Journal of Reliability and Statistical Studies; ISSN (Print): 0974-8024, (Online): 2229 5666 Vol. 11, Issue 1 (2018): 103-115

ACCEPTANCE SAMPLING PLANS FROM TRUNCATED LIFE TESTS USING MARSHALL-OLKIN ESSCHER TRANSFORMED LAPLACE DISTRIBUTION

[1*]Amer I. Al-Omari, [2]Muhammad Aslam, and [3]Amjad D. Al-Nasser

[1]Department of Mathematics, Science Faculty, Al al-Bayt University, Mafraq, Jordan
[2]Department of Statistics, Faculty of Sciences, King Abdulaziz University, Jeddah, Saudi Arabia
[3]Department of Statistics, Science Faculty, Yarmouk University, Irbid, Jordan
[*]E Mail: alomari_amer@yahoo.com
*Corresponding Author

Received August 01, 2017
Modified March 06, 2018
Accepted May 09, 2018

Abstract

The problem of an acceptance sampling plans is considered in this paper when the lifetime follows a Marshall-Olkin Esscher Transformed Laplace Distribution (MOETL), for several values of an acceptance number, confidence levels and in addition to fixed ratio values to the particular mean lifetime. In the proposed sampling plan parameters including the minimum sample sizes, the operating characteristic function and producer's risk are calculated. A real data set is used as an illustrative example.

Key Words: Marshall-Olkin Esscher Transformed Laplace Distribution, Cramér–Von Mises Criterion, Anderson-Darling Criterion, Operating Characteristic Function, Akaike Information Criterion.

1. Introduction

The high quality standard of a given product is the main target of the industry now days. Every industry is trying best to improve the quality standards of product. Statistical quality control (SQC) techniques have been widely used in quality management decision. The control charts have been widely used to monitor the manufacturing process while inspection of finished product is done through acceptance sampling plan. The acceptance sampling plans have been used for the inspection of raw material to finished product. Inspection through a well designed acceptance sampling plan minimizes two types of risk; the producer 's risk and consumer's risk in addition to find the minimum sample size and minimize cost of inspection at the same time.

Due to high reliability product, it may impossible to wait for specified number of failures. Therefore, for the inspection of this type of product, time truncated life tests are performed. In this type of experiment, number of failure and time of experiment is fixed in advance. A random sample of items are selected and tested. Then the decision on a given lot of products is accepted if the number of failures is less than a pre-specified number within specified time. The life test is truncated as the number of failures is greater than the pre-specified number of failures or the time of experiment is terminated, whichever earlier first.

Since the failure of different products follow different statistical distribution. Therefore, several authors in the literature used various distributions to develop a new life time truncated tests. The problem of acceptance sampling based on truncated life tests was considered by many authors, Al-Omari (2014) considered acceptance sampling plans for three parameters Kappa distribution. Al-Nasser and Al-Omari (2013) investigated the problem when the product quality following the exponentiated Fréchet distribution. Al-Omari et al, (2016), discussed the same problem when the truncated distribution is Half Normal. Baklizi et al, (2005) developed new plans in case of Raleigh Model. Kantam et al. (2001) considered the log-logistic distribution for truncated life tests. Ramaswamy and Jayasri (2014) considered time truncated acceptance sampling plans for inverse Rayleigh distribution, Rosaiah and Kantam (2005) for the inverse Raleigh distribution. Aslam and Shabaz (2007) proposed an reliability test plans. More details about acceptance sampling can be found in Al-Nasser and Gogah (2017), Al-Omari et al (2017), Aslam and Jun (2013) and Al-Omari (2015).

The rest of the paper is organized as follows. The Marshall-Olkin Esscher transformed Laplace distribution with its properties are given in Section 2. In Section 3, the proposed sampling plan is given. The results are explained and discussed by some illustrative examples in Section 4. Conclusions are summarized in Section 5.

