Designing of skip-lot sampling plan of type SkSP-R with multiple deferred state MDS (0, 1) sampling plan as reference plan

K K Sureshi[1], Lakshmipriya R[2*]

[1]Professor and HOD, [2]Ph.D Research Scholar, Department of Statistics, Bharathiar University, Coimbatore-46, Tamil Nadu, INDIA.
Email: sureshkk1@rediffmail.com, lakshmivaradu77@gmail.com

Abstract   This paper explains the designing procedure for Skip lot-sampling plan of type SkSP-R with Multiple Deferred Sampling plan MDS (0, 1) as reference plan. The tables are constructed for various combinations of parameters involved in SkSP-R with MDS (0, 1) as reference plan to obtain various parameters for designing of sampling plans.
Keywords: Skip lot sampling plans, SkSP-R, multiple deferred state sampling plan, MDS (0, 1), Quality levels.

[*]**Address for Correspondence:**
Dr. Lakshmipriya R. Ph.D Research Scholar, Department of Statistics, Bharathiar University, Coimbatore-46, Tamil Nadu, INDIA.
Email: lakshmivaradu77@gmail.com

Access this article online	
Quick Response Code:	Website: www.statperson.com
	DOI: 06 February 2016

INTRODUCTION

Statistical Quality Control (SQC) is the term used to describe the set of statistical tools used by quality engineers professionals. One of the major areas of Statistical Quality control is Acceptance sampling. Acceptance sampling is a methodology that deals with procedures, by which decision to accept or reject are based on the inspection of samples. Acceptance sampling is "the middle of the road" approach between no inspection and 100% inspection. There are two major classifications of acceptance plans: by attributes and variables. Therefore, there is a chance of rejecting a good lot (Producer's risk) and accepting a bad lot (Consumer's risk). Skip-lot sampling plans are designed to reduce the inspection cost. Under skip-lot sampling inspection, samples may be drawn from only a fraction of the submitted lots. The main purpose of skip-lot sampling plan is to decrease the frequency of sampling inspection and thus reduce the total inspection costs. The Skip-lot sampling plan was initially proposed by Dodge (1955) which requires a single determination or analysis to ascertain the lot acceptability or non-acceptability. Such plans are called Skip-lot sampling plans of type SkSP-1. Perry (1973) has studied the properties of SkSP-2 plan with single sampling plan as the reference plan and also provided operating characteristics for SkSP-2 plan with some selected parameters. Balamurali and Subramani (2012) developed Optimal designing of Skip-lot Sampling plan of type SkSP-2 with Double Sampling plan as the reference plan. Vijayaraghavan (2000) introduced Design and evaluation of skip-lot sampling plans of type SkSP-3 plans and the operating characteristics functions are derived using the Markov chain approach. Recently Balamurali and Chi-Hyuck Jun (2010) developed SkSP-V plan based on the principles of CSP-V plan. Further Kavithamani (2014) has studied SkSP-V with various attribute reference plans towards acceptable and limiting quality levels of inspection lots. Recently, a new type of skip-lot sampling plan called SkSP-R was developed by Balamurali.et.al (2014) based on the principle of continuous sampling procedure and resampling scheme for the quality inspection of continuous flow of bulk products

SKIP LOT SAMPLING PLAN SkSP-R

The SKSP-R plan is a new system of skip lot sampling procedure based on the principle of continuous sampling procedure and resampling scheme for the quality

inspection of continuous flow of bulk products. The SkSP –R plan uses the reference plan which is similar to the SkSP-2 plan of Perry (1973). The operating procedure of SkSP – R plan is as follows.

Operating procedure for SkSP-R plan

The operating procedure of SkSP-R are as follows

1. Begin the procedure with normal inspection by applying specified reference plan (for instance MDS (0,1)). During normal inspection, lots are inspected one by one in order of being submitted.
2. When i consecutive lots are accepted based on the reference plan under normal inspection, discontinue the normal inspection and switch to skipping inspection.
3. During the skipping inspection, inspect only a fraction f of lots selected at random by applying reference plan. The skipping inspection is continued until a sampled lot is rejected.
4. When a lot is rejected, after *s* consecutively sampled lot have been accepted, then go for re-inspection procedure for the immediate next lot as in step (5) given below.
5. During re-inspection procedure, perform the inspection using the reference plan. If the lot is accepted, then continue the skipping inspection. On non-acceptance of the lot, re-inspection is done m times and the lot is rejected if it has been accepted on $(m-1)^{st}$ resubmission.
6. If a lot is rejected on the re-inspection scheme, then we immediately revert to normal inspection.
7. Replace or correct all non-conforming units found with conforming units in the rejected lots.

