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Designing Special Purpose Double Sampling Plan of Type DSP (0,1) based on Truncated Life Tests for Weighted Exponential Distribution Using Minimum Angle Method

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ABSTRACT: In this paper a new approach of Designing Special Purpose Double Sampling Plan of Type DSP(0,1) for truncated life tests using minimum angle method, is proposed when the life time distribution follows Weighted Exponential distribution. The test termination time and mean ratio time are specified. The acceptance number is also specified. The design parameter is obtained such that it satisfies both the producer's risk and consumer's risk simultaneously. The results are analyzed with the help of tables and examples.

KEYWORDS: Producer's risk, Consumer's risk, Weighted Exponential distribution, minimum angle method, OC curve, Probability of acceptance.

I. INTRODUCTION

Quality control has become one of the most important tools to differentiate between competitive enterprises in a global business market. Two important tools for ensuring quality are the statistical quality control and acceptance sampling. The acceptance sampling plans are concerned with accepting or rejecting the submitted lots on the basis of quality of products inspected in a sample taken from the lot. An acceptance sampling plan is a specified plan that establishes the minimum sample size to be used for testing. In most acceptance sampling plans for a truncated life test, major issue is to determine the sample size from the lot under consideration. Sampling inspection in which the criteria for acceptance and non-acceptance of the lot depend in part on the results of the inspection of immediately preceding lot is adopted in DSP(0,1) sampling plan.

In this paper a new approach of designing special purpose double sampling plan of type DSP(0,1) for truncated life test using minimum angle method, is proposed when the life time distribution follows Weighted Exponential distribution. The test termination time and mean ratio time are specified. The design parameter is obtained such that it satisfies both producer's risk and consumer's risk. The Operating characteristic values for various quality levels are obtained and the results are discussed with the help of table. The table of design parameter are provided for easy selection of the plan parameter. The results are analyzed with the help of table and examples.

II. RELATED WORK

From Cameron table (1952), one can observe a jump between the operating ratios of $c=0$ and $c=1$ and slow reduction of operating ratios for other values of c . It may also be seen that, in between the OC curves of $c=0$ and $c=1$ plans, there is vast gap to be filled which leads one access the possibility of designing plans having OC curves lying between the OC curves of $c=0$ and $c=1$ plans. To overcome such situation, Hald (1981), has proposed Double sampling plan with acceptance number 0 and 1 and rejection number 2.

Sudamani Ramaswamy and Sutharani(2014) planned a technique for designing DSP(0,1) acceptance sampling plan based on truncated life tests for various distribution using minimum angle method. The various distributions they considered are Rayleigh distribution, Generalized Exponential distribution, Weibull distribution, Gamma distribution. Sudamani Ramaswamy and Sowmya(2016) proposed A time truncated special purpose double sampling plan DSP(0,1) for compound Rayleigh distribution.

III. METHODOLOGY

Acceptance sampling plans are statistical tools for rectifying quality assurance. The sampling plan provides the vendor and buyer the decision rules for product acceptance to meet the present quality requirements. Several types of decision rules have been proposed for the acceptance sampling problem but work on designing the parameters to control quality of the received lots based on Minimum Angle Method is scarce. In acceptance sampling plan based on truncated life test, the design parameters are usually determined for the specified experiment time and for the acceptance number which satisfies consumer’s risk only. This method used the one-point approach on operating characteristic curve, so it may not always satisfy the producer’s risk. In this thesis a new approach for designing parameter for acceptance sampling plans based on truncated life test is introduced. An attempt is made to design the parameter such that it satisfies both the conditions of producer’s risk as well as consumer’s risk and at the same time it minimizes the sum of the risks. Using minimum angle method the design parameter is selected such that $L(p_1) \geq 1-\alpha$ and $L(p_2) \leq \beta$ and at the same time sum of risk is minimum.