2. Marshall-Olkin Esscher Transformed Laplace Distribution

The Esscher transformed Laplace (ETL) probability density function (pdf) is given by

$$u(x)=\begin{cases}\dfrac{1-\theta^2}{2}Exp[x(1+\theta)], & x<0,-1<\theta<1,\\[2mm] \dfrac{1-\theta^2}{2}Exp[-x(1-\theta)], & x\geq 0,\end{cases}$$

and the corresponding cumulative distribution function (cdf) is

$$U(x)=\begin{cases}\dfrac{1-\theta}{2}Exp[x(1+\theta)], & x<0,-1<\theta<1,\\[2mm] \dfrac{1-\theta}{2}+\dfrac{1+\theta}{2}\{1-Exp[-x(1-\theta)]\}, & x\geq 0,\end{cases}$$

George and George (2013) used the method suggested by Marshall and Olkin (1997) to introduce a method of obtaining a new family of survival functions $\bar{F}(x)$ by adding a new parameter to the base distribution as

$$\bar{\Psi}(x)=\frac{\bar{F}(x)}{\beta+(1-\beta)\bar{F}(x)},\quad x\in R,\beta>0,$$

where $\bar{\Psi}(x) = \bar{F}(x)$ if $\beta = 0$. George and George (2013) suggested the Marshall-Olkin Esscher Transformed Laplace distribution (MOETLD) with probability density function defined as

$$f(x) = \frac{\lambda k}{1+k^2} \begin{cases} Exp\left(\frac{\lambda}{k}x\right), & x < 0 \\ Exp(-k\lambda x), & x \geq 0, \end{cases} \tag{1}$$

where $\lambda = \sqrt{\beta(1-\theta^2)}$ and $k = \frac{\lambda}{\theta + \sqrt{\lambda + \theta^2}}, |\theta| < 1$, $\beta > 0$. The cumulative distribution function of the MOETL distribution is given by

$$F(x) = \begin{cases} \frac{k^2}{1+k^2} Exp\left(\frac{\lambda}{k}x\right), & x < 0 \\ 1 - \frac{1}{1+k^2} Exp(-k\lambda x), & x \geq 0 \end{cases} \tag{2}$$

where $k > 0$ and $\lambda > 0$ are the parameters of the distribution. The rth raw moment of the MOETL distribution denoted by α_r is given by

$$\alpha_r = \frac{r!\left[1+(-1)^r k^{2(r+1)}\right]}{(\lambda k)^r (1+k^2)} \tag{3}$$

Therefore, the mean and variance of the MOETLD are

$$E(X) = \frac{1-k^2}{\lambda k}, \quad \text{and} \quad \sigma_X^2 = \frac{1+k^4}{\lambda^2 k^2} \tag{4}$$

.

The coefficient of skewness and kurtosis of the MOETLD, respectively, are given by

$$\wp_1 = \frac{4\theta^2 + 3\lambda^2}{2\theta^2}, \tag{5}$$

$$\wp_2 = 6 + \frac{8\theta^2\lambda^2 + 3\lambda^4}{2\theta^2}, \tag{6}$$

The MLEs of the MOETLD parameters are

$$\hat{\eta} = \frac{m}{-S_l + \sqrt{S_r(-S_l)}} \text{ and } \hat{\delta} = \frac{m}{S_r + \sqrt{S_l(-S_l)}}, \tag{7}$$

where $\delta\eta = \lambda^2$, $S_r = \sum_{(X_i \in D | X_i \geq 0)} X_i$, and $S_l = \sum_{(X_i \in D | X_i < 0)} X_i$. For more details see George and George (2013).

3. The suggested acceptance sampling plans

In this section, we develop a new acceptance sampling plans when lifetime distribution is MOETL distribution that defined by (1) and (2).

A sampling plan consists of the following quantities: (1) the number of units *n*, on test; (2) an acceptance number *c*, where if *c* or less failures obtained during the test time, the lot is accepted; (3) the maximum test duration time, *t*; (4) a ratio t / μ_0, where μ_0 is the specified average life.

The producer's risk can be defined in probability terms as the probability of rejecting the lot when $\mu \geq \mu_0$ (is fixed not to exceed $1 - P^*$), in which the true mean life is less the specified life mean μ_0.

3.1 Minimum sample size

In order to use the Binomial theory, we consider that the lot size is sufficiently large to obtain the probability of accepting a lot. Here, the problem is to find the minimum sample size *n* that satisfies a binomial inequality which can be written in the following form:

$$\sum_{i=0}^{c} \binom{m}{i} p^i (1-p)^{m-i} \leq 1 - P^*, \tag{8}$$

up to *c* for given values of P^* $\left(0 < P^* < 1\right)$, where $p = F(t; \mu_0)$ is the probability of a failure observed during the time *t* which depends only on the ratio t / μ_o.

