



Repetitive Acceptance Sampling Plan for Truncated Life Test Using New Rayleigh Pareto Distribution

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ARTICLE INFO	ABSTRACT
Published Online: 05 August 2026	In this paper, we present a repetitive acceptance sampling plan for the new Rayleigh Pareto distribution based on truncated life test with known shape parameter. The design parameters such as sample size and acceptance number are formulated by considering the median life time of the test units as a quality parameter. The values of the design parameter are obtained under the constraint of two risks, known as the producer's risk and consumer's risk at a certain level. We present a detailed study to assist the proposed methods with the help of tables at different values of the known parameters. A comparison is done between the proposed plan and the single acceptance plan. The implementation of the proposed plan is explained with the help of real life data.
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KEYWORDS: Producer's risk, Consumer's risk, repetitive acceptance sampling plan, truncated life test, single acceptance sampling plan, quality level	

1. INTRODUCTION

The quality of the product is the most important aspect of the production field. So, the manufacture's center of attention is the quality of the product which helps to build the reputation of the firm. Scrutiny of the product is also mandatory to safeguard the product quality before the product enters into the market. However, investigation of all the items of the production may not be possible due to time restriction, survey error, and cost. In such cases, apply acceptance sampling inspection which is one of the major elements of statistical quality control. In acceptance sampling, only a few items are chosen at random from the submitted lot and according to the results of random sample items, the entire lot is either accepted or rejected. Acceptance sampling plans have become very useful in today's fast-growing industrial environment to check the life time of a product. Quality of any product is a very important feature, both for the producer and the consumer. Whatever acceptance sampling plans have implemented the producer's and consumer's risks are always associated with the lot decision. The probability of rejecting a good lot is called producer's risk (α) and the chance of accepting a bad

lot is called consumer's risk (β). A sampling plan works well if both the risks are reduced and it saves the time and cost both.

In addition, the life test can be conducted for the pre-assigned time and such type of life test is called as truncated life test. One of the truncated life tests is the single acceptance sampling plan which has two design parameters, namely sample size n and acceptance number c . In single sampling plans, a random sample of n units is placed on a life test for pre-decided time t_0 . Now, our main task is to accept or reject the whole lot from which the sample is taken. If during the test total number of observed failures is less than or equal to c then the lot is accepted, otherwise the experiment is stopped and lot is rejected.

Many researchers have done studies on the truncated life test for various statistical distributions. Single acceptance sampling plans have been developed by [1] for Weibull distribution and by [2] for normal and log-normal distribution. Carrying on with the identical approach by [3] studied the double sampling for assuring the mean life of the product based on truncated life tests under Maxwell distribution. [4] worked on double acceptance sampling

plans with zero one failure proposal, in which a lot is accepted if no failures are observed from the first sample and it is rejected if two or more failure is observed. These researchers developed the plan for generalized log-logistic distribution. According to [5] classification of acceptance sampling plans, special purpose sampling plans dominate a lot. Repetitive group sampling plan (RGSP), Multiple deferred state (MDS) sampling plan number among the special purpose plans. Sherman [6] initiated another sampling plan called repetitive acceptance sampling plan (RASP) which is an attribute sampling plan. According to him, this plan gave results for the sample size which are less than an optimal sample size given by the single acceptance sampling plan. Many researchers have compared these two sampling plans. Recently [7] designed RASP for generalized inverted exponential distribution based on truncated life test and found that it gives better results than single acceptance sampling plan. Also

$$F(t; \sigma, \lambda, \gamma) = 1 - e^{-\frac{1}{2\sigma^2} \left(\frac{t}{\lambda}\right)^{2\gamma}}, t > 0, \sigma, \lambda, \gamma > 0 \quad (1)$$

$$f(t; \sigma, \lambda, \gamma) = \frac{\gamma}{\sigma^2 \lambda} \left(\frac{t}{\lambda}\right)^{2\gamma-1} e^{-\frac{1}{2\sigma^2} \left(\frac{t}{\lambda}\right)^{2\gamma}}, t > 0, \sigma, \lambda, \gamma > 0 \quad (2)$$

where λ, σ are known as scale parameters and γ is the shape parameter

3. REPETITIVE ACCEPTANCE SAMPLING PLAN (RASP)

The operating procedure of repetitive acceptance sampling plan (RASP) under truncated life test is described as follows:

Step 1: Sample of size n is selected at random from a submitted lot and put on a life test, until a specified time t_0 .

