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# Zero Acceptance Number Chained Quick Switching System Indexed By Six Sigma Quality Levels

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**Abstract:-This article deals with Zero Acceptance Number chained quick switching system indexed by six sigma quality levels. A zero acceptance number(Ac=0), is well- known as a zero defect sampling plan (d=0), accept the units in the sample. It leads to the Chained Quick Switching System having zero acceptance numbers, assigned such as ChQSS-1** $\left(n_N, n_T; i\right)$ **system. The ChQSS-1 indexed by six sigma quality levels and relative slope($h_0$) and Tables are constructing for easy selection method.**

**Keywords:**-Chain Sampling; Producer's Risk; Consumer's Risk; Operating Characteristic Curve; Quick Switching System, Relative Slope, Six Sigma Levels.

## I. INTRODUCTION

Acceptance Sampling Plans is instead of doing 100 percent inspection, taking a random sample from a lot based on the result of random whether accepts or reject the lot. Using this technique cost and time reduced.

A single sampling attributes plan needs an inspection of a random sample of size n items. In a Ac=0 plan, also called a defect less sampling plan. If the defective units in a sample'd' are zero then accept a lot. The Ac=0 plan is the normal choice for safety-related inspection of products and services.

Hahn(1974)[5] provided that the Ac=0 plan needs the minimum sample size for a specified Limiting Quality $\left(LQ\right)$ and consumer's risk $\left(\beta\right)$ when compared to Ac >0 single sampling plans, and other types of attribute sampling plans, for example, double and multiple sampling plans. In the most recent production processes are of high quality and the fraction defective is frequently well managed at low levels.

Dodge (1955)[1], Schilling (1978)[8] and Maciulla (2006)[6] have given their operating characteristic (OC) curves to the discriminatory power of Ac=0 plans is rather poor. Dodge's .

(1955)[1] also explained that chain sampling plan of type ChSP-1 improves the discriminatory power of the Ac=0 plan by permitting a rare defective unit as confirmed as the longer nonconformity spacing within sequences of lots.

## II. A BRIEF EXPLANATION OF CHAINED QUICK SWITCHING SYSTEM

Govindaraju (1991) [2] has studied of a quick switching system using two zero acceptance number in single sampling plans. In this system, assigned as QSS-1($n_N$, $n_T$; 0), uses a zero acceptance number plan ($n_N$,0) with sample size of $n_N$, for normal inspection and a larger sample size ($n_N$, $n_T$; 0),for tightened inspection. While a rejection below the normal ($n_N$,0) plan move to the tighten ($n_T$,0) plan for the next lot; or else, the normal inspection plan shall be prolonged.

Using the ChSP-1 plan, a defective unit is considered like a rare one when the previous i(≥0) following samples are free from the defective units. The QSS-1($n_N$,$n_T$;0),system does not utilize a lead to recognize an irregular defective unit. On the other hand, such a rule can be moreover deployed throughout the normal inspection period of a QSS-1($n_N$,$n_T$;0),system. It directs to the Chained Quick Switching System having zero acceptance numbers, assigned such as ChQSS-1 ($n_N$,$n_T$; i) system. Six sigma, Senthil kumar and Esha Raffie (2012)[9] have studied six sigma quick switching variables sampling system $(n_\sigma, k_{T\sigma}, k_{N\sigma})$ the probability of acceptance of the lot is $1-3.4\times10^{-6}$, where (n,$k_N$) and (n, $k_T$), $k_T > k_N$ are respectively the normal and tightened single sampling plans. The method and procedure for designing the six sigma quick switching variables sampling system based on the given six sigma acceptable quality level and six sigma limiting quality level. Also Radhakrishnan and Sivakumaran (2010) [7] have studied a new procedure for the construction and selection of Link Sampling Plan (LSP) indexed through Six Sigma Quality Level-1 (SSQL-1) and Six Sigma Quality Level-2 (SSQL-2) are presented. Tables are constructed and presented for the easy selection of the plans.

