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SELECTION OF SKIP-LOT SAMPLING PLAN OF TYPE SKSP-R INDEXED THROUGH QUALITY REGIONS

[1]V.Sangeetha,[2]K.Bhuvaneswari,

[1]Assistant Professor, [2]Research Scholar,
[1]Department of Statistics,
[1]PSG College of Arts & Science, Coimbatore, Tamilnadu, India.

Abstract : In this article, we propose the optimal designing methodology to determine the parameters of a skip-lot sampling plan of type SkSP-R plan with single sampling plan as the reference plan. The main shove of this paper is to account for the possibility of dependence among the items of a sample. The development of quality by invoking a novel approach called Quality regions. Maximum Allowable Percent Defective (MAPD) is also considered for the selection of parameters for Skip-lot sampling plan. New quality descriptors called Operating ratios are introduced to design the sampling plan**..**

Keywords– Skip-lot sampling plan (SKSP-R), Quality Decision Region, Probabilistic Quality region, Limiting Quality Region, Indifference Quality Regions

I. INTRODUCTION

Acceptance Sampling is a method used in the industry for quality control. This method uses statistical sampling to inspect or test a random sample for determining whether the quality of a batch of product or service is acceptable or not. According to Schilling (1982) "In a very real sense, the goal of acceptance sampling is reduce the need for acceptance sampling". The acceptance sampling Plan used in group of productive enterprises (or) organizations that produce (or) supply goods, services, (or) sources of income. Acceptance sampling is a statistical measure used in quality control. It allows a company to determine the quality of a batch of products by selecting a specified number of testing. The quality of this designated sample will be viewed as the quality level for the entire group of products. The skip lot sampling plan (SkSP) prepared a smaller sample size for the inspection purpose to the single sampling plan. Skip lot sampling plan used in industries to reduce the inspection cost. While the inspection is successful for the purpose of acceptance or rejection of a product.

The acceptance sampling technique helps business ensure that only high quality goods are offered to customers, increasing customer satisfaction & market base. The skip-lot sampling methodology was advanced from the continuous sampling plan. Dodge and Perry (1971)[2]well established the operation of skip lot sampling plan. 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 andSubramani (2012) developed Optimal designing of skip lot sampling plan of type SkSP2 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. Kavithamani (2014) has studied SkSP-V with various attribute reference plans towards acceptable and limiting quality levels of inspection lots. 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. Parker and Kessler(1981) had the extant form of skiplot sampling plan -2 and the principles in which at least one lot is consistently sampled from a construction of lot.Vijayaraghavan (1990) described the skip-lot sampling plan 3 which is also extension of skip-lot sampling plan 2. The acceptance sampling disadvantages are that the sample size is very small compared to the lot size, so it becomes difficult to identify whether the method is appropriate for the case. Perry studied the properties of SkSP-2 plan with SSP as the reference plan. Many authors carried out their research in SkSP with various aspects which can be seen in Parker and Kessler, Liebesman and Saperstein Vijayaraghavan, Vijayaraghavan and Soundararajan, Aslam et al. Balamurali et al. Balamurali and Jun, Balamurali and Subramanian Ayudthya. Balamurali and Usha extended the concept of Resampling scheme for variables inspection. The SkSP-R plan is a new system of skip lot sampling procedure based on the continuous sampling procedure and Resampling scheme for the quality inspection of continuous flow of bulk products.