Step 2: Lot is accepted if the number of failures (d) by the time t_0 , d is smaller than or equal to c_1 (which is called the acceptance number). Truncate the test and reject the lot as soon as the number of failures exceeds c_2 , where $c_2 \geq c_1$.

$$OC = P_A(p) = \frac{P_a(p)}{P_a(p) + P_r(p)}; 0 < p < 1 \quad (3)$$

where $P_a(p)$ is the probability of acceptance of lot fraction defective (p) for the given sample. Similarly, $P_r(p)$ is the probability of rejecting lot, these probabilities can be calculated as follows;

$$P_a(p) = P(d \leq c_1 | p) = \sum_{d=0}^{c_1} \binom{n}{d} p^d (1-p)^{n-d} \quad (4)$$

and

$$P_r(p) = P(d > c_2 | p) = 1 - \sum_{d=0}^{c_2} \binom{n}{d} p^d (1-p)^{n-d} \quad (5)$$

where d denotes the number of failures by time t_0 . Then the OC function in the equation (3) becomes

[8],[9],[10],[11], [12], [13],[14], [15],[16] are discussed on RASP. In this paper, we are using median life time as a quality level, developed the repetitive acceptance sampling plan based on truncated life test using the new Rayleigh Pareto distribution. In this paper, we discussed in Section 2, introduction of the NRPD. The design of repetitive acceptance sampling plan in Section 3, In Section 4, we presented data analysis with real data illustration. In Section 5, comparative study and finally summary and conclusions are given in Section 6.

2. NEW RAYLEIGH PARETO DISTRIBUTION

The NRPD was introduced and developed by Kareema Abed Al-Kadim and Bnadher Dhea'a Mohammed [17]. The probability distribution function (DF) and probability density function (pdf) of New Rayleigh Pareto distribution are respectively given by

Step 3: If $c_1 < d \leq c_2$, then go to step 1 and experiment is repeated.

The above procedure of attribute repetitive acceptance sampling plan (RASP) mainly depends on three characteristics those are namely n , c_1 and c_2 . When $c_1 = c_2$, then this plan reduces to acceptance sampling plan.

The performance of any examining arrangement can be justified by its performance measures. The probability of lot acceptance is determined by using the operating characteristic (OC) function, which is derived to be:

$$P_A(p) = \frac{\sum_{d=0}^{c_1} \binom{n}{d} p^d (1-p)^{n-d}}{\sum_{d=0}^{c_1} \binom{n}{d} p^d (1-p)^{n-d} + 1 - \sum_{d=0}^{c_2} \binom{n}{d} p^d (1-p)^{n-d}} \quad (6)$$

For convenience, express the termination time t_0 as a multiple of the specified length t_q^0 i.e., $t_0 = \delta_q^0 t_q^0$, such that where δ_q^0 is a constant.

In order to find the design parameters n , c_1 and c_2 for the proposed RASP, we take the help of two points on the OC curve and the quality level is mainly depending on the ratio t_q/t_q^0 . This ratio is helpful for the producer to improve the lot quality. Producer point of view, the probability of

acceptance should be at least $1-\alpha$ at acceptable quality level (AQL), p_1 . So, the producer demands the lot should be accepted at various levels of t_q/t_q^0 . Similarly, in consumer point of view the lot rejection probability should not be exceed β at limiting quality level (LQL), p_2 . The design parameters are determined by satisfying the following two inequalities

$$P_a(p_1) = \frac{\sum_{d=0}^{c_1} \binom{n}{d} p_1^d (1-p_1)^{n-d}}{\sum_{d=0}^{c_1} \binom{n}{d} p_1^d (1-p_1)^{n-d} + 1 - \sum_{d=0}^{c_2} \binom{n}{d} p_1^d (1-p_1)^{n-d}} \geq 1-\alpha \quad (7)$$

$$P_a(p_2) = \frac{\sum_{d=0}^{c_1} \binom{n}{d} p_2^d (1-p_2)^{n-d}}{\sum_{d=0}^{c_1} \binom{n}{d} p_2^d (1-p_2)^{n-d} + 1 - \sum_{d=0}^{c_2} \binom{n}{d} p_2^d (1-p_2)^{n-d}} \leq \beta \quad (8)$$

where p_1 and p_2 are given by

$$p_1 = 1 - \exp \left(-\frac{1}{2\sigma^2} \left(\frac{\eta_q \delta_q^0}{\left(\frac{t_q}{t_q^0} \right)} \right)^{2\gamma} \right) \quad \text{and} \quad p_2 = 1 - \exp \left(-\frac{1}{2\sigma^2} \left(\eta_q \delta_q^0 \right)^{2\gamma} \right)$$