The practical performance of a sampling plan is revealed by its operating characteristic curve. Norman Bush et. al. (1953), have used different techniques involving comparison of some portion of the OC curve to that of the ideal curve. The approach of minimum angle method by considering the tangent of the angle between the lines joining the points $(AQL, 1-\alpha), (LQL, \beta)$ is shown in Figure 1 where $p_1 = AQL, p_2 = LQL$. By employing this method one can get a better discriminating plan with the minimum angle. Tangent of angle made by lines AB and AC is

$$\tan\theta = BC/AC$$

$$\tan\theta = (p_2 - p_1) / (Pa(p_1) - Pa(p_2))$$

The smaller the value of this $\tan\theta$, closer is the angle θ approaching zero and the chord AB approaching AC, the ideal condition through $(AQL, 1-\alpha)$. This criterion minimizes simultaneously the consumer’s and producer’s risks. Thus both the producer and consumer favour the plans evolved by the criterion.

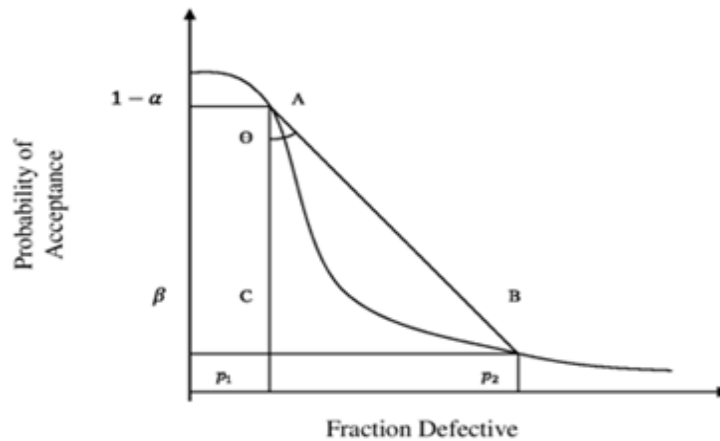
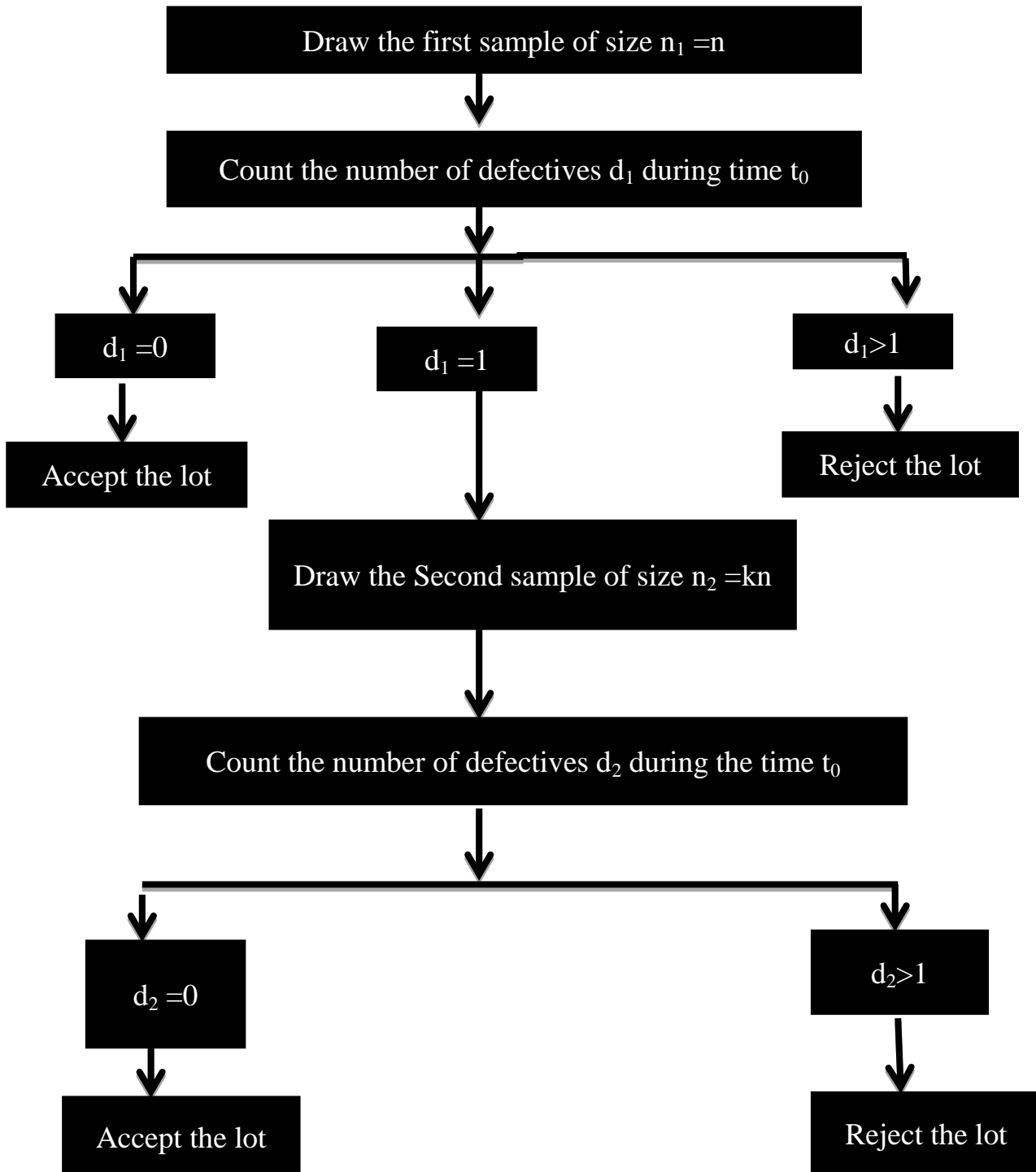