If the number of observed failures during time *t* is at most *c*, then from (8) we can confirm with probability that $F\left(t;\mu\right) \leq F\left(t;\mu_0\right)$, which implies that $\mu_0 \leq \mu$.

Table 1 contained the smallest sample sizes that satisfying Inequality (8) with $t / \mu_o = 0.628$, 0.942, 1.257, 1.571, 2.356, 3.141, 3.927, 4.712 and $P^* = 0.75$, 0.9, 0.95, 0.99. These values of t / μ_o are consistent with the values of Gogah and Al-Nasser (2018), Kantam and Rosaiah (2001) and Baklizi et al. (2005).

3.2 Operating characteristic of the sampling plan $\left(m, c, t / \mu_0\right)$

The operating characteristic (OC) function of the sampling plan $\left(m, c, t / \mu_0\right)$ provides the probability of acceptance the lot and it is defined as

$$OC(p) = P(\text{Accepting a lot}) = \sum_{i=0}^{c} \binom{m}{i} p^i (1-p)^{m-i} = 1 - B_p(c+1, m-c), \tag{9}$$

For a given value of the producer's risk, say $\Re$, based on the new sampling plan, one may be interested in determining what smallest value of μ / μ_0 that will assert the producer's risk is at most $\Re$. The value of μ / μ_0 is the minimum positive number for which $p = F\left(\frac{t}{\mu_0} \frac{\mu_0}{\mu}\right)$ satisfies the inequality

$$PR(p) = \sum_{i=c+1}^{m} \binom{m}{i} p^i (1-p)^{m-i} \leq \Re. \tag{10}$$

For a given acceptance sampling plan $(m, c, t/\mu_0)$ at a given confidence level P^*, the smallest value of μ/μ_0 satisfying Inequality (11) are presented in Table 3.

4. Description of the tables and examples

Assume that an researcher wants to establish the true average life to be at least 1000 hours with confidence level of $P^* = 0.90$ and it is desired to stop the experiment at $t = 628$ hours with acceptance number $c = 2$. Then the minimum sample size from Table (1) is $n = 10$. This plan is implemented as: put 10 items on test for 628 hours, reject the lot if more than 2 failures are noted before specified time, otherwise accept the lot of the product. From Table (2), as an example for $P^* = 0.90$, $t/\mu_0 = 0.628$, the OC value is 0.466687 for $\mu/\mu_0 = 2$. From Table 2 the operating characteristic values for the sampling plan $(m, c, t/\mu_0) = (10, 2, 0.628)$ are as follows:

μ/μ_0	2	4	6	8	10	12
OC	0.466687	0.830618	0.929636	0.96457	0.979737	0.987334

This means that the producer's risk is 0.533313 when $\mu = 2\mu_0$, and it reduces to 0.169382 for $\mu = 3\mu_0$. However, the producer's risk close to zero for $\mu/\mu_0 \geq 6$.

For various values of c and t/μ_0 at producer's risk 0.05 we can get the values of μ/μ_0. For example, for $c = 2$, $t/\mu_0 = 0.628$, the value of μ/μ_0 is 6.940, that is, the product must have a mean life of 6.940 times of the specified average life in order to accept the lot with probability 0.95. Fig. 1 and Fig. 2 illustrate the variation in the sample sizes as well as the OC function for several values of the acceptance number and probability.

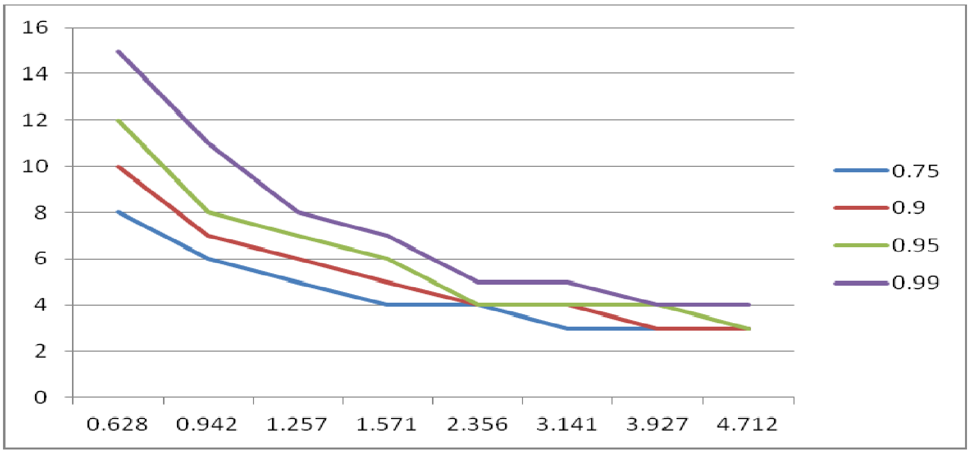

Fig. 1: Minimum Sample size Vs. t/μ_0 with probability P^* and acceptance number *c*=2

