DESIGNING AND EVALUATION OF SKIP-LOT SAMPLING PLAN OF TYPE SkSP-T WITH SINGLE SAMPLING PLAN AS REFERENCE PLAN UNDER THE CONDITION OF INTERVENED POISSON DISTRIBUTION

S. Suganya
•
Assistant Professor,
Department of Statistics,
PSG College of Arts & Science,
Coimbatore, Tamil Nadu, India
suganyas@psgcas.ac.in

K. Pradeepa Veerakumari
•
Assistant Professor,
Department of Statistics,
Bharathiar University,
Coimbatore, Tamil Nadu, India
pradeepaveerakumari@buc.edu.in

Abstract

This paper describes the scheming technique of new system of skip lot sampling plan of type SkSP-T with Single Sampling Plan as Reference plan under the condition of Intervened Poisson Distribution. The designing methodology includes the evaluation of Acceptable Quality Level, Limiting Quality Level, Operating Ratio, and Operating Characteristic curves. Tables are simulated by changing various parametric values of SkSP-T, SSP and IPD and operating characteristic curves are drawn by using R language.

Keywords: Skip-lot sampling plan of type SkSP-T, Intervened Poisson Distribution, Single Sampling Plan.

I. Introduction

Maintenance of quality is decided to improve the production. Good qualities of products facilitate to reduce both producer and consumer risks. Additionally, it manages the production cost and consumer satisfaction. The determination of designing every sampling method is to find out a succession of the process to be tested in a sequence of lots is defined the quality. Statistical Quality control (SQC) is one of the processing techniques throughout that the production quality is sustained and too reduced the production errors. Every quality control technique defines the defective items and the defective items are replaced by good once. Acceptance sampling (AS) is one of the imperative method used in SQC through judgment a lot concerning its quality of 100% inspection and no inspection. The major purpose of acceptance sampling is towards constructing a sampling plan that is mainly characterized by sample size (n) and acceptance number(c); also it is able to minimize the inspection cost and sampling error.

The most important areas of Acceptance Sampling plan is classified into four broad categories.

It includes lot-by-lot sampling plan by attribute and by variables, Continuous sampling plan, and special purpose plans. The special purpose plan includes Skip-lot sampling plan. Skip-lot sampling plans are inspected only the fraction of submitted lots. Such process of sampling is in reducing the cost in provisions of minimizing the time and exertion. On the other hand skip-lot sampling supposed to only be used instantaneously, it has been established that the excellent quality of the submitted lots are very good.

Dodge [5] introduced the skip-lot sampling plan of type SkSP-1 based on the concept of continuous sampling plan of type CSP-1. Perry [13] developed some specified level of Operating Ratio (OR) for corresponding producers and consumer's risk, OC and ASN function (operating characteristic) of the SkSP-2 plan using Markov chain techniques. SkSP-3 is based on the concept of Continuous Sampling Pan of type CSP-2 of Dodge and Terry [8]. SkSP-3 is developed by Vijayaraghavan [16] using Markov chain technique. The multilevel continuous sampling plans are derived Lieberman and Solomon[7]. The CSP-T plans are tightened multilevel plans that include three levels developed by Fordice [6]. Kandasamy and Govindaraju [11] developed the performance measures of CSP-T plan. Balamurali [1] developed Modified Tightened Three level Continuous sampling plan. Balamurali and Chi-Hyuck Jun [2] developed a modified CSP-T sampling procedure.

Pradeepa Veerakumari and Suganya [15] introduced Skip-lot sampling plan of type SkSP-T (T-tightened) based on the concept of continuous sampling plan of type CSP-T, CSP-M, MMLP-T-2, and SkSP-2. Sampling levels are fixed by using CSP-M procedure; sampling fractions are taken from the CSP-T procedure and other concepts are taken by modified CSP-T and SkSP-2 procedures. The main advantage of skip-lot sampling plan of type SkSP-T plan if there is a defect found in skipping the level, and then there is a normal inspection in that fraction level. The stopping rule parameter S is introduced for the tightening inspection which makes the plan convenient. In the proposed plan sampling frequency (f) is minimized by every skipping inspection level. The Operating Characteristic functions for this SkSP-T plan are also derived with single sampling plan as the reference plan under the condition of Intervened Poisson Distribution. SkSP-T plan vary among normal inspection and skipping inspection with three levels. Pradeepa Veerakumari and Suganya [23] developed skip-lot sampling plan of SkSP-T based on fuzzy logic techniques. Suganya and Pradeepa Veerakumari [22] developed SkSP-T plan based on Burr type XII distribution.