The estimated design parameters of the proposed plan should be determined by minimizing the average sample number (ASN) at limiting quality level (LQL). For the proposed RASP, the minimum ASN is required to make a decision to accept or reject the lot and it is given by;

$$ASN(p) = \frac{n}{P_a(p) + P_r(p)} \quad (9)$$

As a result, the desired design parameters can be obtained by solving the optimization problem as defined below;

Minimize $ASN(p)$

Subjection to constraints

$$P_a(p_1) \geq 1-\alpha \quad (10)$$

$$P_a(p_2) \leq \beta \quad (11)$$

$$0 \leq c_1 \leq c_2$$

where n, c_1, c_2 are positive integers.

In Tables 1 to 3, and estimated parameters of the proposed RASP in table 4, we presented optimal design parameters of the proposed RASP of NRPD in Tables 1 to 4 for different combinations of parameter values i.e.,

$\sigma = 1.5, \gamma = 1.5; \sigma = 2.0, \gamma = 1.5; \sigma = 1.5, \gamma = 2.0$ and $\sigma = 194.9336, \gamma = 0.8022$ and $\delta_q^0 = 0.5, 1.0$, for different levels of consumer's risk $\beta = 0.25, 0.10, 0.05, 0.01$ with $\alpha = 0.05$ for the quality level $t_q/t_q^0 = 2, 4, 6, 8, 10$. The average sample number (ASN) values are also presented in Tables 1 to 4.

4. DATA ANALYSIS

4.1 Description of proposed plan of real data illustration

In this section, we present the application of the proposed plan RASP for a real data set given by Picciotto [18] and arose in a test on the cycle at which the yarn failed. The data describes the number of cycles until failure of the yarn (100 units).

15, 20, 20, 38, 38, 40, 40, 42, 55, 55, 61, 61, 65, 71, 76, 81, 86, 88, 90, 93, 98, 105, 121, 124, 124, 131, 135, 135, 137, 143, 146, 149, 151, 157, 166, 169, 175, 176, 180, 180, 180, 182, 185, 185, 186, 188, 188, 193, 194, 195, 196, 198, 198, 203, 203, 211, 220, 224, 229, 229, 236, 239, 244, 246, 246, 249, 250, 251, 262, 264, 264, 264, 277, 279, 282, 284, 286, 290, 292, 315, 321, 325, 337, 338, 341, 350, 353, 364, 393, 396, 398, 400, 400, 423, 497, 568, 571, 597, 653, 829.

