Thailand Statistician
April 2024; 22(2): 274-285
http://statassoc.or.th
Contributed paper

An Acceptance Sampling Plan for Testing of Product's Life using New Weibull-Rayleigh Distribution

Muhammad Bilal [a,b], Muhammad Mohsin [c] and Salman Abbas* [a,d]
[a] Department of Statistics, COMSATS University Islamabad, Lahore Campus, Pakistan
[b] School of Business, University of Veterinary and Animal Sciences, Lahore, Pakistan
[c] College of Statistical and Actuarial Sciences, University of the Punjab, Lahore, Pakistan
[d] Department of Management, Zhengzhou University, Zhengzhou, China
*Corresponding author; e-mail: s.salmanabbas932@gmail.com

Received: 4 September 2020
Revised: 1 October 2020
Accepted: 2 October 2020

Abstract

Acceptance sampling plans are vital in account to make decision about the life of the product. In present article, we propose an acceptance sampling plan for the life length of a product which follows Weibull-Rayleigh distribution. Plans are designed for both finite and infinite sample sizes at different combinations of parameters. Operating characteristic curves are derived to demonstrate the efficiency of the proposed acceptance sampling plan. Numerical and graphical presentation of the proposed plans lead us to draw a useful conclusion for the acceptance probability.

Keywords: Lot acceptance probability, sampling plans, Weibull-Ralyeigh distribution

1. Introduction

Customers satisfaction is an important tool to observe quality of a product. In manufacturing process, quality engineers do not take any risk about the material and other aspects of the product because if a single product does not meet the requirement than all the effort is useless. Therefore, the quality supervisor try its best to produce such product which meet all requirements and have no objection.

Several measure are designed for the acceptance or rejection of a lot. These measures are helpful to make the manufacturing process more efficient and effective. To make a decision about the acceptance or rejection of a lot, quality engineers inspected a set amount of the items. This process is an application of acceptance sampling plans in quality control. An acceptance sampling plan plays an indispensable role in the performance assessment of the product. It is distinct from statistical process control, which is an aim to achieve the goal of improving the future product.

Statistical models, the lifetime distributions, are widely applied in different fields such as medicine, economics, survival analysis, finance, reliability sciences and many more. Sometimes these distributions faced many problems when the real-life data does not assume any of the standard probability models. This flaw always demands new modifications of the existing models. In general, products are categorized according to their lifetime, which is a natural process and follows a particular probability distribution. The competency of sampling plans under different probabilities models depends on the products lifetime behavior. Several accepting sampling plans are designed by using probability models. Goode and Kao (1960) provided the set of an acceptance sampling plan for lifetime testing and reliability under the Weibull distribution. Gupta and Groll (1961) constructed the acceptance-sampling plan for gamma distribution. Rosaiah and Kantam (2005) developed an acceptance sampling plan for inverse Raleigh distribution. Kantam et al. (2001) established the acceptance sampling plan for the log-logistic model. Dumi et.al. (2012) provided a decision making process for assessing the quality of lot using single and double acceptance sampling plan. Shahbaz et al. (2018) described a single and double acceptance sampling plans for the lifetime of product using the Power Lindley distribution. Singh et al. (2019) formed a repetitive acceptance sampling plan for truncated life test using generalized Pareto distribution.

The high demand of quality products encourage researchers to develop more effective and quick tool to handle the situations. In this article, an acceptance sampling plan is designed. For this purpose, we use a new Weibull-Rayleigh (WR) distribution given by Bilal et al (2019). Sampling plans are proposed for both finite and infinite lot sized using WR distribution and graphical demonstration is made on the basis of Operating Characteristic (OC) curves. We hope the work will motivate researchers to enhance their expertise in the dimension.

The article is unfolded. In Section 2, the new WR distribution is proposed. In Section 3, sampling plans are discussed. In Section 4, acceptance sampling plans are established for the proposed distribution. In Section 5, the conclusion is reported.

2. The Weibull Rayleigh Distribution

Bilal et al. (1987) derive a new Weibull Rayleigh (WR) distribution with distribution function (CDF) given as

$$F(x) = 1 - \exp\left(-\alpha\left(\frac{x^2}{2\gamma\sigma^2}\right)^c\right). \tag{1}$$

The corresponding probability density function (pdf) is obtained as

$$f(x) = \left(\frac{c\alpha x}{\gamma\sigma^2}\right)\left(\frac{x^2}{2\gamma\sigma^2}\right)\exp\left(-\alpha\left(\frac{x^2}{2\gamma\sigma^2}\right)^c\right), \quad x > 0, c, \gamma, \sigma > 0, \tag{2}$$

where c is the shape parameter and α, γ, σ^2 are scale parameters. The q-th moment of the WR distribution is extracted as

$$E(x)^q = (2\gamma\sigma^2)^{\frac{q}{2}} \cdot \left(\frac{1}{\alpha}\right)^{\frac{q}{2c}} \Gamma\left(1 + \frac{q}{2c}\right). \tag{3}$$

The quantile of WR distribution is given as follows

$$Q(p) = \sqrt{2\gamma\sigma^2\left(\ln\left(\frac{1}{1-u}\right)\right)^{\frac{1}{c}}}; \alpha, \gamma, \sigma^2, c > 0;\ \ 0 < p < 1. \tag{4}$$

The average and quantile function are playing an important role for developing the acceptance sampling plans.