Operating procedure for MDS(r, b) plan

- For each lot select a sample of n units and test each unit for conformance to specified requirements
- Accept the lot if d (the observed number of observation of defectives) is less than or equal to r, reject the lot if d greater than or equal to r+b.
- If r+1≤d≤r+b, accept the lot if the forthcoming m lots in succession are all accepted.

Operating procedure for MDS (0,1) plan

A multiple deferred State sampling plan of Wortham and Baker (1976) with r=0 and b=1 is operated as follows:

- From each lot, take a random sample of units and observe the non-conforming units d
- If d=0, accept the lot; if d>1, reject the lot. If d=1, accept the lot, provided the forthcoming m_2 lots in succession are all accepted (previous m_2 lots in case of multiple dependent state sampling).

The probability of acceptance based on Poisson model is,

$$e^{-np} + npe^{-np}e^{-npm_2}$$

$P_a(p) =$

The operating characteristic function of MDS(r, b) is as follows

$$P = P_a(p) = P_{a,r}(p) + [P_{a,r+b}(p) - P_{a,r}(p)][P_a(p)]^{m_2}$$

When the parameter r=0, b=1. The probability of acceptance will be

$$e^{-np} + npe^{-np}e^{-npm_2}$$

$P_a(p) =$

Operating procedure for SkSP-R with Multiple Deferred Sampling plan MDS (0,1) as reference plan

Step 1: Begin the procedure with normal inspection following the procedure of Multiple Deferred State Sampling plan MDS (0,1) as the reference plan. During normal inspection, lots are inspected one by one in order of being submitted satisfying the conditions of MDS (0, 1).

Step 2: From each lot submitted for inspection, take a random sample of size n and measure the number of defectives d. If d=0, accept the lot; if d>1, reject the lot. If d=1, accept the lot, provided the forthcoming m lots in succession are all accepted (previous m lots in case of multiple dependent state sampling).

Step 3: When i consecutive lots are accepted based on the reference plan under normal inspection, discontinue the normal inspection and switch to skipping inspection. During the skipping inspection, inspect only a fraction f of lots selected at random by applying Multiple Deferred Sampling plan MDS (0, 1) as the reference plan. The skipping inspection is continued until a sampled lot is rejected.

Step 4: When a lot is rejected, after s consecutively sampled lot have been accepted, then go for re-inspection procedure for the immediate next lot as in step (5) given below.

Step 5: During re-inspection procedure, perform the inspection using the reference plan. If the lot is accepted, then continue the skipping inspection. On non-acceptance of the lot, re-inspection is done m times and the lot is rejected if it has been accepted on $(m-1)^{st}$ resubmission. If a lot is rejected on the re-inspection scheme, then we immediately revert to normal inspection. Replace or correct all non-conforming units found with conforming units in the rejected lots.
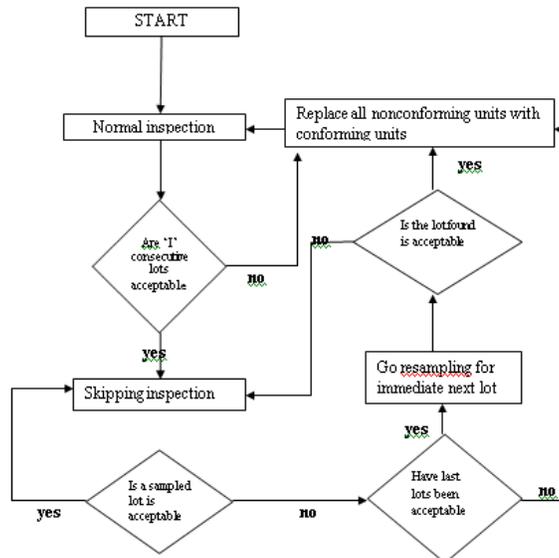
Figure 1: Flowchart for SkSP-R plan

Designing of SkSP-R with MDS (0,1) through acceptable and limiting quality level

The procedure for designing SkSP-R with MDS (0,1) as reference plan indexed through Acceptable and Limiting Quality Level is drawn and Tables are simulated for various combinations of parameter values n, i, s, f,m_1,m_2 and k using MS- Excel Software.