2. Review of the Sampling Plan

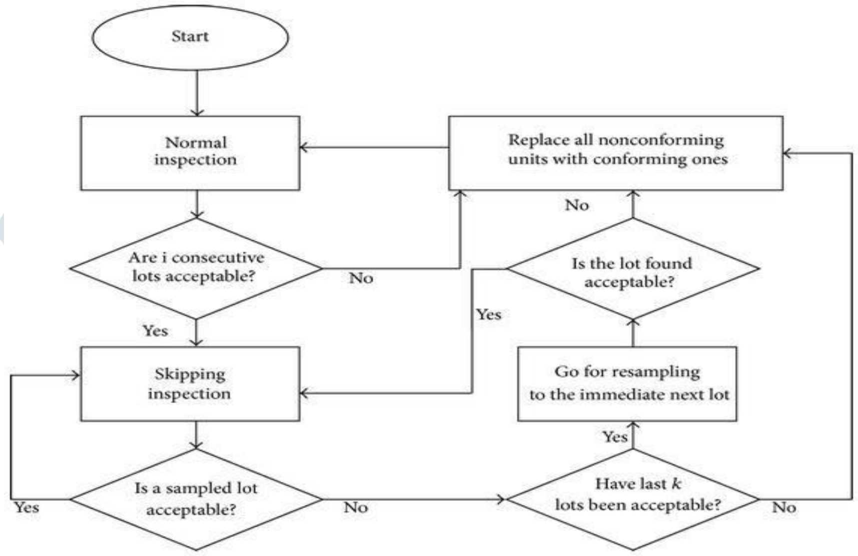
2.1 Operating Procedure for SkSP-R plan The operating procedures of SkSP-R are as follows.

The SKSP-R plan is a new system of skip lot sampling procedure, based on the principles of continuous sampling plans and Resampling scheme for the quality inspection of continuous flow of bulk products. The SkSP-R plan uses the reference plan similar to the SkSP-2 plan of Perry.

The operating procedure of the SkSP-R plan is as follows, which is extension to the one in Balamurali and Jun.

1. Start with the normal inspection using the reference plan. During the normal inspection, lots are inspected one by one in the order of being submitted.
2. When 'i' consecutive lots are accepted on the normal inspection, discontinue the normal inspection and switch to the skipping inspection.
3. During the skipping inspection, inspect only a fraction f of lots selected at random. The skipping inspection is continued until a sampled lot is rejected.
4. When a lot is rejected after k consecutive sampled lots have been accepted, then go for resampling procedure for the immediate next lot as in step 5 given below.
5. During resampling procedure, perform the inspection using the reference plan. On nonacceptance of the lot, resampling is done for m times and the lot is rejected if it has not been accepted on (m-1)st resubmission.
6. If a lot is rejected on resampling scheme, then immediately revert to the normal inspection in step1.
7. Replace or correct all the non conforming units found with conforming units in the rejected lots.

The operation of the proposed plan is depicted by a flow diagram



The proposed plan involves the reference plan and four parameters, namely, f(0 < f < 1), the fraction of lots inspected in skipping inspection , k, the clearance number of sampling inspection , and, m, the number of times the lots are submitted for resampling. In general, i, k, and m are positive integers. So, the plan is designated as SkSP-R (f, i, k, m). Govindaraju and Ganesalingam recommended the use of m=2 for their sampling plan.

3 Selection of Sampling plan with Quality Intervals

3.1 Quality Decision Region (QDR)

This is an interval of quality ($p_1<p<p_*$) in which product is accepted at Engineer's quality average. The quality is maintained up to p*. (MAPD) and sudden decline in quality is expected. This region is also called Reliable Quality Region (RQR).

Quality decision Range denoted as d1= ($p_*- p_1$) is derived from probability of acceptance with

$$P_a(p_1 < p < p_*) = P_a(P) = \frac{fP+(1-f)P^{i+fP^k}(P^i-P)(1-Q^m)}{f(1-P^i)\left[1-P^{k(1-Q^m)}\right]+P^i(1+fQP^k)} \text{ for } p_1 < p < p_*$$

3.2 Probabilistic Quality Region (PQR)

This is an interval of quality ($p_1 < p < p_2$) in which a product is accepted with a minimum probability 0.10 and maximum probability 0.95. Probabilistic Quality Range denoted as $d_2= (p_2- p_1)$ is derived using the probability of acceptance expression.

$$P_a(p_1 < p < p_2) = P_a(P) = \frac{fP+(1-f)P^{i+fP^k}(P^i-P)(1-Q^m)}{f(1-P^i)\left[1-P^{k(1-Q^m)}\right]+P^i(1+fQP^k)} \text{ for } p_1 < p < p_2$$

Where $e^{-np}+npe^{-np}e\text{-}^{npm}{}_{2p}$, Where P is the operating characteristic function of quality intervals $d_1 < d_0 < d_3 < d_2$.