3. Acceptance Sampling Plans

In quality control, the acceptance sampling plans are importantly used to draw conclusion about the acceptance or rejection of the inspected lot. A considerable work on the development of acceptance sampling plans is available in literature. Two effectively used method are single and double acceptance sampling plans. The acceptance of the lot in single sampling plan is based on the number of items to be inspected (m) and the affordable number of defective items (k) among inspected items. For single sampling plan, the probability of acceptance of the lot is computed as

$$L(p) = \sum_{j=0}^{k} \binom{m}{j} p^j (1-p)^{n-j},$$

where, k is maximum allowed defectives in a lot and p is a pre-assigned probability.

The sampling plans are based on continuing an experiment until a prespecified time point, , and terminating the experiment after that. If the defective items are fewer than k in inspected item during given interval $[0, t_0]$, the lot is accepted. The acceptance or rejection of the lot is similarly to the testing of hypothesis such as $H_0 : j > j_0$, where j is life of the component and j_0 is a pre-defined test value. Producer risk a and consumer risk b are the integral parts of the acceptance sampling plans. In the development of single acceptance sampling plan, the values of m and k are obtained by solving following

$$\sum_{j=0}^{k} \binom{m}{j} \text{AQL}^j (1-\text{AQL})^{n-j} \geq 1-a \tag{5}$$

and $$\sum_{j=0}^{k} \binom{m}{j} \text{LTPD}^j (1-\text{LPTD})^{n-j} \leq b \tag{6}$$

for m and k. AQL is acceptable quality level and LTPD is lot tolerance percent defective. Eqns. (5) and (6) utilize binomial distribution as it is accepted the lot size is infinite or $M >> k * m$, here M is lot size and k is adequately large numbers, such as 500 or more. At the finite lot size, the binomial distribution is supplanted by the hyper-geometric distribution.

4. Sampling Plan for WR Distribution

In this section, we derive the sampling plan for life length of the product which follows the WR distribution.

4.1. Sampling plan for infinite lot size

On the account of infinite lot size, the acceptance sampling plan is based upon the values of m and k which satisfies Eqns. (5) and (6), where AQL and LTPD are probabilities acquired from the distribution and quantile function of WR distribution for $\alpha = 1$ as

$$F(x, \gamma, \sigma^2, c) = 1 - \exp\left[-\left(\frac{x^2}{2\gamma\sigma^2}\right)^c\right]$$

and $$Q(p) = \sqrt{2\gamma\sigma^2\left(\ln\left(\frac{1}{1-u}\right)\right)^{\frac{1}{c}}}, \ \gamma, \sigma^2, c > 0; \ \ 0 < p < 1.$$

Now assuming that the life length of the product is $t_o = \alpha_o\mu_o$, where μ_o is the average life of the product, then using $x = \alpha_o\mu_o = \alpha\mu\left(\frac{\mu}{\mu_o}\right)^{-1}$ and further using $\mu = Q(u)$, we can write Eqn. (1) as

$$p = 1 - \exp\left[-\left(\frac{a_0^2 Q^2 u}{2\gamma\sigma^2\left(\frac{\mu}{\mu_0}\right)^2}\right)^c\right].$$

The acceptance sampling plans are constructed for various ratios of $\frac{\mu}{\mu_o}$,γ, σ^2 and c. The values of n and c which satisfy inequalities Eqns. (5) and (6), for different values of , are given in Table A.1 and

Table A.2, respectively, in Appendix A. The values of LTPD have been obtained by using $\mu = \mu_o$. The values of n and c in these tables provide information about number of items to be put on test and number of defective items observed for rejection of the lot. For example, in Table A.1, the values of n and c for $\gamma = 2, \sigma^2 = 0.5, c = 1.25, \alpha_o = 0.75, p = 0.95, \alpha = 0.05, \beta = 0.01$and $\mu = 3\mu_o$ are 7 and 2, respectively. These values indicate that if the quality control engineer is interested in testing the hypothesis that life length of a component is 1000 hours and true average life is thrice this value, then the engineer can test 7 items; if fewer than 2 items fail in 750 hours; as $\alpha_o = 0.75$ and life length is in thousands of hours; then the engineer can conclude with 95% confidence that the life is more than 3000 hours.