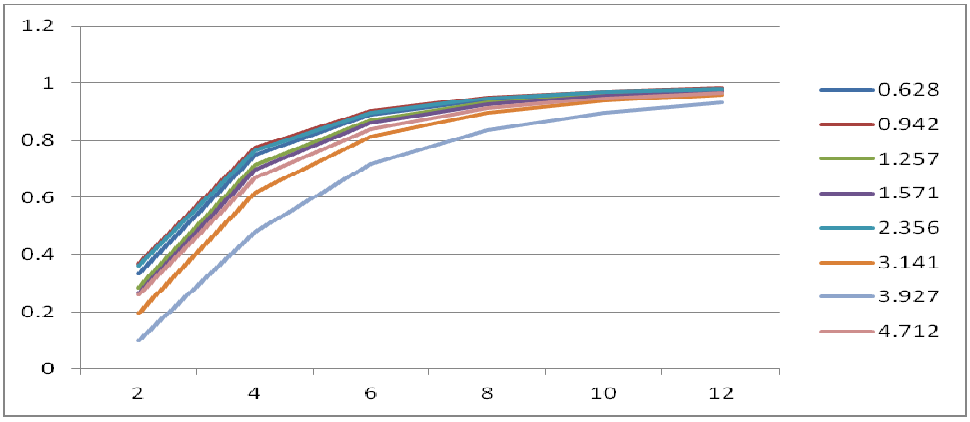

Fig. 2: OC function when P^* = 0.95 Vs. μ/μ_0 and acceptance number *c*

		t/μ_0							
P^*	c	0.628	0.942	1.257	1.571	2.356	3.141	3.927	4.712
0.75	0	3	2	2	1	1	1	1	1
	1	5	4	3	3	2	2	2	2
	2	8	6	5	4	4	3	3	3
	3	10	8	6	6	5	4	4	4
	4	13	9	8	7	6	5	5	5
	5	15	11	9	8	7	6	6	6
	6	17	13	11	10	8	8	7	7
	7	20	15	12	11	9	9	8	8
	8	22	17	14	12	10	10	9	9
	9	24	18	15	14	12	11	10	10
	10	27	20	17	15	13	12	11	11
0.90	0	4	3	2	2	1	1	1	1
	1	7	5	4	4	3	2	2	2
	2	10	7	6	5	4	4	3	3
	3	13	9	8	7	5	5	4	4
	4	15	11	9	8	7	6	5	5
	5	18	13	11	9	8	7	7	6
	6	21	15	12	11	9	8	8	7
	7	23	17	14	12	10	9	9	8
	8	26	19	16	14	11	10	10	9
	9	28	21	17	15	12	11	11	10
	10	30	23	19	16	14	12	12	11

0.95	0	5	4	3	2	2	1	1	1
	1	9	6	5	4	3	3	2	2
	2	12	8	7	6	4	4	4	3
	3	14	10	8	7	6	5	5	4
	4	17	12	10	9	7	6	6	5
	5	20	14	12	10	8	7	7	7
	6	23	16	13	12	9	8	8	8
	7	25	18	15	13	11	10	9	9
	8	28	20	17	15	12	11	10	10
	9	30	22	18	16	13	12	11	11
	10	33	24	20	17	14	13	12	12
0.99	0	8	5	4	3	2	2	2	1
	1	12	8	6	5	4	3	3	3
	2	15	11	8	7	5	5	4	4
	3	18	13	10	9	7	6	5	5
	4	21	15	12	10	8	7	6	6
	5	24	17	14	12	9	8	7	7
	6	27	19	16	13	11	9	9	8
	7	30	21	17	15	12	10	10	9
	8	33	23	19	16	13	12	11	10
	9	35	25	21	18	14	13	12	11
	10	38	28	22	19	16	14	13	12

Table 1: Minimum sample sizes necessary to assert the mean life to exceed a given value μ_0, with probability P^* and acceptance number *c*, under the MOETLD with $k = 0.03$