Figure:1 Minimum angle for given p_1 and p_2

IV. EXPERIMENTAL RESULTS



Weighted Exponential Distribution

The weighted exponential distribution has attracted much attention. Gupta and Kundu (2009) discussed different properties of this model and compared with the corresponding properties of well-known distributions. This

model can be used as an alternative to any of Weibull, gamma, or generalized exponential distributions. It is observed that this model can also be obtained as a hidden truncation model. The PDF of the weighted exponential distribution is given by

$$f(t; \alpha; \lambda) = \frac{\alpha + 1}{\alpha} \lambda e^{-\lambda t} (1 - e^{-\alpha \lambda t}), \quad t > 0$$

Where $\alpha > 0$ is the shape parameter and $\lambda > 0$ is the scale parameter. We denote it by writing $T \sim WE(\alpha, \lambda)$. The PDF is always unimodal with $\log(1 + \alpha) / (\alpha \lambda)$. As $\alpha \rightarrow \infty$, the weighted exponential distribution T converges to Exponential distribution $Exp(\lambda)$. As $\alpha \rightarrow 0$, the weighted exponential distribution T converges to a gamma distribution $Gamma(2, \lambda)$. The corresponding cumulative distribution function of T is

$$F(t; \alpha; \lambda) = \frac{\alpha + 1}{\alpha} \left[\frac{e^{-(\alpha+1)\lambda t}}{\alpha + 1} - e^{-\lambda t} + 1 \right], \quad t > 0$$

The weighted exponential distribution has an increasing failure function and it is given by $\frac{(\alpha+1)\lambda(e^{\alpha\lambda t}-1)}{(\alpha+1)(e^{\alpha\lambda t}-1)}$. The failure rate function starts at 0 and converges to λ as $t \rightarrow \infty$. This is suitable for modelling life time data when wear-out or aging is present.

Operating characteristic curve

The Figure 3 shows the OC curve of special purpose double sampling plan of type DSP(0,1) when the life time of the items follows Weighted Exponential distribution. From the Figure 3 one can observe that the probability of acceptance increases as the mean ratio increases.