Shanmugam [18] introduced the Intervened Poisson Distribution which is designated as IPD. It is a moderated adaptation of the zero-truncated Poisson distribution (ZTPD). IPD is compared with ZTPD it concludes that IPD produces good quality of products and provide an additional report about the capability of the intervention made in the manufacturing or production process. It is supportive of accepting the result of the corresponding process. The area of IPD has been applied by various product control, process control, manufacturing industries, biologists, and etc. Much real-time (cholera disease, health improvement for before and after treatment) examples can establish in Shanmugam [18,19]. Huang and Fung [9] developed intervened truncated poisson distribution. In Scollnik [20] introduced the new concept it is called intervened generalized Poisson distribution (IGPD) and it is an extension of IPD. Scollnik [21] developed the Bayesian analysis for IPD using Gibbs sampling approach. Dhanavanthan [3,4] introduced the Compound Intervened Poisson distribution (CIPD) also estimated its characteristic parameters for using the concept of statistical inference and probability. Satheesh and Shibu [17] introduced the modified intervened Poisson distribution (MIPD). MIPD parameters can be estimated by using the method of factorial moment, mixed moment, likelihood estimators and uniformly best estimators. Pradeepa Veerakumari and Azarudheen [14] developed various attribute acceptances sampling plan using SSP under the condition of IPD as a reference plan. Jayakumar and Rehana [10] develop and Characterizations , Different Methods of Estimation and Applications of Exponential Intervened Poisson Distribution. Muhammed Rasheed Irshad et.al [12] developed Intervened Poisson Distribution by Lagrangian Approach.

II. Design of SkSP-T plan and its Operating Characteristic function

Operating procedure of the SkSP-T plan is stated as follows:
Step1: Initiate SkSP-T procedure with normal inspection using the single sampling plan as a reference plan under the condition of Intervened Poisson Distribution.
Step2: When i successive lots are received on normal inspection, terminate the normal inspection and change to skipping inspection.
Step3: On skipping inspection, inspect only a fraction f of the lots selected at random, level 1.
Step4: After i consecutive lots in succession have been founded without a non-conforming at level 1, the system then switches to skipping inspection with a fraction of f/2, level 2.
Step5: After i consecutive lots in succession have been founded without a non-conforming at level 2, the system then switches to skipping inspection with a fraction of f/4, level 3.
Step6: If a non-conforming lot is found on either skipping level, the system reverts to normal inspection.

The Operating Characteristics Function of SkSP-T plan is given by

$$P_a(p) = \frac{P^i(f_2 f_3(1-P^i)+f_1 f_3 P^i(1-P^i)+f_1 f_2 P^{2i})}{f_1 f_2 f_3(1-P^i)+P^i(f_2 f_3(1-P^i)+f_1 f_3 P^i(1-P^i)+f_1 f_2 P^{2i})} \tag{1}$$

III. Origin of Intervened Poisson Distribution (IPD)

Let us consider the number of defectives in a lot as Y_1. Implementation of, the number of defectives in a lot produced as of a progression in no way to be perfect due to random inconsistency, which implies the event $Y_1 > 0$. Y_1 is a random variable and it is an infrequent event. Then the zero-truncated Poisson distribution with pdf is

$$P(Y_1 = y_1) = \frac{\theta^{y_1}}{(e^{\theta}-1)y!}; y_1 = 1,2, \dots \tag{2}$$

Where θ>0 is called incidence parameter. The above equation can be used this example if the manufactures make any modification in a manufacturing system in order to produce the better quality of products. In this position, $\rho\theta$ can be changed to θ. Where ρ ($\rho \geq 0$) is called an intervention parameter (IP) and Y_2 be the no. of defectives that occurred after modify in the production process. And Y_2 is denoted that a Poisson random variable with mean $\rho\theta$.
A random variable $Y=Y_1+Y_2$ i.e., the total no. of defectives occurred. The random variable Y is formed by Intervened Poisson Distribution with probability function,

$$P(Y = y) = \frac{[(1+\rho)^y - \rho^y]\theta^y}{e^{\rho\vartheta}(e^{\theta}-1)y!}; x = 1, 2 \dots \tag{3}$$