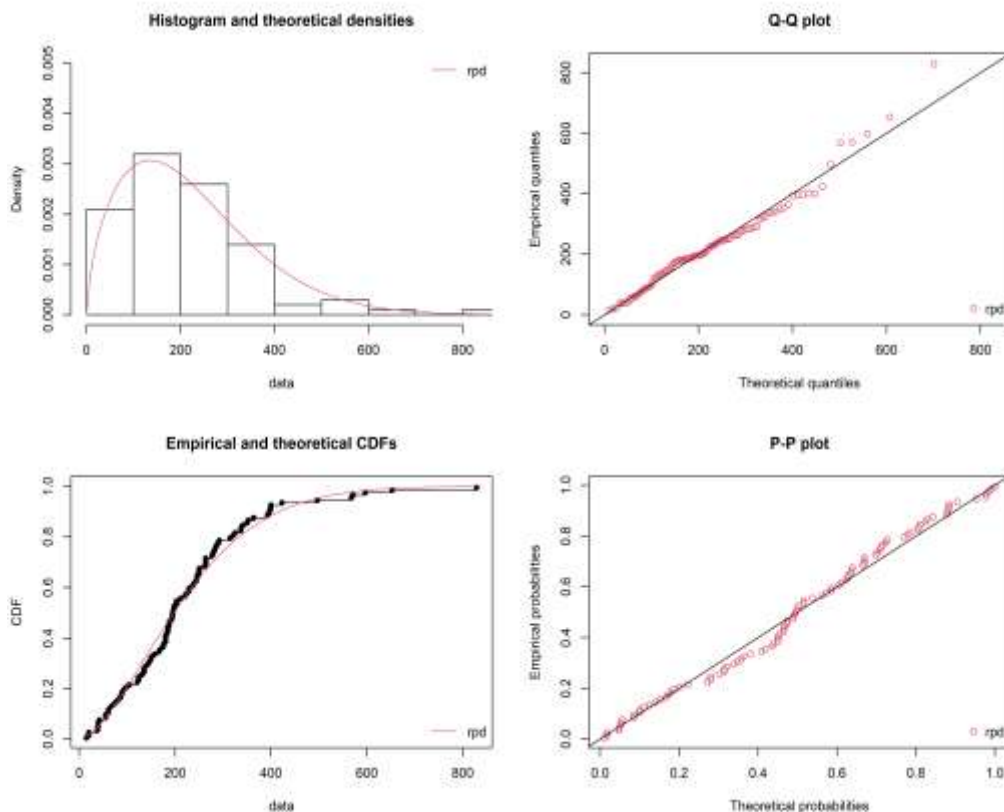


Figure 4.1: Theoretical and Empirical probability density function, Q-Q plot and Empirical and theoretical CDFs, P-P plot for cycles until yarn failure data.

The maximum likelihood estimates (MLEs) of the parameters are obtained $\sigma = 194.9336, \gamma = 0.8021$. To test the goodness of fit, we apply the Kolmogorov-Smirnov test, we determine that the maximum distance between the data and the fitted of the NRPD is 0.0756 with p-value is 0.6165, the NRPD provides reasonable fit for the real data set for cycles until yarn failure data.

5. COMPARATIVE STUDY

We compare the acceptance sampling plan (ASP) and Repetitive sampling plan with 50th percentile for the parameter values $\sigma = 2.0, \gamma = 1.5, \beta = 0.01, \delta_q^0 = 1.0, t_q/t_q^0 = 2, c_2 = c$ (say) = 2 and

the sample size $n=8$, $ASN=9.31$ are in RASP, in acceptance sampling plan (ASP) by taking above parameter values and for $\beta = 0.01, \delta_q^0 = 1.0, t_q/t_q^0 = 2$, the sample size $n= 17$ and these are presented in Table 5. Hence, RASP is better than the ASP with respect to sample size. Also, we observed that in all cases, sample size is minimum in RASP for $t_q/t_q^0 = 2$ and maximum sample size in ASP remaining sample sizes are same in both the plans. So, we conclude that both the plans are recommended for $t_q/t_q^0 > 2$.

6. SUMMARY AND CONCLUSIONS

In this article, we present RASP for truncated life test when the life time of a product follows NRPD. We determine the

values of design parameters by considering the median lifetime (50th percentile) the product which satisfies both the producer's risk (α) and consumer's risk (β). A comparative study is done with the acceptance sampling plan (ASP). Moreover, the sample size can be significantly reduced by allowing just a small number of in the proposed sampling plan. It is also observed that the proposed RASP

has smaller sample size than the acceptance sampling plan. Also, we observed that in all cases first sample size is minimum in RASP for $t_q/t_q^0 = 2$ and maximum sample size in ASP remaining sample sizes are same in both the plans. So, we conclude that both the plans are recommended $t_q/t_q^0 > 2$.

Table 1: The Plan parameters of the RASP with minimum average sample number (ASN) and probability of acceptance for NRPD with 50th percentile for $\sigma = 1.5, \gamma = 1.5$.