			μ / μ_0					
P^*	n	t / μ_0	2	4	6	8	10	12
0.75	8	0.628	0.628347	0.901487	0.961809	0.981451	0.989623	0.993610
	6	0.942	0.594152	0.887971	0.955957	0.978480	0.987929	0.992560
	5	1.257	0.562092	0.874144	0.949766	0.975273	0.986075	0.991397
	4	1.571	0.618460	0.896011	0.959300	0.980173	0.988908	0.993180
	4	2.356	0.362336	0.764731	0.896059	0.946028	0.968604	0.980184
	3	3.141	0.503297	0.838938	0.932177	0.965644	0.980316	0.987704
	3	3.927	0.365026	0.755448	0.889090	0.941503	0.965628	0.978158
	3	4.712	0.258572	0.668545	0.838904	0.911687	0.946824	0.965635
0.90	10	0.628	0.466687	0.830618	0.929636	0.96457	0.979737	0.987334
	7	0.942	0.473277	0.833681	0.931149	0.965438	0.980291	0.987716
	6	1.257	0.407901	0.797513	0.913496	0.955873	0.974598	0.984073
	5	1.571	0.417563	0.802066	0.915622	0.957015	0.975283	0.984518

	4	2.356	0.362336	0.764731	0.896059	0.946028	0.968604	0.980184
	4	3.141	0.193283	0.618644	0.811686	0.896083	0.937208	0.959331
	3	3.927	0.365026	0.755448	0.88909	0.941503	0.965628	0.978158
	3	4.712	0.258572	0.668545	0.838904	0.911687	0.946824	0.965635
0.95	12	0.628	0.331519	0.749688	0.888873	0.942042	0.966125	0.978513
	8	0.942	0.367666	0.773663	0.901487	0.949221	0.970566	0.981451
	7	1.257	0.284576	0.713615	0.869406	0.931022	0.959429	0.974188
	6	1.571	0.264947	0.696404	0.859632	0.925322	0.95589	0.971861
	4	2.356	0.362336	0.764731	0.896059	0.946028	0.968604	0.980184
	4	3.141	0.193283	0.618644	0.811686	0.896083	0.937208	0.959331
	4	3.927	0.097408	0.480584	0.716224	0.834137	0.89604	0.930948
	3	4.712	0.258572	0.668545	0.838904	0.911687	0.946824	0.965635
0.99	15	0.628	0.186465	0.621968	0.815552	0.898762	0.938918	0.960406
	11	0.942	0.154266	0.583000	0.791021	0.883731	0.929320	0.953989
	8	1.257	0.192514	0.627884	0.819382	0.901313	0.940715	0.961734
	7	1.571	0.160602	0.589449	0.795038	0.886287	0.931048	0.955220
	5	2.356	0.173747	0.601705	0.802147	0.890524	0.933743	0.957037
	5	3.141	0.064288	0.417773	0.668978	0.802188	0.874272	0.915683
	4	3.927	0.097408	0.480584	0.716224	0.834137	0.896040	0.930948
	4	4.712	0.047456	0.362336	0.618583	0.764731	0.847285	0.896059

Table 2: Operating characteristic values for the sampling plan $(n, c, t/\mu_0)$ for a given probability P^*, with acceptance number $c = 2$ under the MOETLD with $k = 0.03$

		t/μ_0							
P^*	c	0.628	0.942	1.257	1.571	2.356	3.141	3.927	4.712
0.75	0	38.735	38.031	50.749	31.147	46.71	62.274	77.857	93.42
	1	7.981	9.245	8.69	10.86	9.334	12.444	15.558	18.668
	2	5.368	5.693	6.012	5.509	8.262	6.843	8.556	10.266
	3	3.882	4.411	3.979	4.973	5.624	4.908	6.137	7.363
	4	3.482	3.262	3.689	3.769	4.354	3.943	4.929	5.915
	5	2.976	2.983	2.976	3.075	3.613	3.364	4.206	5.047
	6	2.645	2.790	2.924	3.146	3.128	4.170	3.722	4.466
	7	2.574	2.646	2.539	2.749	2.786	3.714	3.375	4.049
	8	2.377	2.535	2.542	2.457	2.531	3.375	3.112	3.734
	9	2.226	2.265	2.291	2.552	2.856	3.112	2.906	3.486
	10	2.210	2.214	2.312	2.340	2.644	2.901	2.739	3.286
0.90	0	52.621	58.103	50.749	63.426	46.71	62.274	77.857	93.42
	1	11.63	11.971	12.336	15.417	16.287	12.444	15.558	18.668
	2	6.940	6.874	7.596	7.514	8.262	11.015	8.556	10.266