Mean and Variance of the Intervened Poisson Distribution (IPD) is

$$\mu = E(X) = \theta\left[(1+\rho) + \frac{1}{(e^{\theta}-1)}\right] \tag{4}$$

And

$$\sigma^2 = Var(X) = \mu - e^{\theta}\left(\frac{\theta}{e^{\theta}-1}\right)^2 \tag{5}$$

From the Intervened Poisson Distribution (IPD) than the mean (μ) is greater than its variance (σ^2). In equation (2) substitute $\rho = 0$ then the Intervened Poisson Distribution is reduced to zero-truncated Poisson distribution (ZTPD).

The Operating Characteristic function for Single Sampling Plan under the conditions of Intervened Poisson D (θ, ρ) can be defined as,

$$P_a(p) = \sum_{x=1}^{c} P(Y = y|\theta, \rho) = \sum_{y=1}^{c} \frac{[(1+\rho)^y - \rho^y]\theta^y}{e^{\rho\theta}(e^{\theta}-1)y!}$$

Where θ = np and ρ is measured in percentage.

IV. Designing of Single Sampling Plan under the conditions of Intervened Poisson Distribution (IPD)

The attribute Single Sampling Plan for the necessary parameters are sample size (n), acceptance number (c), the lot size (N), the number of defective in the sample (d) and proportion defective (p). In general, then the defective item $d \leq c$ (acceptance number) then the lot will be accepted, otherwise, the lot will be rejected.

The skip-lot sampling plan of type SkSP-T, Single Sampling plan and intervened Poisson distribution parameters are determined with the primary objective to carry out both the consumer's and the producer's risk. Both the risk's can be satisfying the subsequent conditions for the particular strength (p1, α, p2, β),

$$P_a(p_1) = 1 - \alpha$$
$$P_a(p_2) = \beta$$

Where, p_1 = is the proportion defective for that the risk of rejection is to be α

And p_2 = is the proportion defective for that the risk of acceptance to be 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 a different combination of α and β.
4.

V. Numerical Illustration

The following examples to obtain the new system of skip lot sampling plan of type SkSP-T with Single Sampling Plan as reference plan under the conditions of Intervened Poisson Distribution (IPD) for calculating the Probability of Acceptance, Operating Characteristic (OC) Curve, Average Sample Number (ASN), Average Outgoing Quality (AOQ) and Average Total Inspection (ATI). The SkSP-T, SSP, and IPD parameters n – sample size, c – acceptance number, i – clearance interval, f- sampling frequency, N- lot size, p - proportion or fraction defective, P_a (p) - Probability of Acceptance θ - incidence parameter and ϱ - intervention parameter.

In the production process assume there is a 1% of intervention occurred in the experimental session and it is preferred to establish a proposed sampling plan for a certain set of values say, α=0.05, β=0.10 and p_1=0.028741, p_2=0.1428. Then the Operating Ratio OR=p_2/p_1= 0.142879/0.028741 = 4.97. And np_1 value is determined from table 1 as 1.437025 and the corresponding sample size n is computed as n = np_1/p_1 = 1.437025/0.028741= 49.99 ≈ 50. Hence the parameters of SkSP-T with Single Sampling Plan as reference plan under the Condition of Intervened Poisson Distribution indexed through Acceptable and Limiting Quality Levels.

Table 1 considers the new system of skip-lot sampling plan of type SkSP-T with Single Sampling plan as reference plan under the condition of Intervened Poisson Distribution (IPD) parameter values are estimated and derived its Acceptable Quality Level (AQL) and Limiting Quality Level (LQL). And also calculated the Operating Ratio (OR) it explains the ratio of limiting quality level to acceptable quality level. The new proposed plan system is designing several combinations of OC curves for various parameter values of SkSP-T, SSP and IPD.

In Acceptance Sampling plan five important basic measures are defined in ISO standard (2006). The measures of Acceptance Sampling plan is 1. Probability of Acceptance (Pa (p)) 2.Average Sample Number (ASN) 3.Average Outgoing Quality (AOQ) 4.Average Outgoing Quality Limit (AOQL) and 5.Average Total Inspection (ATI).