4.2. Sampling plan for finite lot size

We will now discuss the sampling plans when the life length of product follows W Rayleigh and the lot has finite number of components. The inequalities Eqns. (5) and (6) are slightly modified in this case and are given as

$$\sum_{i=0}^{c} \frac{\binom{N\times AQL}{i}\binom{N-N\times AQL}{i}}{\binom{N}{n}} \geq 1-\alpha, \tag{7}$$

and

$$\sum_{i=0}^{c} \frac{\binom{N\times LTPD}{i}\binom{N-N\times LTPD}{i}}{\binom{N}{n}} \leq \beta. \tag{8}$$

where N is lot size. Now, using equation Eqns. (7) and (8), the values of AQL and LTPD can be obtained for various choices of and various choices of parameters , $\frac{\mu}{\mu_o}$ and c. The values of n and c which satisfy Eqns. (7) and (8) are given in Tables A.3 through A.5. The values of n and c in these tables are the number of items to be put on test and the number of defective items observed for rejection of the lot, respectively. For example, in Table A.3, the values of n and c for $N = 50, \gamma = 2.0, \sigma^2 = 0.5, c = 1.25, \alpha_o = 0.75, p = 0.95, \alpha = 0.05, \beta = 0.01$ and $\mu = 3\mu_o$ are 10 and 5. These values indicate that if the quality control engineer is interested in testing the hypothesis that the life length of a component is 1000 hours and true average life is thrice this value, then the engineer can test 5 items out of 50; if fewer than 1 items fail in 750 hours; as $\alpha_o = 0.75$ and life length is in thousands of hours; then the engineer can conclude with 95% confidence that the life is more than 3000 hours.

4.3. Operating characteristic curves

The operating characteristic (OC) curve provides useful information about performance of an acceptance sampling plan. The OC values for a sampling plan gives the probability of acceptance of the lot under a specific sampling plan when actual lot contains a specified percentage of defective items and is given in Eqn. 4. The OC values for the given sampling plan under WRayleigh distribution with specific values of the parameters given in Table A.6 in Appendix A. We see that the probability of acceptance decreases as the value of α_o increases for fixed ratio. Additionally, we can see that for fixed value of α_o, the acceptance probability increases with increase in $\frac{\mu}{\mu_o}$. Figures 1 and 2 demonstrate the OC curve depicts the oppressive control of an acceptance-inspecting plan. It can see in Figures 1 and 2 as defective ratio increases the probability of acceptance increases for fixed value of α_o.

5. Conclusions and Recommendations

In this article, we develop the acceptance sampling plans for when the length of life length of the product follows the WR distribution. The sampling plans are developed for various choices of the proposed distribution parameters. We constructed single acceptance sampling plans. The single-acceptance sampling plans are obtained for finite and infinite lot sizes. It is seen that the acceptance number decreases with an increase in the design parameters. It is also observed that with an increase in the ratio, $\frac{\mu}{\mu_o}$ the number of defective items required for acceptance of the lot decreases. It is suspected that the total number of components to be observed is smaller for a finite lot size compared with the infinite lot size, and this difference decreases with an increase in the lot size. The constructed sampling plans are useful when the life length of components follow the WR distribution. In such cases, the quality control engineer can use this plan for efficient decision making.

Acknowledgments

We would like to thank the referees for his comments and suggestions on the manuscript.

References

Bilal M, Mohsin M, Aslam M. Weibull-exponential distribution and its application in monitoring industrial process. Math Probl Eng. 2021; 1–13.

Dumičić, Ksenija and Žmuk, Berislav. Decision making based on single and double acceptance sampling plans for assessing quality of lots. Bus Sys Res. 2012; 3(2):27-40.

Goode HP, Kao JHK. Sampling plans based on the Weibull distribution. Department of Industrial and Engineering Administration, Sibley School of Mechanical Engineering: Cornell University; 1960.

Gupta SS, Groll PA. Gamma distribution in acceptance sampling based on life tests. J Am Stat Assoc. 1961; 56:942–970.

Kantam RRL, Rosaiah K, Rao GS. Acceptance sampling based on life tests: log-logistic model. J Appl Stat. 2001; 28(1):121–128.

Lee C, Famoye F, Alzaatreh AY. Methods for generating families of univariate continuous distributions in the recent decades. WIREs Comput Stat. 2013; 5(3):219–238.

Nadarajah S, Kotz S. The beta Gumbel distribution. Math Probl Eng. 2004; (2004):323–332.

Nadarajah S, Kotz S. The beta exponential distribution. Reliability engineering & system safety. 2006; 91(6): 689–697.

Rosaiah K, Kantam RRL. Acceptance sampling based on the inverse Rayleigh distribution. Walter de Gruyter GmbH & Co. KG; 2005.

