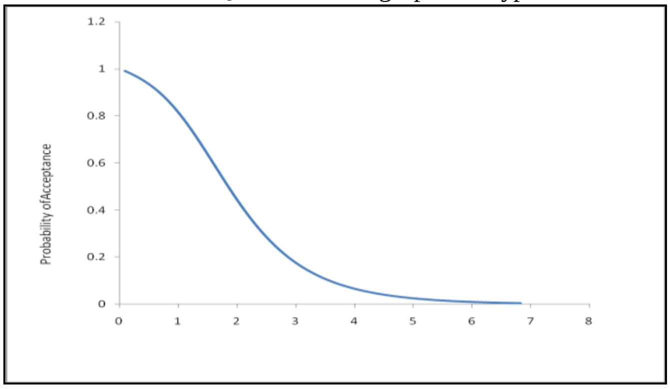

Figure1: Operating Characteristic curve for QSSTDSS-2

Designing QSSTDSS-2 for different parameters Plotting the OC curve

The OC curve for a QSSTDSS-2 can be constructed using table 1. This can be done by dividing each entry for the given values by the values of sample size n. The result of each division is the number of nonconformities per unit for which the probability of acceptance is shown in the column heading.

L(p)	*0.99*	*0.95*	*0.90*	*0.50*	*0.10*	*0.05*	*0.01*
p	*3.361*	*4.131*	*5.148*	*5.844*	*7.532*	*8.23*	*10.017*

For example, with n = 35, c_0 = 6, ϕ = 0.5 and k = 1.5 division of each of the entries in the row of table 1 by 35 leads to the value given in the following table for plotting the OC curve of QSSTDSS-1 (35; 53, 6).

Designing systems given p_1,p_2, α, β

Table 2 can be used to design QSSTDSS-2 (n;k_n,c_0) for given p_1, **α;**.p_2 and **β** by the following steps:

1. Find the value of p_2/ p_1
2. Determine the value of p2/ p1 in Table 2 in the column for appropriate α and β that is closer to the computed p_2/ p_1
3. Fix the values of c_0,k_n and ϕ corresponding to the ratio located.
4. Corresponding to the selected c0,kn and ϕ from Table 2 find the value of np_1.
5. The sample size of the system is found by dividing np_1 by p_1.

Example

To obtain QSSTDSS-2 (n.k_n,c_0) for givenp1= 0.02, **α**=0.05, p2 = 0.06 and **β** = 0.10, the following steps are to be followed by

1. Compute p_2/ p_1 = 0.06/0.02 = 3
2. The value of p_2/ p_1 which is nearly equal to 3.0 in Table 4.2 under the column of α=0.05 and β=0.10 is 3.253462
3. The values of c_0 and K_n and corresponding to 3.253462 are c_0=2, k=1 and 0.5.
4. For C_0=2,k=1and=0.5, value of np_1obtained from Table 1 is 1.661.
5. The Sample size is determined as n=np_2/p_1=1.661/0.02=83.05≈83.

Construction of Tables

Under the assumption of Poisson model, the OC function of ***QSSTDSS-2*** is given by

$$P_a(P) = \frac{P_N P_T^2 + p_T(1-p_N)(1+P_T)}{P_T^2 + (1-P_N)(1+P_T)}$$

Where,

$$\begin{aligned} P_N &= e^{-np}(1+np) \\ &= ne^{-np} - (1+np)(ne^{-np}) \\ &= ne^{-np}(-1-np) \end{aligned}$$

and,

$$\begin{aligned} P_T &= e^{-knp}(1+knp) \\ &= kne^{-np}(-1-knp) \end{aligned}$$

For assumed values of Pa(p) of $np_{0.95}$ and $np_{0.10}$ for QSSTDSS-2 are obtained through iteration techniques. Using Pa(p) the operating ratio p_2/p_1 are obtained. Table 1 and 2 were provides various np values for the given c_0,kn, and Pa(p).using table 2 for assumed values of α and β, operating ratio p_2/p_1 is calculated and the values are presented

CONCLUSION

Using acceptance sampling methodologies, the unit's sampling cost and inspection cost are reduced for the manufacturer and the quality of output products are improved. For practical utility of the plan, Poisson unity values have been tabulated for a wider range of plan parameters. The present development would be a valuable addition to the literature and useful device to the quality control practitioners. The concept of this investigation may be assistance to the quality control engineers and plan designers towards the development of further new plans towards maintaining standard in production competency. Further research can be carried out by selecting acceptance sampling plan and their effects of the sampling cost levels to study simultaneously the normal and tightened case of two situation of sample size through Bayesian approach that may be useful for future research