### *A. Operating Procedure of the Chqss-1 $\left(n_N, n_T; i\right)$ System Indexed By Six Sigma Quality Levels*

Step1: Use Tightened plan with the sample $n_T$ items and observe the number of defective items $d_T$.
Step 2: Count the defective items if $d_T$=0, then accept the current lot and move to the normal plan for the next lot.
Step 3: If the defective items $d_T$>0 then reject the current lot and go on to the tightened plan for the next lot.
Step 4: In Normal Plan, Select the samples $d_T$>0 items and examine the number of defective items $d_N$ Check whether the defective items $d_N$=0 or not.

Step 5: If the defective items $d_N$ =0 then accept the current lot and move to the normal plan for the next lot.
Step 6: If the defective items $d_N$>1 then reject the current lot and go on to the tightened plan for the next lot.
Step 7: If the defective items $d_N$ or $d_T$>0 in any of their preceding samples. Reject the current lot and invoke the tightened plan for the next lot. If $d_N$=$d_T$=0 accept the current lot and continue the normal inspection plan for the next lot.
Where $n_N$- Normal plan sample size, $d_N$ - Defective items in the normal sample, $n_T$- Tightened plan sample size, $d_T$- Defective items in the tightened sample.

*B. Designing of ChQSS-1*

For the procedures, mainly when there are lesser than i preceding lots, the above conditions are doubtful to be satisfied, and for this reason the ChSP-1 plan or the ChQSS-1 system also cannot be used. Since a consumer's approach, the make use of the tighter ($n_T$,0) plan is needed for the initial periods until i or more preceding lots are accepted. Consumer's risk of accepting poor quality and it is higher than the actual consumer risk under the tightened plan and as well as the producer's risk also very high. To avoid these consequences, the steady state OC of the ChQSS-1 ($n_N$,$n_T$;i) system will be equivalent to the QSS-1 system having ($n_T$,0) plan for the tightened inspection level and the ChSP-1($n_N$,i) plan for the normal inspection level. Tightened inspection level plan ($n_T$,0) OC function under Poisson probability as

$$P_T(p)=e^{-x_T} \qquad \text{..... (1)}$$

Here, $x_T=n_Tp$. This estimation is applicable when $n_Tp\leq 5$, a situation well fitted in practice for the reason that the fraction defective is commonly low. Use the Poisson distribution is too accurate and exact when the OC function of the ChSP-1 ($n_N$,i) plan is for non conformities, equivalent OC function is

$$P_N(p)=e^{-x_N}+x_N e^{-x_N(i+1)} \qquad \text{....... (2)}$$

Here, $x_N=n_Np$. Equation (2) is accurate for independent defective and is repeatedly a good estimate for defective units.

For a QSS-1 system, the possible number of lots under tightened inspection before a switch to normal inspection is given by

$$c_T(p)=\frac{1}{P_T(p)} \qquad \text{....... (3)}$$

And the possible number of lots under normal inspection by a switch to tightened inspection is given by

$$c_N(p)=\frac{1}{(1-P_N(p))} \qquad \text{......... (4)}$$

With (3) & (4) equations, the stable state or combined OC function of the QSS-1 system is given by

$$P_a(p)=\frac{c_T(p)P_T(p)+c_N(p)P_N(p)}{c_T(p)+c_N(p)}$$

$$=\frac{P_T(p)}{1-P_N(p)+P_T(p)} \qquad \text{........ (5)}$$

Using equations (1) & (2) values into (5), notice that the stable state OC function of the ChQSS-1($n_N$, $n_T$; 0) system turn into $P_a(p)=\dfrac{e^{-x_T}}{1-e^{-rx_T}-rx_Te^{-rx_T(i+1)}+e^{-x_T}}$

=1-□ = 0.9999966 ........ (6)

$$P_a(p)=\frac{e^{-x_T}}{1-e^{-rx_T}-rx_Te^{-rx_T(i+1)}+e^{-x_T}}$$

= β = 0.0000068 ....... (7)

Here, r = $\frac{n_N}{n_T}$ is the ratio of normal inspection sample size to the tightened inspection sample size.