Shahbaz SH, Khan K, Shahbaz MQ. Acceptance sampling plans for finite and infinite lot size under power Lindley distribution. Symmetry. 2018; 10(10): 496.

Singh N, Singh N, Kaur H. Acceptance sampling plan for truncated life test having generalized Pareto distribution. Life Cycle Reliab Saf Eng. 2019; 8(2):151–156.

Appendix A

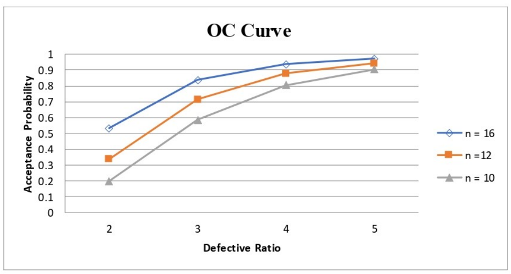

Figure 1 Plot of OC Curve of WR distribution at$\gamma = 2.5, \sigma^2 = 1.5, c = 0.75, p = 0.85, c = 2$

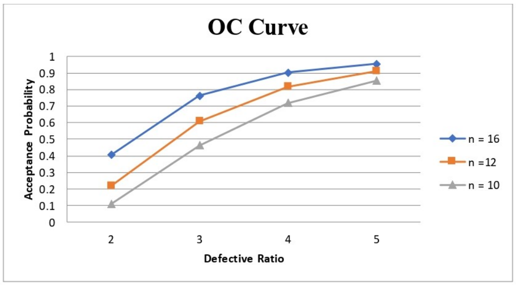

Figure 2 Plot of OC Curve of WR distribution at$\gamma = 2.5, \sigma^2 = 1.5, c = 0.75, p = 0.90, c = 2$

Table 1 Values of (n, c) for infinite lot size at different p values and $\alpha = 0.05$

				μ/μ_o				
γ, σ^2, c	α_o	p	β	1.5	2	3	4	5
(1.5,2.5,0.5)	0.75	0.75	0.01	179,100	68,34	31,13	22,8	18,6
			0.05	126,72	48,25	23,10	15,6	13,5
			0.1	102,59	36,19	19,9	12,5	10,4
			0.25	62,37	25,14	12,6	9,4	5,2
		0.95	0.01	151,125	53,41	22,15	16,10	12,7
			0.05	105,88	38,30	17,12	11,7	8,5
			0.1	89,75	30,24	14,10	9,6	8,5
			0.25	56,48	22,18	8,6	7,5	6,4
	1	0.75	0.01	158,105	58,35	27,14	19,9	15,6
			0.05	111,75	42,26	20,11	14,7	9,4
			0.1	91,62	33,21	16,9	10,5	9,4
			0.25	57,40	23,15	10,6	7,4	6,3
		0.95	0.01	167,151	56,48	23,18	14,10	12,8
			0.05	122,111	39,34	15,12	11,8	7,5
			0.1	94,86	33,29	15,12	8,6	7,5
			0.25	65,60	26,23	11,9	5,4	4,3
(2.5,1.5,0.75)	0.75	0.75	0.01	92,43	39,15	20,6	13,3	11,2
			0.05	66,32	27,11	13,4	11,3	9,2
			0.1	53,26	19,8	12,4	8,2	8,2
			0.25	33,17	13,6	8,3	6,2	4,1
		0.95	0.01	66,49	26,17	12,6	9,4	8,3
			0.05	49,37	18,12	9,5	6,3	5,2
			0.1	39,30	16,11	7,4	6,3	5,2
			0.25	28,22	11,8	5,3	4,2	4,2
	1	0.75	0.01	74,46	30,16	15,6	9,3	9,3
			0.05	52,33	20,11	9,4	8,3	6,2
			0.1	43,28	16,9	9,4	7,3	6,2
			0.25	28,19	10,6	6,3	5,2	3,1
		0.95	0.01	71,62	24,19	9,6	7,4	6,3
			0.05	51,45	16,13	7,5	5,3	4,2
			0.1	45,40	16,13	7,5	5,3	4,2
			0.25	30,27	12,10	4,3	3,2	3,2
(2.0,0.5,1.25)	0.75	0.75	0.01	48,15	23,5	14,2	11,1	11,1
			0.05	33,11	16,4	8,1	8,1	8,1
			0.1	26,9	12,3	7,1	7,1	4,1
			0.25	16,6	7,2	5,1	5,1	3,1
		0.95	0.01	29,16	12,5	7,2	6,1	6,1
			0.05	21,12	9,4	4,1	4,1	4,1
			0.1	17,10	8,4	4,1	4,1	4,1
			0.25	11,7	4,2	3,1	2,1	2,1
	1	0.75	0.01	30,16	13,5	8,2	6,1	6,1
			0.05	23,13	9,4	6,2	5,1	5,1
			0.1	19,11	7,3	4,1	4,1	2,1
			0.25	13,8	6,3	3,1	2,1	2,1
		0.95	0.01	25,20	9,6	5,2	3,1	3,1
			0.05	21,17	6,4	4,2	3,1	3,1
			0.1	17,14	6,4	2,1	2,1	2,1
			0.25	13,11	4,3	2,1	2,1	2,1