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Table 1 – Probability of acceptance values for QSSTDS-2 plan

c_0	*ϕ*	*k*	*0.99*	*0.95*	*0.75*	*0.5*	*0.1*	*0.05*	*0.01*
1	*0.5*	*1*	*0.357*	*0.653*	*1.225*	*1.794*	*3.84*	*4.692*	*6.586*
1	*0.5*	*1.5*	*0.649*	*0.985*	*1.533*	*2.014*	*3.835*	*4.679*	*6.573*
1	*0.5*	*2*	*0.267*	*0.486*	*0.903*	*1.37*	*3.843*	*4.67*	*6.56*
1	*0.5*	*2.5*	*1.261*	*1.63*	*2.15*	*2.544*	*3.883*	*4.664*	*6.547*
2	*0.5*	*1*	*1.119*	*1.661*	*2.539*	*3.264*	*5.404*	*6.297*	*8.329*
2	*0.5*	*1.5*	*1.519*	*2.069*	*2.879*	*3.508*	*5.42*	*6.291*	*8.317*
2	*0.5*	*2*	*1.909*	*2.456*	*3.217*	*3.782*	*5.465*	*6.292*	*8.304*
2	*0.5*	*2.5*	*2.287*	*2.828*	*3.553*	*4.072*	*5.551*	*6.311*	*8.291*
3	*0.5*	*1*	*1.516*	*2.118*	*3.024*	*3.718*	*5.611*	*6.416*	*8.336*
3	*0.5*	*1.5*	*1.931*	*2.531*	*3.373*	*3.989*	*5.67*	*6.43*	*8.324*

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3	0.5	2	2.333	2.925	3.719	4.28	5.773	6.468	8.314
3	0.5	2.5	2.708	3.303	4.061	4.583	5.921	6.543	8.307
4	0.5	1	1.92	2.561	4.152	4.941	5.875	6.598	8.383
4	0.5	1.5	2.341	2.977	3.468	4.445	5.984	6.649	8.377
4	0.5	2	2.75	3.375	4.192	4.752	6.137	6.739	8.378
4	0.5	2.5	3.146	3.758	4.541	5.066	6.33	6.871	8.392
5	0.5	1	2.463	3.228	4.318	5.108	7.124	7.952	9.944
5	0.5	1.5	2.92	3.671	4.684	5.395	7.207	7.985	9.934
5	0.5	2	3.362	4.093	5.046	5.699	7.333	8.046	9.929
5	0.5	2.5	3.787	4.499	5.404	6.013	7.499	8.145	9.929
6	0.5	1	2.905	3.691	4.774	5.537	7.404	8.16	10.017
6	0.5	1.5	3.361	4.131	5.148	5.844	7.532	8.23	10.017
6	0.5	2	3.802	4.554	5.516	6.162	7.703	8.338	10.027
7	0.5	2.5	3.341	4.139	5.213	6.486	7.711	8.409	10.153
7	0.5	1	3.793	4.577	5.593	6.277	7.879	8.52	10.193
7	0.5	1.5	4.233	4.999	5.376	6.608	8.082	8.669	10.26
7	0.5	2	4.661	5.408	6.337	6.942	8.314	8.853	10.293
8	0.5	2.5	3.769	4.574	5.638	6.359	8.033	8.686	10.341
8	0.5	1	4.218	5.009	6.024	6.697	8.237	8.836	10.418
8	0.5	1.5	4.655	5.431	6.403	7.039	7.723	9.022	10.528
8	0.5	2	5.082	5.84	6.777	7.381	8.724	9.236	11.724
8	0.5	2.5	5.672	5.901	6.984	7.334	8.797	9.941	11.755