Construction of tables

The operating characteristic function $P_a(p)$ to SkSP-R sampling plan with Multiple Deferred Sampling plan as reference plan [MDS (0, 1)] as reference plan is given as:

$$P_a(p) = \frac{fP + (1-f)P^i + (P^i - P)(1 - Q^{m_1})}{f(1-p^i)[1 - P^s(1 - Q^{m_1}) + P^i(1 + fPQ^s)]}$$

Where, P is the probability of acceptance for reference plan and Q=1-P. The reference plan is Multiple Deferred State Sampling Plan with parameters fixed as r = 0, b = 1. The Operating Characteristic function of MDS (0,1) is

$$P_a(p) = e^{-np} + np\ e^{-np}e^{-npm_2}$$

Designing plans for given AQL, LQL, α and β

1. Specify p_1 = Acceptable Quality Level at α = 0.05 or 0.01.
2. Specify p_2 = Limiting Quality Level at β = 0.10 or 0.05.
3. Obtain the corresponding ratio OR = p_2 / p_1 at different combination of α and β.
4. Choose a plan having the parameters i and m with nearest OR in the corresponding table.
5. The actual np_1 and np_2 values corresponding to the OR value has been noted.
6. Determine the sample size n= np_1 / p_1 Round up the value for determining the sample size.
7. Thus the plan consists of the parameter n, i, f, m_1, m_2 and s.

Illustration: For given, at α = 0.05, p_1=0.005206 and β = 0.05, p_2=0.03906. Then the Operating Ratio OR= p_2/p_1 = 7.5028. And np_1 value is selected from table 1 as 0.5206 and the corresponding sample size n is computed as n = np_1/p_1 = 0.5206/0.005206, n = 100. Hence the parameters of SkSP-R with Multiple Deferred Sampling Plan indexed through Acceptable and Limiting Quality Levels is n=100, i=1, k=1 m_1 =2 and m_2=1.
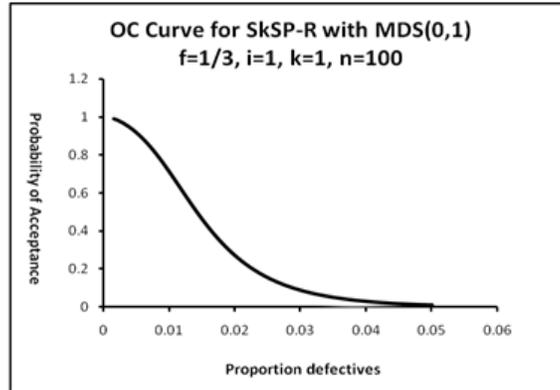
Figure 2: Operating Charateristic Curve for SkSP-R Sampling Plan with MDS (0,1) through specified parametric values
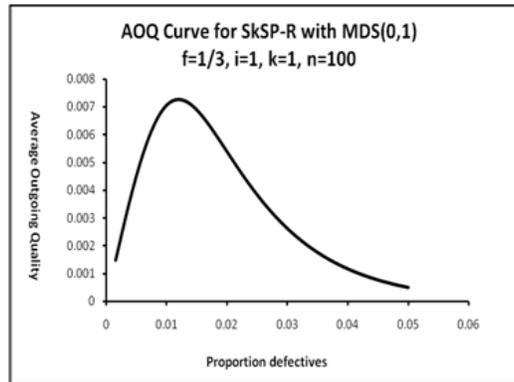

Figure 3: Average Outgoing Quality Curve for SkSP-R Sampling Plan with MDS (0,1) through specified parametric values

Table 1: Table for unity values and Operating Ratio for SKSP –R with MDS(0,1) as the reference plan