Table 2 Values of (n, c) for infinite lot size at different p values and $\alpha = 0.01$

				μ/μ_o				
γ, σ^2, c	α_o	p	β	1.5	2	3	4	5
(1.5,2.5,0.5)	0.75	0.75	0.01	248,142	92,48	42,19	29,12	24,9
			0.05	178,104	70,38	31,15	23,10	17,7
			0.1	152,90	56,31	26,13	19,9	14,6
			0.25	105,64	43,25	19,10	12,6	11,5
		0.95	0.01	211,177	73,58	29,21	21,14	16,10
			0.05	158,134	53,43	24,18	16,11	12,8
			0.1	131,112	45,37	21,16	14,10	10,7
			0.25	97,84	32,27	15,12	9,7	8,6
	1	0.75	0.01	217,147	80,50	36,20	24,12	19,9
			0.05	161,111	59,38	26,15	19,10	14,7
			0.1	135,94	50,33	23,14	16,9	13,7
			0.25	98,70	35,24	16,10	10,6	9,5
		0.95	0.01	238,217	79,69	32,26	21,16	15,11
			0.05	182,167	61,54	24,20	15,12	12,9
			0.1	153,141	48,43	20,17	15,12	9,7
			0.25	114,106	42,38	15,13	11,9	9,7
(2.5,1.5,0.75)	0.75	0.75	0.01	130,63	50,21	24,8	18,5	16,4
			0.05	96,48	38,17	19,7	13,4	11,3
			0.1	76,39	31,14	16,6	12,4	10,3
			0.25	54,29	22,11	12,5	8,3	6,2
		0.95	0.01	92,70	35,24	16,9	10,5	9,4
			0.05	71,55	27,19	13,8	9,5	6,3
			0.1	60,47	22,16	11,7	7,4	6,3
			0.25	42,34	17,13	9,6	5,3	5,3
	1	0.75	0.01	103,66	39,22	19,9	15,6	11,4
			0.05	76,50	29,17	14,7	9,4	8,3
			0.1	63,42	23,14	12,6	9,4	7,3
			0.25	46,32	17,11	7,4	6,3	6,3
		0.95	0.01	98,87	34,28	14,10	9,6	7,4
			0.05	78,70	26,22	12,9	7,5	6,4
			0.1	63,57	21,18	9,7	7,5	6,4
			0.25	48,44	17,15	9,7	4,3	4,3
(2.0,0.5,1.25)	0.75	0.75	0.01	65,22	31,8	17,3	14,2	11,1
			0.05	48,17	21,6	11,2	11,2	8,1
			0.1	40,15	17,5	9,2	7,1	7,1
			0.25	27,11	12,4	7,2	5,1	5,1
		0.95	0.01	41,24	17,8	9,3	7,2	6,1
			0.05	31,19	12,6	8,3	6,2	4,1
			0.1	27,17	11,6	5,2	5,2	4,1
			0.25	18,12	7,4	4,2	3,1	3,1
	1	0.75	0.01	42,24	18,8	9,3	8,2	6,1
			0.05	32,19	14,7	8,3	6,2	5,1
			0.1	26,16	10,5	7,3	6,2	4,1
			0.25	17,11	7,4	5,2	3,1	3,1
		0.95	0.01	35,29	13,9	7,4	5,2	3,1
			0.05	27,23	11,8	5,3	4,2	3,1
			0.1	22,19	9,7	5,3	2,1	2,1
			0.25	17,15	9,7	3,2	2,1	2,1

Table 3 Values of (n, c) for lot size of 50 at different parameters values and $\alpha = 0.05$