$\delta_q^0 = 0.5$							$\delta_q^0 = 1.0$				
β	t_q/t_q^0	c_1	c_2	n	$P_A(p)$	ASN	c_1	c_2	n	$P_A(p)$	ASN
0.25	2	0	1	21	0.9740	30.35	0	1	3	0.9753	4.80
	4	0	1	21	0.9996	30.35	0	1	3	0.9996	4.80
	6	0	1	21	1.0000	30.35	0	1	3	1.0000	4.80
	8	0	1	21	1.0000	30.35	0	1	3	1.0000	4.80
	10	0	1	21	1.0000	30.35	0	1	3	1.0000	4.80
0.10	2	1	2	48	0.9836	56.10	0	1	4	0.9504	5.33
	4	0	1	73	0.9992	37.59	0	1	4	0.9993	5.33
	6	0	1	73	0.9999	37.59	0	1	4	0.9999	5.33
	8	0	1	73	1.0000	37.59	0	1	4	1.0000	5.33
	10	0	1	73	1.0000	37.59	0	1	4	1.0000	5.33
0.05	2	0	2	40	0.9860	42.81	0	2	6	0.9844	8.93
	4	0	1	37	0.9988	42.81	0	1	5	0.9988	5.93
	6	0	1	37	0.9999	42.81	0	1	5	0.9999	5.93
	8	0	1	37	1.0000	42.81	0	1	5	1.0000	5.93
	10	0	1	37	1.0000	42.81	0	1	5	1.0000	5.93
0.01	2	0	2	55	0.9622	64.41	0	2	8	0.9555	9.31
	4	0	1	54	0.9973	56.57	0	1	7	0.9975	7.40
	6	0	1	54	0.9999	56.57	0	1	7	0.9998	7.40
	8	0	1	54	1.0000	56.57	0	1	7	1.0000	7.40
	10	0	1	54	1.0000	56.57	0	1	7	1.0000	7.40

Table 2: The Plan parameters of the RASP with minimum average sample number (ASN) and probability of acceptance for NRPD with 50th percentile for $\sigma = 2.0, \gamma = 1.5$.

$\delta_q^0 = 0.5$							$\delta_q^0 = 1.0$				
β	t_q/t_q^0	c_1	c_2	n	$P_A(p)$	ASN	c_1	c_2	n	$P_A(p)$	ASN
0.25	2	0	1	21	0.9740	30.35	0	1	3	0.9753	4.80
	4	0	1	21	0.9996	30.35	0	1	3	0.9996	4.80
	6	0	1	21	1.0000	30.35	0	1	3	1.0000	4.80
	8	0	1	21	1.0000	30.35	0	1	3	1.0000	4.80
	10	0	1	21	1.0000	30.35	0	1	3	1.0000	4.80
0.10	2	1	2	48	0.9836	56.10	0	1	4	0.9504	5.33
	4	0	1	73	0.9992	37.59	0	1	4	0.9993	5.33
	6	0	1	73	0.9999	37.59	0	1	4	0.9999	5.33
	8	0	1	73	1.0000	37.59	0	1	4	1.0000	5.33
	10	0	1	73	1.0000	37.59	0	1	4	1.0000	5.33
0.05	2	0	2	40	0.9860	42.81	0	2	6	0.9844	8.93
	4	0	1	37	0.9988	42.81	0	1	5	0.9988	5.93
	6	0	1	37	0.9999	42.81	0	1	5	0.9999	5.93

	8	0	1	37	1.0000	42.81	0	1	5	1.0000	5.93
	10	0	1	37	1.0000	42.81	0	1	5	1.0000	5.93
0.01	2	0	2	55	0.9622	64.41	0	2	8	0.9555	9.31
	4	0	1	54	0.9973	56.57	0	1	7	0.9975	7.40
	6	0	1	54	0.9999	56.57	0	1	7	0.9998	7.40
	8	0	1	54	1.0000	56.57	0	1	7	1.0000	7.40
	10	0	1	54	1.0000	56.57	0	1	7	1.0000	7.40

Table 3: The Plan parameters of the RASP with minimum average sample number (ASN) and probability of acceptance for NRPD with 50th percentile for $\sigma = 1.5, \gamma = 2.0$.