3.3 Limiting Quality Region (LQR)

It is an interval quality (($p_* < p < p_2$) in which product is accepted with a minimum probability 0.10 and maximum probability 0.95. Limiting Quality Range denoted as $d_3=(p_2-p_*)$ is derived from t he average probability of acceptance

$$P_a(p_1< p<p_2)=P_a(P) = \frac{fP+(1-f)P^{i+fP^k}(P^i-P)(1-Q^m)}{f(1-P^i)\left[1-P^{k(1-Q^m)}\right]+P^i(1+fQP^k)} \text{ for } p_*< p < p_2$$

3.4 Indifference Quality Region(IQR

It is an interval quality (($p_1<p<p_0$) in which product is accepted with a minimum probability 0.50 and maximum probability 0.95. Indifference Quality Range denoted as $d_0=(p_0-p_1)$ is derived from the average probability of acceptance

$$P_a(p_1< p<p_0)=P_a(P) = \frac{fP+(1-f)P^{i+fP^k}(P^i-P)(1-Q^m)}{f(1-P^i)\left[1-P^{k(1-Q^m)}\right]+P^i(1+fQP^k)} \text{ for } p_1< p < p_0$$

4. Construction of Tables

4.1 Operating characteristic curve for SkSP-R sampling plan with SSP as reference plan through specified parametric values with construction of Tables

The probability of acceptance for skip lot sampling plan R with single sampling plan as reference plan to obtain various parameters for indexed through Quality intervals.

$$P_a(p_1< p<p_*)=P_a(P) = \frac{fP+(1-f)P^{i+fP^k}(P^i-P)(1-Q^m)}{f(1-P^i)\left[1-P^{k(1-Q^m)}\right]+P^i(1+fQP^k)} \text{ for } p_1< p < p_*$$

Where $e^{-np}+npe^{-np}e^{-npm}{}_2$, The Operating Characteristic Values are shown in Table 4.1. and the Parametric values of Quality interval values are in the table 4.2 . The Operating ratio for the selection of sampling plan are given in Table 4.3
For example when n=100, f=1/2, i= 1, k=1, m=1,c=1 each of the entries by n and leads to the values given below

Table: 4.1.1Operating characteristic curve for SkSP-R sampling plan with SSP as reference plan

$P_a(p)$	0.99	0.95	0.9	0.5	0.1	0.05	0.01
p	0.980026	0.949171	0.860266	0.500059	0.100921	0.02575	0.01011

Figure: 4.1 Operating characteristic curves for SkSP-R sampling plan with SSP as reference plan

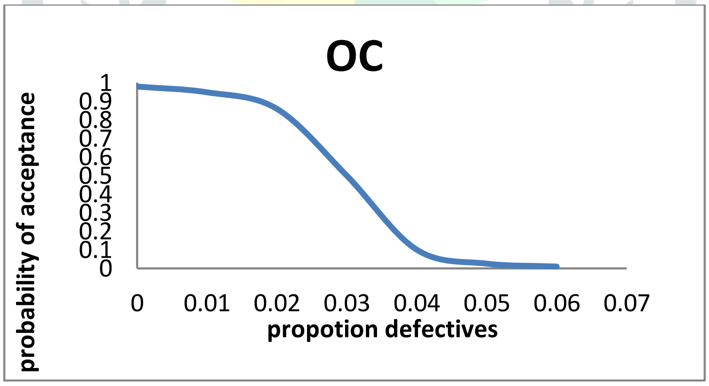
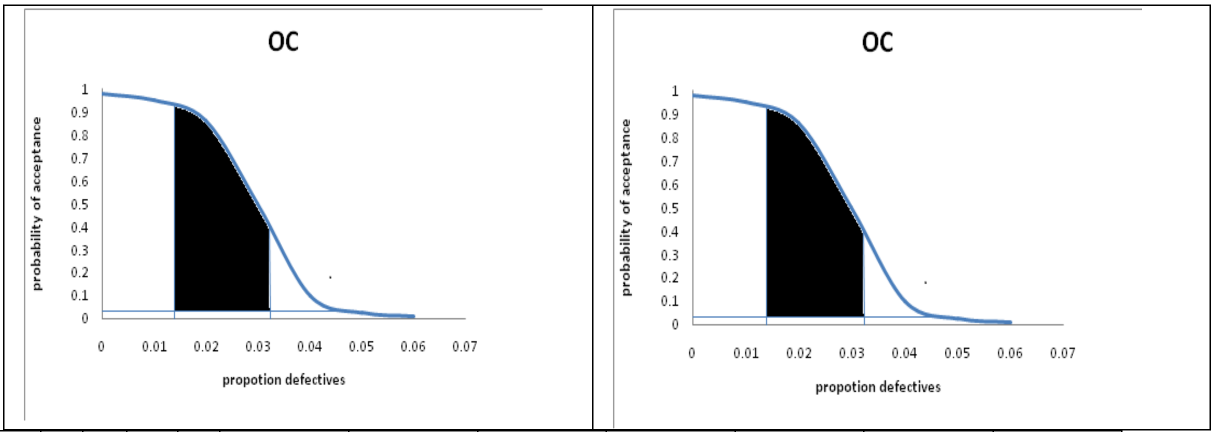