	3	5.289	5.118	5.885	6.170	5.624	7.498	6.137	7.363
	4	4.132	4.245	4.352	4.610	5.652	5.804	4.929	5.915
	5	3.711	3.726	3.981	3.719	4.612	4.816	6.021	5.047
	6	3.425	3.380	3.325	3.654	3.939	4.170	5.213	4.466
	7	3.056	3.134	3.203	3.173	3.470	3.714	4.643	4.049
	8	2.923	2.949	3.104	3.177	3.123	3.375	4.219	3.734
	9	2.698	2.804	2.781	2.863	2.856	3.112	3.890	3.486
	10	2.521	2.688	2.742	2.617	3.084	2.901	3.627	3.286
0.95	0	67.041	78.932	77.532	63.426	95.118	62.274	77.857	93.42
	1	15.308	14.703	15.974	15.417	16.287	21.713	15.558	18.668
	2	8.516	8.052	9.172	9.493	8.262	11.015	13.771	10.266
	3	5.758	5.823	5.885	6.170	7.458	7.498	9.374	7.363
	4	4.782	4.735	5.010	5.439	5.652	5.804	7.256	5.915
	5	4.200	4.095	4.477	4.350	4.612	4.816	6.021	7.225
	6	3.814	3.674	3.722	4.155	3.939	4.170	5.213	6.255
	7	3.378	3.377	3.531	3.590	4.122	4.625	4.643	5.571
	8	3.195	3.155	3.382	3.530	3.684	4.163	4.219	5.062
	9	2.934	2.982	3.023	3.171	3.349	3.807	3.89	4.668
	10	2.832	2.845	2.954	2.889	3.084	3.525	3.627	4.352
0.99	0	113.83	100.561	105.326	96.899	95.118	126.81	158.543	93.42
	1	20.891	20.197	19.620	19.965	23.121	21.713	27.147	32.573
	2	10.888	11.591	10.745	11.463	11.268	15.023	13.771	16.523
	3	7.638	7.934	7.769	8.534	9.253	9.943	9.374	11.248
	4	6.082	6.198	6.318	6.261	6.913	7.535	7.256	8.707
	5	5.179	5.199	5.464	5.595	5.577	6.148	6.021	7.225
	6	4.592	4.553	4.903	4.652	5.480	5.252	6.566	6.255
	7	4.180	4.102	4.182	4.412	4.758	4.625	5.783	5.571
	8	3.875	3.770	3.935	3.880	4.229	4.911	5.204	5.062
	9	3.522	3.516	3.742	3.778	3.826	4.464	4.760	4.668
	10	3.349	3.470	3.377	3.426	3.924	4.111	4.407	4.352

Table 3: Minimum ratio of true mean life to specified life for the acceptability of a lot with producer's risk of 0.05 and under MOETLD with $k = 0.03$

In Table (4), we summarized the minimum sample sizes obtained by other researchers for different distributions. However, for fixed probability and an acceptance number, we noted that the minimum sample sizes based on the suggested sampling plans are less than their counterparts obtained by Baklizi and El Masri (2004) for the Birnbaum Saunders distribution, Kantam et al. (2001) for the log-logistic model, and Balakrishnan et al. (2007) for the Generalized Birnbaum–Saunders Distribution.

		t/μ_0							
	c	0.628	0.942	1.257	1.571	2.356	3.141	3.927	4.712
Baklizi and El Masri (2004)	0	12	8	6	5	3	3	2	2
	1	18	11	8	7	5	4	4	3
	2	23	15	11	9	7	6	5	5
	3	28	18	13	11	8	7	6	6
	4	33	21	16	13	10	8	7	7