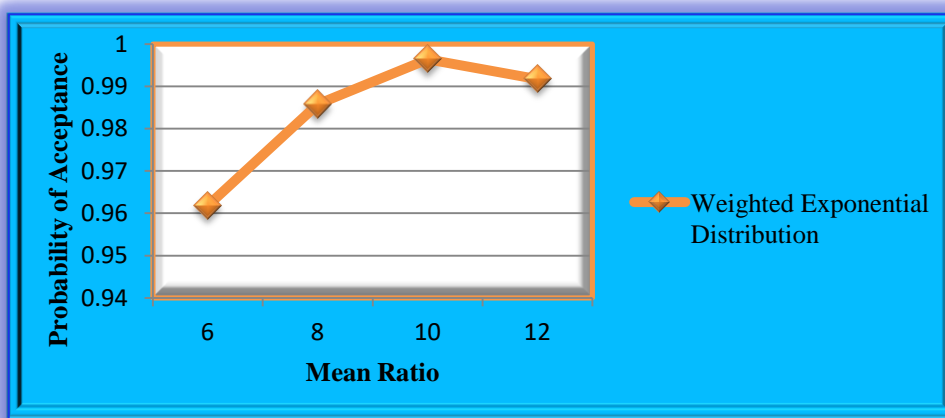


Figure: 3 OC curve for special purpose double sampling plan of type DSP(0,1) when the life time of the items follows Weighted Exponential distributions with $(t_0/\mu_0=0.6)$

Construction of Table

The probability of acceptance DSP(0,1) or the probability of acceptance DSP(0,1) is given by,

$$L(P) = (1 - P)^{n_1} + n_1 P (1 - P)^{(n_1+k+1)-1}$$

The failure probability of an item by time t_0 , given by

$$P = F(t_0, \mu)$$

The Table 1 is constructed using OC function for special purpose Double sampling plan of type DSP(0,1) when the life time of items follows Weighted Exponential distributions. The test termination ratio t_0/μ_0 values are fixed as 0.4, 0.6, 0.8, 1, 1.5, 2, 2.5 and 3, and the mean ratio μ/μ_0 values are fixed as 2, 4, 6, 8, 10, 12. For various time ratios t_0/μ_0 and mean ratios μ/μ_0 the parameter values $n_1 = n$ and $n_2 = kn$ are obtained and satisfying $L(p_1) \geq 0.95$ and $L(p_2) \leq 0.10$ for Weighted Exponential distribution and provided in Table 1. The values of θ and $\tan\theta$ are also provided in the Table 1. The parameters can be selected such that the angle is minimum.



Table – 1 Sample size and probability of acceptance for DSP(0,1) Sampling plan using minimum angle method when the life time of the items follows Weighted Exponential distribution