Table 4.1 Operating characteristic curve for SkSP-R sampling plan with SSP as reference plan

F	i	k	m	c	0.99	0.95	0.9	0.5	0.1	0.05	0.01
1/2	1	1	1	1	0.98975	0.94925	0.89954	0.49996	0.100045	0.050355	0.010278
1/3	1	1	1	1	0.666444	0.666222	0.665999	0.500068	0.100836	0.050269	0.010131
1/5	1	1	1	1	0.39992	0.39984	0.399759	0.399679	0.010168	0.05007	0.010664
2/5	1	1	1	1	0.79968	0.799359	0.799038	0.500065	0.100716	0.050113	0.010132
1/5	2	1	1	2	0.39992	0.39984	0.39976	0.39968	0.100721	0.05009	0.010198
1/5	3	1	1	2	0.39992	0.39984	0.399759	0.399679	0.062418	0.027819	0.005448
1/5	4	1	1	2	0.39992	0.399839	0.399757	0.399675	0.099676	0.050101	0.010251
1/5	5	1	1	2	0.399907	0.399741	0.399442	0.39895	0.398204	0.39714	0.395706
1/4	1	1	1	3	0.499875	0.49975	0.499624	0.499491	0.074892	0.186756	0.078145
1/4	1	2	1	3	0.499875	0.49975	0.499624	0.050229	0.100298	0.050737	0.010702

1/4	1	3	1	3	0.499875	0.49975	0.499624	0.499491	0.100561	0.050088	0.010508
1/4	1	4	1	3	0.499875	0.49975	0.499624	0.499401	0.100561	0.050088	0.010508
2/3	1	1	1	4	1.325288	1.321875	0.900053	0.500056	0.100512	0.050391	0.010543

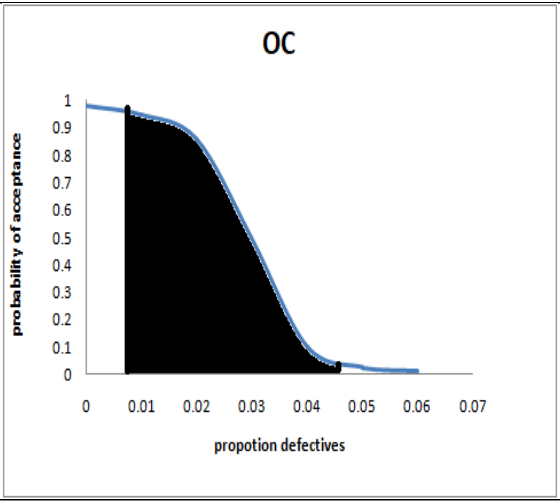


2/3	1	1	2	4	0.98916	0.949552	0.900248	0.500049	0.100713	0.050486	0.010215
2/3	1	1	3	4	0.990031	0.949085	0.900988	0.500295	0.100838	0.05054	0.010146
2/3	1	1	4	4	0.990026	0.949171	0.900266	0.500588	0.100921	0.050575	0.01011
2/3	1	1	5	4	0.990015	0.01011	0.899355	0.500759	0.100977	0.0506	0.01011