				μ/μ_o				
γ, σ^2, c	α_o	p	β	1.5	2	3	4	5
(1.5,2.5,0.5)	0.75	0.75	0.01	40,22	29,14	21,9	16,6	13,4
			0.05	38,21	24,12	16,7	11,4	9,3
			0.1	37,21	23,12	15,7	10,4	8,3
			0.25	31,18	19,10	12,6	7,3	5,2
		0.95	0.01	36,30	26,20	15,10	11,7	9,5
			0.05	36,30	23,18	10,7	8,5	7,4
			0.1	32,27	20,16	10,7	8,5	7,4
			0.25	27,23	16,13	8,6	6,4	6,4
	1	0.75	0.01	40,26	27,16	19,10	15,7	12,5
			0.05	36,24	23,14	15,8	12,6	9,4
			0.1	36,24	21,13	13,7	10,5	7,3
			0.25	29,20	17,11	10,6	7,4	6,3
		0.95	0.01	38,34	27,23	17,13	10,7	9,6
			0.05	38,34	27,23	14,11	10,7	7,5
			0.1	38,34	23,20	14,11	8,6	7,5
			0.25	32,29	23,20	11,9	8,6	4,3
(2.5,1.5,0.75)	0.75	0.75	0.01	31,14	21,8	14,4	10,2	10,2
			0.05	28,13	19,8	10,3	8,2	8,2
			0.1	25,12	16,7	9,3	7,2	5,1
			0.25	20,10	11,5	6,2	4,1	4,1
		0.95	0.01	31,23	17,11	10,5	7,3	6,2
			0.05	25,19	12,8	7,4	6,3	5,2
			0.1	25,19	12,8	7,4	4,2	4,2
			0.25	18,14	10,7	5,3	4,2	4,2
	1	0.75	0.01	30,18	19,10	12,5	9,3	7,2
			0.05	26,16	15,8	9,4	6,2	6,2
			0.1	24,15	13,7	7,3	6,2	6,2
			0.25	20,13	10,6	6,3	5,2	3,1
		0.95	0.01	30,26	18,14	9,6	7,4	6,3
			0.05	30,26	15,12	7,5	5,3	4,2
			0.1	24,21	15,12	7,5	5,3	4,2
			0.25	24,21	11,9	4,3	3,2	3,2
(2.0,0.5,1.25)	0.75	0.75	0.01	26,8	17,4	10,1	10,1	10,1
			0.05	21,7	12,3	7,1	7,1	7,1
			0.1	18,6	11,3	6,1	6,1	6,1
			0.25	11,4	7,2	5,1	2,1	2,1
		0.95	0.01	20,11	10,4	5,1	5,1	5,1
			0.05	16,9	7,3	4,1	4,1	4,1
			0.1	14,8	7,3	4,1	4,1	2,1
			0.25	11,7	4,2	3,1	2,1	2,1
	1	0.75	0.01	19,10	11,4	7,2	6,1	6,1
			0.05	16,9	9,4	4,1	4,1	4,1
			0.1	14,8	7,3	4,1	4,1	2,1
			0.25	10,6	6,3	3,1	3,1	2,1
		0.95	0.01	18,14	8,5	5,2	3,1	3,1
			0.05	15,12	6,4	4,2	3,1	3,1
			0.1	15,12	6,4	4,2	3,1	3,1
			0.25	11,9	4,3	2,1	2,1	2,1

Table 4 Values of (n, c) for lot size of 100 at different parameters values and $\alpha = 0.05$

				μ/μ_o				
γ, σ^2, c	α_o	p	β	1.5	2	3	4	5
(1.5,2.5,0.5)	0.75	0.75	0.01	63,35	40,20	24,10	19,7	15,5
			0.05	56,32	33,17	18,8	13,5	11,4
			0.1	52,30	30,16	15,7	10,4	8,3
			0.25	37,22	20,11	10,5	7,3	5,2
		0.95	0.01	63,52	34,26	19,13	13,8	11,6
			0.05	59,49	27,21	14,10	11,7	8,5
			0.1	50,42	24,19	14,10	9,6	8,5
			0.25	40,34	16,13	8,6	7,5	6,4
	1	0.75	0.01	62,41	37,22	22,11	16,7	12,5
			0.05	54,36	31,19	15,8	12,6	9,4
			0.1	49,33	27,17	14,8	10,5	9,4
			0.25	36,25	20,13	10,6	7,4	6,3
		0.95	0.01	60,54	35,30	18,14	11,8	9,6
			0.05	53,48	30,26	14,11	8,6	7,5
			0.1	53,48	25,22	11,9	8,6	7,5
			0.25	45,41	19,17	11,9	5,4	4,3
(2.5,1.5,0.75)	0.75	0.75	0.01	52,24	29,11	17,5	13,3	11,2
			0.05	42,20	20,8	13,4	8,2	8,2
			0.1	35,17	17,7	11,4	7,2	5,1
			0.25	29,15	13,6	8,3	6,2	4,1
		0.95	0.01	38,28	20,13	10,5	7,3	7,3
			0.05	32,24	15,10	9,5	6,3	5,2
			0.1	29,22	13,9	7,4	4,2	4,2
			0.25	22,17	10,7	5,3	4,2	4,2
	1	0.75	0.01	42,26	23,12	12,5	9,3	9,3
			0.05	35,22	18,10	9,4	8,3	6,2
			0.1	31,20	14,8	7,3	5,2	5,2
			0.25	21,14	10,6	6,3	5,2	3,1
		0.95	0.01	39,34	19,15	9,6	7,4	6,3
			0.05	33,29	15,12	7,5	5,3	4,2
			0.1	33,29	15,12	7,5	5,3	4,2
			0.25	27,24	12,10	4,3	3,2	3,2
(2.0,0.5,1.25)	0.75	0.75	0.01	35,11	19,4	10,1	10,1	10,1
			0.05	27,9	13,3	8,1	8,1	5,1
			0.1	21,7	12,3	7,1	7,1	4,1
			0.25	16,6	7,2	5,1	5,1	3,1
		0.95	0.01	22,12	10,4	7,2	5,1	5,1
			0.05	19,11	7,3	4,1	4,1	4,1
			0.1	15,9	7,3	4,1	4,1	4,1
			0.25	11,7	4,2	3,1	2,1	2,1
	1	0.75	0.01	24,13	12,5	8,2	6,1	6,1
			0.05	18,10	9,4	4,1	4,1	4,1
			0.1	14,8	7,3	4,1	4,1	2,1
			0.25	10,6	6,3	3,1	2,1	2,1
		0.95	0.01	20,16	8,5	5,2	3,1	3,1
			0.05	16,13	6,4	4,2	3,1	3,1
			0.1	16,13	6,4	2,1	2,1	2,1
			0.25	12,10	4,3	2,1	2,1	2,1