t_0/μ_0	μ/μ_0	K	n	L(p1)	L(p2)	tan θ	Θ
0.6	6	1	8	0.961809	0.035214	0.355883	19.589779
	6	3	6	0.952724	0.074025	0.375282	20.570188
	8	1	8	0.985765	0.035214	0.356642	19.628372
	8	1	7	0.988996	0.056622	0.363595	19.981014
	8	1	6	0.986716	0.091753	0.374503	20.531100
	8	1	10	0.950641	0.013944	0.353928	19.490303
	10	1	6	0.996388	0.091753	0.379734	20.793451
	10	1	10	0.976295	0.013944	0.351615	19.372434
	10	3	10	0.978480	0.013022	0.355811	19.586108
	10	3	7	0.965096	0.047913	0.366343	20.119968
	12	2	10	0.991717	0.013034	0.353592	19.473201
	12	3	10	0.981309	0.013022	0.355432	19.566866
	12	1	8	0.991789	0.035214	0.357848	19.689651
	12	3	9	0.969657	0.020102	0.358639	19.729807
0.8	8	1	7	0.970152	0.009745	0.485138	25.879772
	8	2	4	0.963317	0.069772	0.508214	26.940301
	8	2	4	0.952985	0.069772	0.508415	26.949466
	10	2	4	0.992310	0.069772	0.513250	27.169184
	10	2	5	0.980953	0.035277	0.496167	26.389105
	10	2	5	0.972874	0.035277	0.496139	26.387813
	10	3	4	0.968248	0.068627	0.512970	27.156484
	12	1	7	0.992794	0.009745	0.486025	25.920907
	12	1	6	0.991211	0.019789	0.488609	26.040533
	12	1	5	0.991005	0.040941	0.496424	26.400919
	12	2	9	0.956388	0.002404	0.494384	26.307068
	12	1	7	0.976903	0.009745	0.484751	25.861827
	12	3	7	0.951444	0.009182	0.497559	26.453049
	1	6	1	3	0.952304	0.080059	0.613326
8		1	4	0.978096	0.028427	0.600192	30.971832
8		1	3	0.980710	0.080059	0.623238	31.932734
8		1	3	0.966409	0.080059	0.616945	31.672313
10		2	3	0.990355	0.063427	0.626939	32.085196
10		1	6	0.965027	0.004022	0.598305	30.892309
10		3	4	0.951184	0.024711	0.614490	31.570329
10		2	4	0.963317	0.024801	0.606605	31.241230
10		2	4	0.952985	0.024801	0.607892	31.295092
12		3	7	0.965667	0.001540	0.609380	31.357299
12		1	9	0.959361	0.000243	0.607788	31.290741
12		1	8	0.953832	0.000615	0.607039	31.259379
12		2	5	0.959673	0.009804	0.605044	31.175775
1.5		8	1	2	0.968878	0.052621	0.782851
	8	1	2	0.959418	0.052621	0.777197	37.854251
	8	1	2	0.950938	0.052621	0.773190	37.710839
	10	2	2	0.973787	0.040384	0.795751	38.511041
	10	2	2	0.964909	0.040384	0.792821	38.408102
	10	1	2	0.973951	0.052621	0.786593	38.188338
	12	2	3	0.979301	0.007969	0.789398	38.287499
	12	2	2	0.979912	0.040384	0.798651	38.612654
	12	3	2	0.965181	0.039896	0.803658	38.787385
	2	8	3	1	0.968022	0.097922	0.912265
10		1	2	0.973837	0.011080	0.859129	40.666842



	10	1	2	0.962198	0.011080	0.852566	40.449790
	10	3	1	0.964083	0.097922	0.908396	42.251886
	12	3	2	0.966396	0.009428	0.885403	41.521771
	12	3	1	0.0978387	0.097922	0.924642	42.757755
2.5	8	1	1	0.967878	0.090804	0.882811	41.438432
	8	1	1	0.955684	0.090804	0.859084	40.665351
	10	2	1	0.977476	0.048543	0.908973	42.269976
	10	2	1	0.960567	0.048543	0.885596	41.527966
	12	1	1	0.993423	0.090804	0.966539	44.025207
	12	1	2	0.957341	0.002352	0.895710	41.851110
	12	1	1	0.987457	0.090804	0.938514	43.183284
3	8	1	1	0.959289	0.043701	0.847691	40.287660
	10	1	1	0.978941	0.043701	0.890454	41.683599
	10	1	1	0.959950	0.043701	0.848874	40.327063
	12	1	1	0.978733	0.043701	0.889887	41.665480
	12	2	1	0.953954	0.022572	0.880190	41.353918

Example

Suppose one wants to design DSP(0,1) under Weighted Exponential Distribution, for specified values $t_0/\mu_0 = 0.6$, $\mu/\mu_0 = 10$, $k = 1$. One can observe that from the Table 1, among the various values of θ the minimum angle is $\theta = 19.372434^0$ and also $\alpha = 0.023705$ and $\beta = 0.013944$ which corresponds to $n = 10$. It is very much less than the specified risk. Thus the required DSP(0,1) plan has parameters(10,10) which satisfies both the producer’s risk and consumer’s risk.

v. CONCLUSION

In this paper, designing DSP(0,1) based on truncated life test for Weighted Exponential Distribution using minimum angle method is presented. The sample size for various values of μ/μ_0 and different experiment times are calculated using Weighted Exponential Distribution. By applying minimum angle method there is a reduction in the sample size and minimizes simultaneously the consumer’s risk and producer’s risk. The minimum angle method provides better differentiation of accepting good lots.

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