Table: 4.2 Certain parametric value of Quality Interval Skip lot sampling plan with SSP Indexed through Quality Region

f	I	k	m	C	d_1	d_2	d_3	d_0
1/2	1	1	1	1	4.8539652	4.059765	4.560785	4.853965
1/3	1	1	1	1	2.657316	6.020235	6.010239	2.657316
1/5	1	1	1	1	1.953E-06	8.382171	8.372173	1.95E-06
2/5	1	1	1	1	2.0071138	4.532956	4.522956	2.007114
1/5	2	1	1	2	5.859E-06	5.307778	5.287784	5.86E-06
1/5	3	1	1	2	1.953E-06	5.881324	5.861326	1.95E-06
1/5	4	1	1	2	1.953E-06	5.242857	5.222859	1.95E-06
1/5	5	1	1	2	0.2042897	7.840353	7.820359	0.20429
1/4	1	1	1	3	0.2042897	7.840353	7.810359	0.20429
1/4	1	2	1	3	8.4501205	7.378698	7.348886	8.45012
1/4	1	3	1	3	0.1998125	7.374353	7.344541	0.199813
1/4	1	4	1	3	0.3998125	7.374353	7.344541	0.399813
2/3	1	1	1	4	4.659844	7.648257	8.913542	4.659844
2/3	1	1	2	4	1.7127456	4.541288	8.917593	1.712746
2/3	1	1	3	4	1.5713155	4.328788	8.919228	1.571316
2/3	1	1	4	4	1.5100988	4.227032	8.921165	1.510099

Figure: 4.2 Operating characteristic curves for SkSP-R sampling plan with SSP as reference plan using quality regions



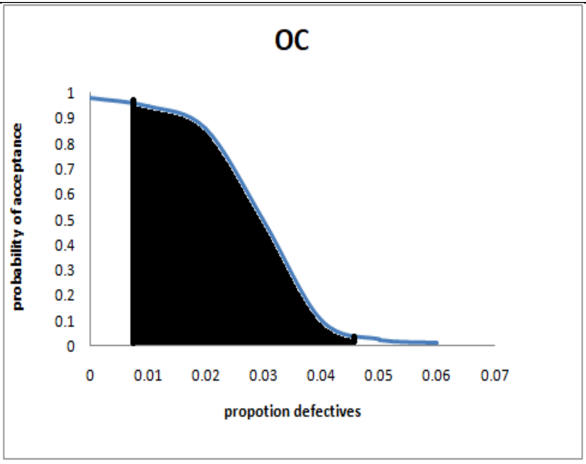


Table: 4.3 Certain values of QDR, PQR, LQR, IQR & Operating characteristics Ratio using Skip lot sampling plan with SSP Selection of the sampling plan

f	i	k	m	c	$T=d_1/d_2$	$T_1=d_1/d_3$	$T_2=d_1/d_0$
1/2	1	1	1	1	1.195627	1.064283	0.9994
1/3	1	1	1	1	0.441397	0.442131	0.9990
1/5	1	1	1	1	0.000233	2.33E-07	0.9989
2/5	1	1	1	1	0.442783	0.443762	0.9987
1/5	2	1	1	2	0.000011	1.11E-06	0.9986
1/5	3	1	1	2	0.000332	3.33E-07	0.9978
1/5	4	1	1	2	0.000373	3.74E-07	0.97997
1/5	**5**	1	1	2	0.026056	0.026123	0.9476
1/4	1	1	1	3	0.026056	0.026156	0.9278
1/4	1	2	1	3	1.145205	1.149851	0.9067
1/4	1	3	1	3	0.027096	0.027206	0.8976
1/4	1	4	1	3	0.054217	0.054437	0.8678
2/3	1	1	1	4	0.609269	0.522782	0.8596
2/3	1	1	2	4	0.37715	0.192064	0.8356
2/3	1	1	3	4	0.362992	0.176172	0.8282
2/3	1	1	4	4	0.357248	0.169271	0.8098

Conclusions

In this article we have developed tabled and designing methodology for selecting the parameters of a system of skip-lot sampling plan of type sksp-R with single sampling plan as the reference plan under the conditions of Quality regions. The approach of two points on the OC curve is adopted to find the design parameters of proposed plan.In this proposed plan is useful in reducing the cost and the time of the inspection of the material or the product where skiplot sampling is used.

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