Table 5 Values of (n, c) for lot size of 100 at different parameters values and $\alpha = 0.05$

				μ/μ_o				
γ, σ^2, c	α_o	p	β	1.5	2	3	4	5
(1.5,2.5,0.5)	0.75	0.75	0.01	136,76	60,30	29,12	22,8	18,6
			0.05	100,57	45,23	22,10	15,6	13,5
			0.1	83,48	36,19	18,8	12,5	10,4
			0.25	57,34	25,14	12,6	9,4	5,2
		0.95	0.01	116,96	48,37	22,15	13,8	12,7
			0.05	91,76	33,26	17,12	11,7	8,5
			0.1	76,64	29,23	14,10	9,6	8,5
			0.25	55,47	21,17	8,6	7,5	6,4
	1	0.75	0.01	122,81	53,32	25,13	18,8	14,6
			0.05	92,62	39,24	19,10	14,7	9,4
			0.1	76,52	30,19	16,9	10,5	9,4
			0.25	53,37	23,15	10,6	7,4	6,3
		0.95	0.01	124,112	49,42	22,17	14,10	9,6
			0.05	99,90	38,33	15,12	11,8	7,5
			0.1	81,74	32,28	15,12	8,6	7,5
			0.25	63,58	19,17	11,9	5,4	4,3
(2.5,1.5,0.75)	0.75	0.75	0.01	79,37	34,13	20,6	13,3	11,2
			0.05	56,27	25,10	13,4	11,3	9,2
			0.1	49,24	19,8	12,4	8,2	8,2
			0.25	29,15	13,6	8,3	6,2	4,1
		0.95	0.01	58,43	23,15	12,6	7,3	7,3
			0.05	45,34	18,12	9,5	6,3	5,2
			0.1	38,29	13,9	7,4	4,2	4,2
			0.25	24,19	11,8	5,3	4,2	4,2
	1	0.75	0.01	63,39	28,15	14,6	9,3	9,3
			0.05	47,30	20,11	9,4	8,3	6,2
			0.1	40,26	16,9	9,4	7,3	6,2
			0.25	27,18	10,6	6,3	5,2	3,1
		0.95	0.01	63,55	24,19	9,6	7,4	6,3
			0.05	50,44	16,13	7,5	5,3	4,2
			0.1	43,38	16,13	7,5	5,3	4,2
			0.25	30,27	12,10	4,3	3,2	3,2
(2.0,0.5,1.25)	0.75	0.75	0.01	42,13	22,5	14,2	11,1	11,1
			0.05	33,11	13,3	8,1	8,1	8,1
			0.1	26,9	12,3	7,1	7,1	4,1
			0.25	16,6	7,2	5,1	5,1	3,1
		0.95	0.01	27,15	12,5	7,2	6,1	6,1
			0.05	19,11	9,4	4,1	4,1	4,1
			0.1	17,10	8,4	4,1	4,1	4,1
			0.25	11,7	4,2	3,1	2,1	2,1
	1	0.75	0.01	28,15	13,5	8,2	6,1	6,1
			0.05	20,11	9,4	6,2	5,1	5,1
			0.1	19,11	7,3	4,1	4,1	2,1
			0.25	13,8	6,3	3,1	2,1	2,1
		0.95	0.01	24,19	9,6	5,2	3,1	3,1
			0.05	17,14	6,4	4,2	3,1	3,1
			0.1	17,14	6,4	2,1	2,1	2,1
			0.25	12,10	4,3	2,1	2,1	2,1