Table – 2 Operating Ratio values for QSSTDSS-2 plan

c_0	ϕ	k	p_2/p_1 for α=0.05			p_2/p_1 for α=0.01		
			α=0.05 β=0.10	α=0.05 β=0.05	α=0.05 β=0.01	α=0.01 β=0.10	α=0.01 β=0.05	α=0.01 β=0.01
1	0.5	1	5.880551	7.185299	10.08576	10.7563	13.14286	18.44818
1	0.5	1.5	3.893401	4.750254	6.673096	5.909091	7.209553	10.12789
1	0.5	2	7.907407	9.609053	13.49794	14.39326	17.49064	24.56929
1	0.5	2.5	2.382209	2.86135	4.016564	3.079302	3.698652	5.191911
2	0.5	1	3.253462	3.79109	5.014449	4.829312	5.627346	7.443253
2	0.5	1.5	2.619623	3.040599	4.019816	3.568137	4.14154	5.475313
2	0.5	2	2.225163	2.561889	3.381107	2.862755	3.295966	4.349921
2	0.5	2.5	1.962871	2.231612	2.931754	2.427197	2.75951	3.625273
3	0.5	1	2.649197	3.029273	3.935788	3.701187	4.23219	5.498681
3	0.5	1.5	2.240221	2.540498	3.288819	2.936302	3.329881	4.31072
3	0.5	2	1.973675	2.211282	2.842393	2.474496	2.772396	3.563652
3	0.5	2.5	1.792613	1.980926	2.514986	2.186484	2.416174	3.067578
4	0.5	1	2.294026	2.576337	3.273331	3.059896	3.436458	4.366146
4	0.5	1.5	2.010077	2.233456	2.813907	2.556173	2.840239	3.578385
4	0.5	2	1.81837	1.996741	2.48237	2.231636	2.450545	3.046545
4	0.5	2.5	1.684407	1.828366	2.233103	2.012079	2.184043	2.667514
5	0.5	1	2.206939	2.463445	3.080545	2.892408	3.228583	4.037353
5	0.5	1.5	1.963225	2.175157	2.706075	2.468151	2.734589	3.402055
5	0.5	2	1.791595	1.965795	2.425849	2.181142	2.393218	2.953302
5	0.5	2.5	1.666815	1.810402	2.206935	1.980195	2.150779	2.621864
6	0.5	1	2.00596	2.210783	2.713899	2.548709	2.80895	3.448193

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6	0.5	1.5	1.823287	1.992254	2.424837	2.241	2.448676	2.980363
6	0.5	2	1.69148	1.830918	2.201801	2.026039	2.193056	2.637296
7	0.5	2.5	1.86301	2.03165	2.453008	2.307992	2.516911	3.038911
7	0.5	1	1.721433	1.861481	2.227005	2.077248	2.246243	2.687319
7	0.5	1.5	1.616723	1.734147	2.05241	1.909284	2.047957	2.423813
7	0.5	2	1.537352	1.637019	1.903291	1.783737	1.899378	2.208324
8	0.5	2.5	1.756231	1.898994	2.260822	2.131335	2.30459	2.743699
8	0.5	1	1.64444	1.764025	2.079856	1.952821	2.094832	2.469891
8	0.5	1.5	1.422022	1.661204	1.938501	1.659076	1.938131	2.261654
8	0.5	2	1.493836	1.581507	2.007534	1.716647	1.817395	2.306966
8	0.5	2.5	1.490764	1.68463	1.992035	1.550952	1.752645	2.072461

Table – 3 AQL, LQL and IQL values for QSSTDSS-1 plan

c_0	ϕ	k	np_1	np_2	np_0	OR
1	0.5	1	0.653	3.84	1.794	5.880551
1	0.5	1.5	0.985	3.835	2.014	3.893401
1	0.5	2	0.486	3.843	1.37	7.907407
1	0.5	2.5	1.63	3.883	2.544	2.382209
2	0.5	1	1.661	5.404	3.264	3.253462
2	0.5	1.5	2.069	5.42	3.508	2.619623
2	0.5	2	2.456	5.465	3.782	2.225163
2	0.5	2.5	2.828	5.551	4.072	1.962871
3	0.5	1	2.118	5.611	3.718	2.649197
3	0.5	1.5	2.531	5.67	3.989	2.240221
3	0.5	2	2.925	5.773	4.28	1.973675
3	0.5	2.5	3.303	5.921	4.583	1.792613
4	0.5	1	2.561	5.875	4.941	2.294026
4	0.5	1.5	2.977	5.984	4.445	2.010077
4	0.5	2	3.375	6.137	4.752	1.81837
4	0.5	2.5	3.758	6.33	5.066	1.684407
5	0.5	1	3.228	7.124	5.108	2.206939
5	0.5	1.5	3.671	7.207	5.395	1.963225
5	0.5	2	4.093	7.333	5.699	1.791595
5	0.5	2.5	4.499	7.499	6.013	1.666815
6	0.5	1	3.691	7.404	5.537	2.00596
6	0.5	1.5	4.131	7.532	5.844	1.823287
6	0.5	2	4.554	7.703	6.162	1.69148
7	0.5	2.5	4.139	7.711	6.486	1.86301
7	0.5	1	4.577	7.879	6.277	1.721433
7	0.5	1.5	4.999	8.082	6.608	1.616723
7	0.5	2	5.408	8.314	6.942	1.537352
8	0.5	2.5	4.574	8.033	6.359	1.756231
8	0.5	1	5.009	8.237	6.697	1.64444
8	0.5	1.5	5.431	7.723	7.039	1.422022
8	0.5	2	5.84	8.724	7.381	1.493836
8	0.5	2.5	5.901	8.797	7.334	1.490764

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