	5	37	23	18	15	11	10	9	8
	6	42	26	20	17	13	11	10	9
	7	46	29	22	19	14	12	11	10
	8	50	32	24	21	16	14	12	12
	9	54	34	27	22	17	15	14	13
	10	58	37	29	24	19	16	15	14
Kantam et al. (2001)	0	14	8	5	4	3	2	2	2
	1	21	11	8	6	5	4	4	3
	2	27	15	10	8	6	5	5	5
	3	32	18	13	10	8	7	6	6
	4	37	21	15	12	9	8	7	7
	5	43	24	17	14	11	9	9	8
	6	47	27	19	16	12	10	10	9
	7	52	29	21	17	13	12	11	10
	8	57	32	23	19	15	13	12	12
	9	62	35	25	21	16	14	13	13
	10	66	38	27	23	17	15	14	14
Balakrishnan et al. (2007)	0	12	8	6	5	3	3	2	2
	1	18	11	9	7	5	4	4	4
	2	23	15	11	9	7	6	5	5
	3	27	18	14	11	9	7	7	6
	4	32	21	16	13	10	9	8	8
	5	36	23	18	15	12	10	9	9
	6	40	26	20	17	13	12	11	10
	7	44	29	23	19	15	13	12	11
	8	48	32	25	21	16	14	13	12
	9	52	34	27	23	18	16	14	14
	10	56	37	29	25	19	17	16	15

Table 4: Minimum sample sizes obtained by other researchers with probability $P^* = 0.99$

4. An Application

In this section, we consider an example with real data set to illustrate the proposed acceptance sampling plan. This data set represents the thirty ($n = 30$) successive values of March precipitation (in inches) given by Hinkley (1977) where the data are 0.32, 0.47, 0.52, 0.59, 0.77, 0.81, 0.81, 0.9, 0.96, 1.18, 1.2, 1.2, 1.31, 1.35, 1.43, 1.51, 1.62, 1.74, 1.87, 1.89, 1.95, 2.05, 2.1, 2.2, 2.48, 2.81, 3, 3.09, 3.37, 4.75. The descriptive statistics for the data are $\mu = 1.675$, $\sigma^2 = 1.00123$, $Q_1 = 0.9$, $Q_2 = 1.47$, $Q_3 = 2.1$.

We first verify whether the Marshall-Olkin Esscher transformed Laplace distribution fits the given data set. The values of the criterion, Cramér–von Mises criterion (C-M), Anderson-Darling criterion (A-D), Bayesian Information criterion (BIC), Consistent Akaike Information criterion (CAIC), Akaike Information criterion (AIC), the maximized log-likelihood (MLL), and Hannan-Quinn Information criterion (HQIC) are obtained and summarized in Table (5) where

$$\text{AIC} = -2MLL + 2q \,,\ \text{CAIC}=-2MLL+\frac{2qn}{n-q-1} \,,\ \text{BIC} = -2MLL + qLog(n) \,,$$

$$\text{HQIC} = 2Log\left[Log(n)(q - 2MLL)\right],$$

where q is the number of parameters and n is the sample size.

AIC	CAIC	BIC	HQIC	W
94.99685	95.44129	97.79924	95.89336	0.01356112

A-D	K-S	-2MLL
0.1027043	0.2358657	45.49842

Table 5: The AIC, CAIC, BIC, HQIC, *W, A-D,* K-S, and -2MLL for the successive values of March precipitation data

The Kolmogorov-Smirnov test is fitted by these eleven observations as the K-S is 0.2358657 with p-value is 0.07101557, where this p-value indicated that the Marshall-Olkin Esscher transformed Laplace distribution as a reasonable goodness-of-fit for these thirty observations.

We used the method of maximum likelihood estimation (MLE) for estimating the unknown parameters of the distribution, and the respective standard deviations (S-D) and confidence intervals (CI) are obtained based on the successive values of March precipitation data, and the results are given in Table (6).

Parameter	MLE	S-D	Inf. 95% CI	Sup. 95% CI
$\hat{k}$	0.028304	0.094981	-0.157851	0.214458
$\hat{\lambda}$	21.105267	70.967954	-117.989366	160.199900

Table 6: The MLEs of the parameters, standard deviation and CI for the successive values of March precipitation data

The MLE of the unknown parameters of the MOETL distribution for these observations is $\hat{k} = 0.028304$ and $\hat{\lambda} = 21.105267$. Therefore,

$$\hat{\mu}_0 = \frac{1-(0.028304)^2}{(0.028304)(21.105267)} = 1.67268 \,.$$

Assume that the experimenter hope to stop the experiment at 1050 hours with confidence $P^* = 0.99$. Since $\hat{\mu}_0 = 1.67268$, therefore from Table (1), the t/μ_0 is 0.628 and the correspondence acceptance sampling number is $c = 7$, and because the number of successive values of March precipitation data are will more than 7, the researcher reject the lot.