$\delta_q^0 = 0.5$							$\delta_q^0 = 1.0$				
β	t_q/t_q^0	c_1	c_2	n	$P_A(p)$	ASN	c_1	c_2	n	$P_A(p)$	ASN
0.25	2	0	1	41	0.9937	59.18	0	1	3	0.9940	4.8
	4	0	1	41	0.9999	59.18	0	1	3	0.9996	4.8
	6	0	1	41	0.9999	59.18	0	1	3	0.9999	4.8
	8	0	1	41	1.0000	59.18	0	1	3	1.0000	4.8
	10	0	1	41	1.0000	59.18	0	1	3	1.0000	4.8
0.10	2	0	1	59	0.9869	74.00	0	1	4	0.9880	5.33
	4	0	1	59	0.9999	74.00	0	1	4	0.9999	5.33
	6	0	1	59	0.9999	74.00	0	1	4	0.9999	5.33
	8	0	1	59	1.0000	74.00	0	1	4	1.0000	5.33
	10	0	1	59	1.0000	74.00	0	1	4	1.0000	5.23
0.05	2	6	1	73	0.9552	84.56	0	1	5	0.9799	5.93
	4	0	1	73	0.9998	84.56	0	1	5	0.9999	5.93
	6	0	1	73	0.9999	84.56	0	1	5	0.9999	5.93
	8	0	1	73	1.0000	84.56	0	1	5	1.0000	5.93
	10	0	1	73	1.0000	84.56	0	1	5	1.0000	5.93
0.01	2	0	1	108	0.9552	113.02	0	1	7	0.9575	7.40
	4	0	1	108	0.9998	113.02	0	1	7	0.9998	7.40
	6	0	1	108	0.9999	113.02	0	1	7	0.9999	7.40
	8	0	1	108	1.0000	113.02	0	1	7	1.0000	7.40
	10	0	1	108	1.0000	113.02	0	1	7	1.0000	7.40

Table 4: The Plan parameters of the RASP with minimum average sample number (ASN) and probability of acceptance for NRPD with 50th percentile for $\sigma = 194.9336, \gamma = 0.8022$.

$\delta_q^0 = 0.5$							$\delta_q^0 = 1.0$				
β	t_q/t_q^0	c_1	c_2	n	$P_A(p)$	ASN	c_1	c_2	n	$P_A(p)$	ASN
0.25	2	1	3	16	0.9650	29.0878	3	4	10	0.9610	12.58
	4	0	1	8	0.9819	11.9520	1	1	3	0.9816	4.8
	6	0	1	8	0.9952	11.9520	0	1	3	0.9951	4.8
	8	0	1	8	0.9981	11.9520	0	1	3	0.9981	4.8
	10	0	1	8	0.9990	11.9520	0	1	3	0.9990	4.8
0.10	2	1	4	23	0.9575	41.4996	3	5	13	0.9573	17.20
	4	0	1	12	0.9571	14.9865	0	1	4	0.9631	5.33
	6	0	1	12	0.9885	14.9865	0	1	4	0.9902	5.33
	8	0	1	12	0.9955	14.9865	0	1	4	0.9962	5.23
	10	0	1	12	0.9978	14.9865	0	1	4	0.9981	5.23
0.05	2	2	5	33	0.9515	46.2048	1	4	9	0.9524	17.32
	4	0	2	16	0.9906	23.2477	0	2	6	0.9900	8.93
	6	0	1	14	0.9941	16.4198	0	2	5	0.9837	5.93

	8	0	1	14	0.9938	16.4198	0	1	5	0.9936	5.93
	10	0	1	14	0.9970	16.4198	0	1	5	0.9969	5.93
0.01	2	2	6	40	0.9501	53.9926	2	6	15	0.9504	21.42
	4	0	2	21	0.9773	24.9876	0	2	8	0.9716	9.30
	6	0	1	21	0.9631	21.9854	0	1	7	0.9655	7.40
	8	0	1	21	0.9855	21.9854	0	1	7	0.9965	7.40
	10	0	1	21	0.9930	21.9854	0	1	7	0.9935	7.40

Table 5: Comparison between sample sizes of ASP and RASP for NRPD with 50th percentile for $\delta_q^0 = 1.0, \sigma = 2.0, \gamma = 1.5, \beta = 0.01$.

β	t_q/t_q^0	ASP			RASP		
		c	n	$P_a(p_1)$	c	n	$P_a(p_1)$
0.01	2	3	17	0.9530	2	8	0.9575
	4	1	11	0.9940	1	7	0.9998
	6	0	7	0.9778	1	7	0.9999
	8	0	7	0.9906	1	7	1.0000
	10	0	7	0.9952	1	7	1.0000

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