f	i	K	m_1	m_2	0.99	0.95	0.9	0.5	0.1	0.05	0.01	OR(0.99,0.01)	OR(0.95,0.05)
1/3					0.1593	0.3998	0.5896	1.4402	2.8801	3.5003	4.9648	31.1682	8.75453
1/5	1	2	2	1	0.2131	0.5206	0.7506	1.7163	3.3065	3.9606	5.4679	25.6567	7.60706
1/7					0.251	0.6181	0.8676	1.917	3.6004	4.2728	5.8022	23.1163	6.91289
2/5					0.1421	0.3566	0.5371	1.351	2.7347	3.3408	4.787	33.6928	9.36817
2/7					0.171	0.4292	0.6359	1.5191	3.0059	3.6372	5.116	29.9181	8.47414
	1				0.111	0.2786	0.4268	1.1467	2.4215	3.0133	4.4005	39.6442	10.8155
	2				0.111	0.2786	0.4158	1.0121	2.0868	2.6194	3.9994	36.0306	9.40165
3/5	3	3	2	1	0.111	0.2786	0.4064	0.9472	2.0303	2.5765	3.9872	35.9211	9.24758
	4				0.111	0.2786	0.401	0.9401	2.0295	2.5763	3.9872	35.9209	9.24682
	5				0.111	0.2744	0.3968	0.9377	2.0293	2.5762	3.9872	35.9209	9.38899
		1			0.171	0.4174	0.5824	1.118	2.0926	2.6155	3.9967	23.3724	6.26566
		2			0.171	0.406	0.5532	1.0757	2.0604	2.5901	3.988	23.3217	6.37927
2/7	3	3	2	1	0.171	0.3969	0.5367	1.0593	2.0553	2.5878	3.9879	23.3209	6.5193
		4			0.171	0.3903	0.5259	1.052	2.0544	2.5876	3.9879	23.3209	6.62964
		5			0.171	0.3853	0.5184	1.0486	2.0542	2.5876	3.9879	23.3209	6.71522
			1		0.2035	0.3955	0.4983	0.9051	1.9621	2.5366	3.9758	19.541	6.41345
			2		0.2113	0.4376	0.5535	0.9791	2.0236	2.5744	3.987	18.8663	5.88352
1/5	5	2	3	1	0.2117	0.4489	0.574	1.0273	2.0676	2.6079	3.9964	18.8812	5.80985
			4		0.2117	0.4514	0.5805	1.0583	2.1112	2.6381	4.0053	18.922	5.84447
			5		0.2117	0.4519	0.5805	1.0777	2.1487	2.6654	4.014	18.963	5.89851
				1	0.1416	0.3296	0.4463	0.9118	2.0169	2.5719	3.9867	28.146	7.802
				2	0.1103	0.261	0.356	0.7547	1.8245	2.4111	3.9093	35.4479	9.23929
2/5	5	3	2	3	0.0931	0.2239	0.3103	0.6846	1.7854	2.3937	3.9067	41.9519	10.6922
				4	0.0862	0.2033	0.2823	0.6478	1.7777	2.392	3.9065	45.3156	11.7642
				5	0.0731	0.189	0.2632	0.6273	1.776	2.3919	3.9065	53.4406	12.6539

CONCLUSION

This paper provide a new procedure has been evolved involving two methodologies namely Skip-lot Sampling Plan of type SkSP-R and Multiple Deferred Sampling plan MDS (0,1) as reference plan. This plan evolves the Acceptable Quality Level (AQL), Limiting Quality Level (LQL) and Operating Ratio has been studied. Under Skip-lot sampling inspection, samples may be drawn from only a fraction of the submitted lots. The main purpose for Skip-lot sampling is to decrease the frequency of sampling inspection and reduce the total inspection costs.

REFERENCES

1. ASLAM, M., BALAMURALI, S., JUN, C. H. AND AHMAD, M. (2010): Optimal designing of a Skip lot Sampling Plan by two point method, Pakistan Journal of Statistics, Vol.26, No.4, pp.585-592.
2. BALAMURALI, S. AND SUBRAMANI, J. (2012): Optimal designing of Skip-lot Sampling plan of type SkSP-2 with double sampling plan as the reference plan, Journal of Statistical Theory and Practice, Vol.6, pp.354-36
3. DODGE, H.F. (1955): Skip-lot Sampling Plan, Industrial Quality control, Vol.11, No.5, pp.3-5.
4. PERRY, R.L. (1973): Skip-lot Sampling Plans, Journal of Quality Technology, Vol.5, No.3, pp.123-130.
5. BALAMURALI, S., ASLAM, M. and JUN, C.-H. (2014), A new system of product inspection based on skip-lot sampling plans including resampling, The Scientific World Journal pp. 1–6. ID 192412.
6. VIJAYARAGHAVAN, R (2000): Design and evaluation of skip-lot sampling plans of type SkSP-3, Journal of Applied Statistics, Vol. 27, No. 7, p. 901-908.
7. KAVITHAMANI. M (2014): Designing on System of Skip Lot Sampling Plan with Different Attribute Reference Plans, Ph.D. Thesis, Bharathiar University, Coimbatore, India.
8. WORTHAM.A.W and BAKER, R.C., (1976): Multiple Deferred State Sampling Inspection" The International Journal of Production Research. Vol.14, No.6, pp.719-731.