Figure 1 represents the OC curves for SkSP-T with SSP as reference plan under the conditions of IPD for c and n are fixed and by changing the ϱ values. From this figure conclude that smaller intervention occurs in the production process then the producer's risk will be minimized. Also the acceptance number c = 1 it concludes that proportion defective p is decreases.

From figure 2 for n and ϱ values are fixed and by changing the c values. It concludes that then the probability of acceptance (Pa (p)) is increased although the acceptance number c also increases. Figure 3 design the OC curve for fixed c and ϱ and by changing then n (sample size) values. From this figure denotes then the sample size (n) increases consumers are safeguarded. However, the sample size is smaller the producers are safeguarded.

Figure 4 specifies the OC curve for proposed sampling plan. It is observed that p (proportion defective) increases Pa (p) (Probability of Acceptance) decreases. OC curves specify the manufacturing to the producer's and consumer's quality level. The Characteristic curve is used for the purpose of Probability of Acceptance depends upon the fraction defective and also conclude that the producer risk (α) and consumer risk (β). It concludes that sample size increase, producer risk is maximized and consumer risk minimized. It is the inequity of Sampling Plan between Good lots and Bad Lots.

Table 1: *Optimal parameters of SkSP-T plan with single sampling plan as Reference plan under the condition of Intervened Poisson Distribution (IPD)*

ϱ	i	f_1	f_2	f_3	c	Probability of Acceptance $P_a(p)$							Operating Ratio (OR)		
						0.99	0.95	0.90	0.50	0.10	0.05	0.01	α=0.01 β=0.01	α=0.05 β=0.05	α=0.05 β=0.10
0.01	1	1/2	1/4	1/8	1	0.148	0.624	1.053	3.140	5.711	6.577	8.386	56.662	10.540	9.152
		1/3	1/6	1/12		0.215	0.833	1.356	3.605	6.164	7.022	8.810	40.977	8.4298	7.400
		1/5	1/10	1/20		0.340	1.181	1.804	4.203	6.759	7.593	9.427	27.726	6.4300	5.723
		1/7	1/14	1/28		0.445	1.450	2.127	4.594	7.140	7.985	9.778	21.973	5.5069	4.924
		1/9	1/18	1/36		0.552	1.659	2.387	4.891	7.428	8.251	10.07	18.243	4.9735	4.477
0.05	2	1/2	1/4	1/8	2	0.070	0.297	0.510	1.610	3.014	3.485	4.432	63.314	11.734	10.15
		1/3	1/6	1/12		0.102	0.401	0.668	1.863	3.265	3.734	4.737	46.441	9.3117	8.142
		1/5	1/10	1/20		0.161	0.579	0.898	2.190	3.582	4.034	5.011	31.124	6.9672	6.187
		1/7	1/14	1/28		0.211	0.711	1.066	2.404	3.788	4.241	5.192	24.607	5.9648	5.328
		1/9	1/18	1/36		0.262	0.821	1.205	2.567	3.943	4.383	5.346	20.405	5.3386	4.803
0.10	3	1/2	1/4	1/8	3	0.042	0.182	0.317	1.030	1.972	2.289	2.985	71.071	12.577	10.84
		1/3	1/6	1/12		0.061	0.248	0.415	1.196	2.140	2.456	3.119	51.131	9.9032	8.629
		1/5	1/10	1/20		0.098	0.357	0.563	1.415	2.360	2.666	3.334	34.02	7.4678	6.611
		1/7	1/14	1/28		0.128	0.444	0.672	1.559	2.500	2.810	3.459	27.023	6.3288	5.631
		1/9	1/18	1/36		0.161	0.514	0.762	1.669	2.606	2.907	3.564	22.137	5.6556	5.070
0.15	4	1/2	1/4	1/8	4	0.029	0.127	0.221	0.729	1.418	1.653	2.159	74.448	13.016	11.17
		1/3	1/6	1/12		0.042	0.172	0.289	0.850	1.544	1.779	2.270	54.048	10.343	8.977
		1/5	1/10	1/20		0.068	0.249	0.395	1.009	1.707	1.936	2.436	35.824	7.7751	6.855
		1/7	1/14	1/28		0.089	0.311	0.473	1.116	1.812	2.043	2.531	28.438	6.5691	5.826
		1/9	1/18	1/36		0.112	0.360	0.537	1.195	1.891	2.116	2.610	23.304	5.8778	5.253
0.20	5	1/2	1/4	1/8	5	0.022	0.093	0.164	0.549	1.077	2.261	1.688	76.727	24.312	11.58
		1/3	1/6	1/12		0.028	0.128	0.216	0.641	1.176	1.360	1.753	62.607	10.625	9.188
		1/5	1/10	1/20		0.049	0.186	0.296	0.763	1.304	1.483	1.876	38.286	7.9731	7.011
		1/7	1/14	1/28		0.064	0.232	0.354	0.845	1.386	1.567	1.950	30.469	6.7543	5.974
		1/9	1/18	1/36		0.084	0.269	0.404	0.907	1.447	1.625	2.002	23.833	6.0409	5.379