Table 6 OC Values for Weibull-Ralyeigh sampling plan

$\gamma=2.5, \sigma^2=1.5, c=0.75, p=0.85, c=2$						$\gamma=2.5, \sigma^2=1.5, c=0.75, p=0.90, c=2$					
		μ/μ_o						μ/μ_o			
n	A	2	3	4	5	n	A	2	3	4	5
16	0.4	0.5338	0.8377	0.9374	0.9724	16	0.4	0.4053	0.763	0.9024	0.9554
12	0.6	0.3375	0.7148	0.8778	0.9429	12	0.6	0.2185	0.6078	0.8174	0.9104
10	0.8	0.1996	0.5866	0.8042	0.903	10	0.8	0.1093	0.4615	0.7193	0.8527
8	1	0.1599	0.5369	0.7719	0.8844	8	1	0.0821	0.4089	0.6783	0.8266
7	1.2	0.1105	0.4615	0.7186	0.8521	7	1.2	0.0511	0.3332	0.6128	0.7826
6	1.4	0.0961	0.4338	0.697	0.8383	6	1.4	0.0429	0.307	0.5873	0.7643
5	1.6	0.1114	0.4581	0.7145	0.8491	5	1.6	0.0523	0.3311	0.6087	0.7789

$\gamma=2.5, \sigma^2=1.5, c=0.75, p=0.95, c=2$						$\gamma=2.5, \sigma^2=1.5, c=0.75, p=0.99, c=2$					
		μ/μ_o						μ/μ_o			
n	A	2	3	4	5	n	A	2	3	4	5
12	0.4	0.4383	0.7838	0.9125	0.9604	12	0.4	0.1731	0.5553	0.7845	0.8918
10	0.6	0.1861	0.5709	0.7943	0.8974	10	0.6	0.0362	0.2892	0.5718	0.7539
8	0.8	0.1072	0.4567	0.7154	0.8502	8	0.8	0.0139	0.1881	0.4577	0.6654
7	1	0.0535	0.3399	0.6189	0.7868	7	1	0.0043	0.1085	0.3409	0.5608
6	1.2	0.0368	0.287	0.5676	0.7501	6	1.2	0.0024	0.0803	0.2879	0.5068
5	1.4	0.0393	0.2915	0.5706	0.7516	5	1.4	0.0028	0.0839	0.2925	0.5102
4	1.6	0.0701	0.3684	0.6391	0.7987	4	1.6	0.0078	0.1315	0.3694	0.5834

$\gamma=1.5, \sigma^2=0.75, c=1.25, p=0.85, c=2$						$\gamma=1.5, \sigma^2=0.75, c=1.25, p=0.90, c=2$					
		μ/μ_o						μ/μ_o			
n	A	2	3	4	5	n	A	2	3	4	5
16	0.4	0.985	0.9991	0.9999	1	16	0.4	0.9752	0.9984	0.9998	1
12	0.6	0.915	0.9935	0.9991	0.9998	12	0.6	0.8698	0.989	0.9985	0.9997
10	0.8	0.7526	0.9744	0.9963	0.9992	10	0.8	0.654	0.9585	0.9936	0.9987
9	1	0.5036	0.9256	0.9877	0.9973	9	1	0.3746	0.8851	0.9795	0.9954
7	1.2	0.3966	0.8926	0.9811	0.9958	7	1.2	0.2717	0.8382	0.969	0.9928
6	1.4	0.2711	0.837	0.9686	0.9927	6	1.4	0.1644	0.7625	0.9495	0.9878
5	1.6	0.2162	0.8013	0.9597	0.9904	5	1.6	0.123	0.7162	0.9359	0.984

$\gamma=1.5, \sigma^2=0.75, c=1.25, p=0.95, c=2$						$\gamma=1.5, \sigma^2=0.75, c=1.25, p=0.99, c=2$					
		μ/μ_o						μ/μ_o			
n	A	2	3	4	5	n	A	2	3	4	5
12	0.4	0.9781	0.9986	0.9998	1	12	0.4	0.9366	0.9954	0.9994	0.9999
10	0.6	0.8521	0.9871	0.9982	0.9996	10	0.6	0.6685	0.9611	0.9941	0.9988
8	0.8	0.6497	0.9576	0.9935	0.9986	8	0.8	0.3754	0.8852	0.9795	0.9954
7	1	0.3959	0.8924	0.981	0.9958	7	1	0.144	0.7443	0.9446	0.9864
6	1.2	0.229	0.8119	0.9625	0.9912	6	1.2	0.0536	0.6012	0.8973	0.9728
5	1.4	0.1537	0.7497	0.9457	0.9867	5	1.4	0.0273	0.5076	0.8577	0.9602
4	1.6	0.1509	0.7404	0.9425	0.9858	4	1.6	0.0279	0.4973	0.851	0.9577