5. Conclusions

In this paper, the Marshall-Olkin Esscher Transformed Laplace Distribution is introduced in the area of acceptance sampling plan. The tables are preselected obtained through the non-linear optimization solution for practical use in the industry. The efficiency of the proposed sampling plan is compared with the new sampling plans in terms of sample size. The proposed plan provides the smaller sample size as compared to existing sampling plans. The inspection of items using the proposed sampling plan will be more economic than the existing sampling plans. The proposed plan can be used in any electronic industry for the testing of lots. Also, the proposed plan using the cost model as well as analysis of failure time of the same distribution can be considered as future research.

Acknowledgments

The authors would like to thank the reviewers for their valuable suggestions that improved the quality of paper.

References

1. Al-Nasser, A.D. and Al-Omari, A.I. (2013). Acceptance sampling plan based on truncated life tests for exponentiated Frechet distribution, Journal of Statistics and Management Systems, 16(1), p. 13-24.
2. Al-Nasser, A.D. and Gogah, F. (2017). On using the median ranked set sampling for developing reliability test plans under generalized exponential distribution, Pakistan Journal of Statistics and Operation Research. 13(4), p. 757 -774.
3. Al-Omari, A., Al-Nasser, A.D. & Gogah, F. (2016). Double acceptance sampling plan for time truncated life tests based on transmuted new Weibull-Pareto distribution, Electronic Journal of Applied Statistical Analysis, *9*(3), p. 520 - 529.
4. Al-Omari, A.I. (2015). Time truncated acceptance sampling plans for generalized inverted exponential distribution, Electronic Journal of Applied Statistical Analysis, 8(1), p. 1-12.
5. Al-Omari, A.I., Al-Nasser, A.D., Gogah, F. and Haq, M.A. (2017). On exponentiated generalized inverse Rayleigh distribution based on truncated life tests in double acceptance sampling plan, Stochastics and Quality Control, 32(1), p. 37- 48.
6. Al-Omari, A.I. (2014). Acceptance sampling plan based on truncated life tests for three parameter kappa distribution, Stochastics and Quality Control, 29(1), p. 53-62.

7. Al-Omari, A.I. (2015). Time truncated acceptance sampling plans for generalized inverted exponential distribution, Electronic Journal of Applied Statistical Analysis, 8(1), p. 1-12.
8. Aslam, M. and Shabaz, M.Q. (2007). Economic reliability test plans using the generalized exponential distribution, Journal of Statistics, 14, p. 53 - 60.
9. Aslam, M., & Jun, C. (2013). Designing of time truncated acceptance sampling plans by using two-point approach, Electronic Journal Of Applied Statistical Analysis, *6*(1), p. 18-31.
10. Baklizi, A., and El Masri, A. and Al-Nasser, A.D. (2005). Acceptance sampling plans in the Raleigh model, The Korean Communications in Statistics, April 2005. 12 (1), p. 11-18.
11. Balakrishnan, N., Leiva, V. and Lopez, J. (2007). Acceptance sampling plans from truncated life tests based on the generalized Birnbaum–Saunders distribution, Communications in Statistics—Simulation and Computation, 36, p. 643–656.
12. Georgea, D. and Georgea, S. (2013). Marshall–Olkin Esscher transformed Laplace distribution and processes, Brazilian Journal of Probability and Statistics, 27(2), p. 162–184.
13. Gogah F., and Al-Nasser A.D. (2018). Median ranked acceptance sampling plans for exponential distribution, Afrika Matematika, https://doi.org/10.1007/s13370-018-0555-7
14. Hinkley, D. (1977). On quick choice of power transformations, The American Statistician, 26: p. 67–69.
15. Kantam, R.R.L., Rosaiah, K. and Rao, G.S. (2001). Acceptance sampling based on life tests: log-logistic model, Journal of Applied Statistics, 28, p. 121–128.
16. Ramaswamy, A.R.S. and Jayasri, S. (2014). Time truncated chain sampling plans for inverse Rayleigh distribution, International Journal of Engineering Inventions, 3(6), p. 41-45.
17. Rosaiah, K. and Kantam, R.R.L. (2005). Acceptance sampling based on the inverse Rayleigh distribution, Economic Quality Control, 20, p. 277- 286.