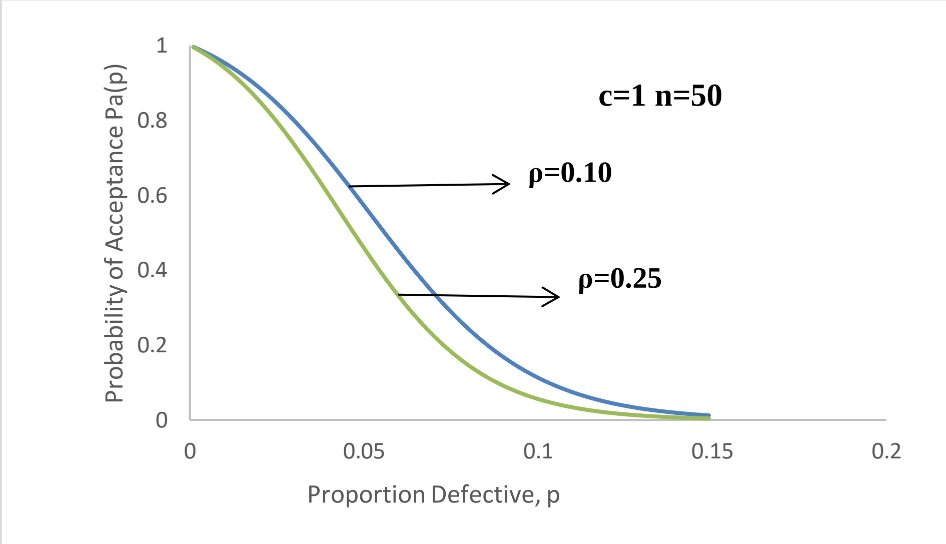

Figure 1: Operating Characteristic Curve for Fixed c and n

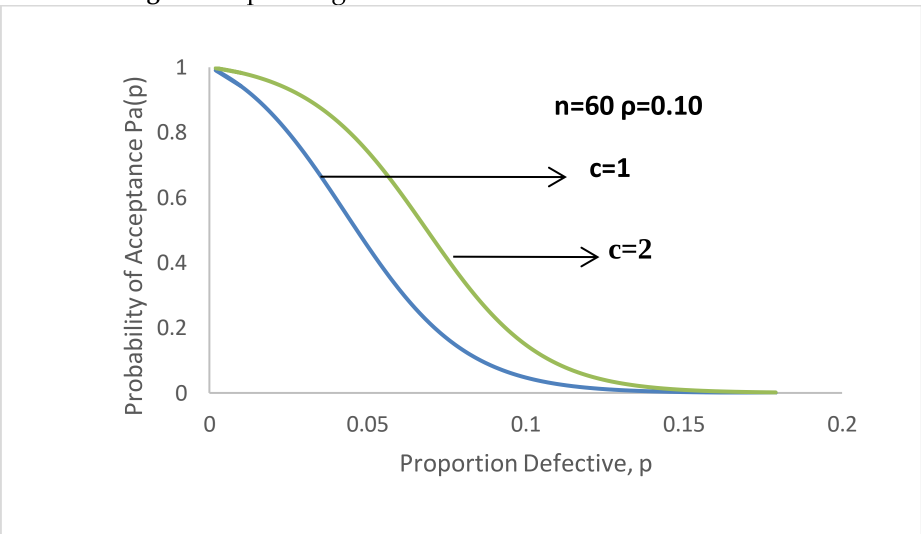

Figure 2: Operating Characteristic Curve for Fixed n and ρ

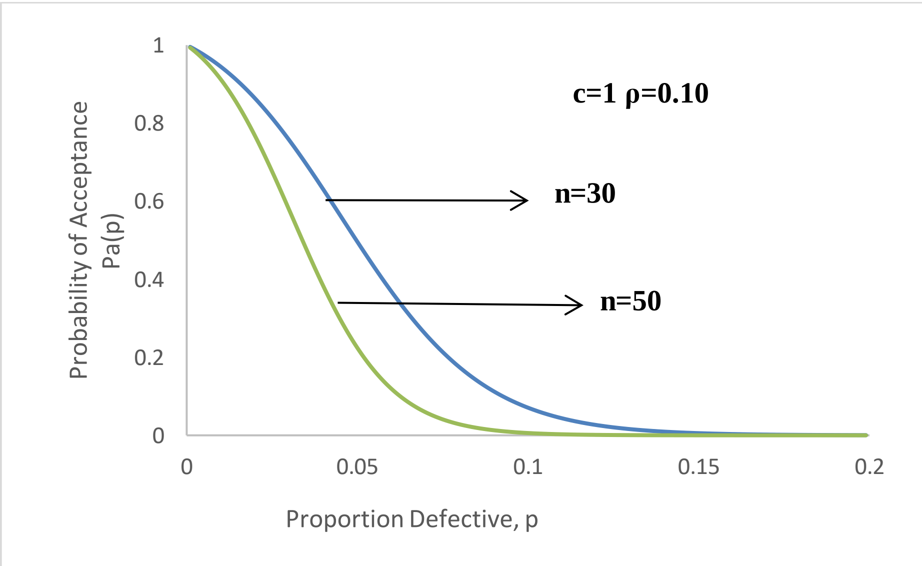

Figure 3: Operating Characteristic Curve for Fixed c and ρ

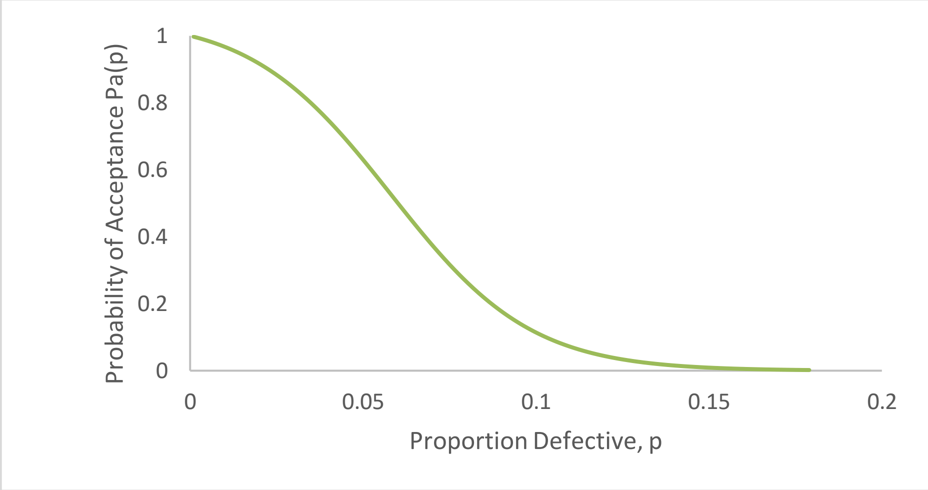

Figure 4: Operating Characteristic Curve for SkSP-T With SSP as reference plan under the condition of IPD

VI. Conclusion

The new proposed skip-lot sampling plan of type SkSP-T with single sampling plan as refence plan under the condition of intervened poisson distribution is apply during the production process to improve the quality of products to produce. The comparison results have specified that the SkSP-T with IPD is more efficient than the conventional sampling plans. The necessary tables and examples are contributed and applied for the formulation of the new proposed sampling plan.

References

[1] Balamurali, S., (2002). "Modified Tightened Three level Continuous sampling plan", Economic Quality Control, Vol. 17, p. 221-234.

[2] Balamurali, S., and Chi-Hyuck Jun, (2004). "Modified CSP-T sampling procedures for continuous production process", Quality Technology and Quantitative Management Vol. 1, No. 2, pp. 175-188.

[3] Dhanavanthan, P. (1998). Compound intervened Poisson distribution, Biometrical Journal 40: pp. 941-946.

[4] Dhanavanthan, P. (2000). Estimation of the parameters of compound intervened Poisson distribution, Biometrical Journal 42: pp. 315-320.

[5] Dodge H.F, (1955). "Skip-Lot sampling plan", Industrial Quality Control, 11(5), pp. 3-5.

[6] Fordice, J.J. (1972). "A Tightened Multi-Level Continuous Sampling Plan CSP-T", Report No.QEM 21230-10, Ammunition Procurement and Supply Agency, Joliety, Illinois.

[7] G. J. Lieberman and H. Solomon (1954). "Multi-level continuous sampling plans," Technical Report No. 17, Applied Mathematics and Statistics Laboratory, Stanford University.

[8] H. F. Dodge and M. N. Torrey (1951). "Additional continuous sampling inspection plans," Industrial Quality Control, Vol. 7 (1951), pp. 7-12.

[9] Huang, M., Fung, K.Y. (1989). Intervened truncated Poisson distribution, Sankhya 51:pp.302-310.

[10] Jayakumar. K and Rehana. C.J. (2022). "Exponential Intervened Poisson Distribution: Characterizations , Different Methods of Estimation and Applications", Journal of the Indian Society for Probability and Statistics, Vol. 24, pp 75-92.

[11] Kandasamy, C. and Govindaraju, K., (1993). "Selection of CSP-T plans", Communication in Statistics - Simulation and Computation, Vol. 22, No.1, pp. 265-283.

[12] Muhammed Rasheed Irshad et.al (2023). "A Novel Flexible Class of Intervened Poisson Distribution by Lagrangian Approach", Stats, Vol.6, pp.150-168.

[13] Perry. R. L, (1973). Skip lot Sampling Plans, Journal of Quality Technology, 5 (3), pp. 123-130.

[14] Pradeepa Veerakumari. K and Azarudheen. S (2016). "Evaluation of Single Sampling plan under the conditions of Intervened Poisson Distribution", Communications in Statistics-Simulation and Computation , pp.1-9

[15] Pradeepa Veerakumari. K and Suganya. S (2016). "A New System of SkSP-T with Single Sampling Plan as Reference Plan", Research Journal of Mathematics and Statistics, Vol.4 (4), 1-6.

[16] R. Vijayaraghavan (2000). "Design and evaluation of skip-lot sampling plans of type SkSP-3", Journal of Applied Statistics, Vol. 27, No. 7, p. 901-908.

[17] Satheesh Kumar, C., Shibu, D.S. (2011). Modified Intervened Poisson Distribution, Statistica 4: pp.489-498.

[18] Shanmugam, R. (1985). An intervened Poisson distribution and its medical application, Biometrics 41:pp. 1025-1029.

[19] Shanmugam, R. (1992). An inferential procedure for the Poisson intervention parameter, Biometrics 48:pp. 559-565.

[20] Scollnik, D.P.M. (2006). On the intervened generalized Poisson distribution, Communication in Statistics-Theory & Methods 35: pp. 953-963.

[21] Scollnik, D.P.M. (1995). Bayesian analysis of an intervened Poisson distribution, Communications in Statistics-Theory & Methods 24: pp. 735-754.

[22] Suganya. S and Pradeepa Veerakumari. K (2022). "Skip-lot Sampling Plan of Type SkSP-T with Group Acceptance Sampling Plan as Reference Plan Under Burr-Type XII Distribution", Reliability: Theory & Applications, Vol. 17, Issue 1 (67), pp.240-251.

[23] Suganya. S and Pradeepa Veerakumari. K (2022)."Selection of Skip-lot Sampling plan of Type SkSP-T Using Special Type Double Sampling Plan as Reference Plan Based On Fuzzy Logic Techniques Using R programming Language", Reliability: Theory & Applications, Vol.17, Issue 3 (69), pp. 97-108.