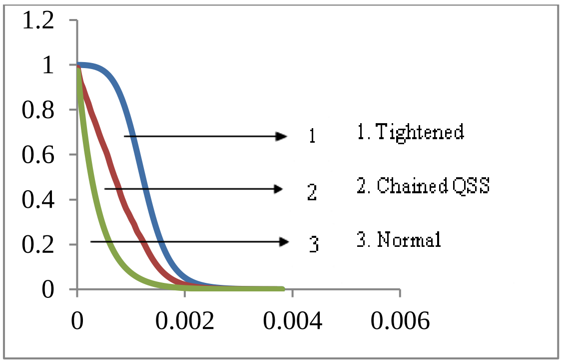


Fig-1: OC Curve of the Chqss-1(523, 2613; 5) System

From the above Fig-1 indicates the OC curve of the ChQSS-1(523,2613;5) system together with the (2613,0) single sampling plan for the tightened inspection level, and the ChSP-1 (523,5) plan for the normal inspection level. It is obvious to the stable state OC curve of the ChQSS-1(523,2613;5) system is nearer to the OC curve of the ChSP-1 (523,5) plan at high-quality levels except moves in the direction of the OC curve of the tightened inspection plan (2613,0) while the incoming quality go down. Next to good quality levels, the ChQSS-1 system uses a smaller sample size $n_N$ and therefore performs more similar to a ChSP -1 plan permitting simply rare defective units. On poor quality levels, the ChQSS-1 system uses a larger sample size $n_T$ and for this reason performs further similar to a zero acceptance number plan rejecting any defective item can say this, the ChQSS-1 system combine the useful characteristic of the ChSP-1 and Ac=0 plans at good in addition to poor quality levels. On the other hand, the ChQSS-1 system is not especially useful at reasonable quality levels (at which the probability of acceptance is neither too high nor low) since the OC curve of the ChQSS-1 system basically lies in the middle of the normal and tightened plans.

### *C. Evaluation of the Chained Quick Switching System*

Let $p_1$ be the acceptance quality limit (AQL) and α be the producer's risk of rejecting lots of $p_1$ quality. In addition, allow $p_2$be the limiting quality and β is the consumer's risk of accepting lots of $p_2$ quality. In this the operating ratio $\frac{p_2}{p_1}$ corresponding to the required producer risk and consumer risk is an opposite measure in a good way a sampling system differentiate among good and poor quality lots. For an established ChQSS-1($rn_T$,$n_T$;i) system, the operating ratio $p_2/p_1$ can be calculated using (6) & (7) in the below steps:

1. For the needed α, and for specified r and i solve $P_a(p_1)=0.9999966$ for $x_T=x_{1T}=n_Tp_1$.
2. For the required β, and for specified r and i solve $P_a(p_2)$ = 0.0000068 for $x_T=x_{2T}=n_Tp_2$.
3. Find the operating ratio $\frac{p_2}{p_1}$ =$x_{2T}x_{1T}$.

| i | r=0.1 | r=0.2 | r=0.3 | r=0.4 | r=0.5 | r=0.6 | r=0.7 | r=0.8 | r=0.9 | r=1 |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0.0261 | 0.0131 | 0.0085 | 0.0064 | 0.0052 | 0.0043 | 0.0037 | 0.0032 | 0.0029 | 0.0026 |
| 1 | 0.0151 | 0.0075 | 0.005 | 0.0038 | 0.003 | 0.0025 | 0.0021 | 0.0019 | 0.0017 | 0.0015 |
| 2 | 0.0116 | 0.0058 | 0.0039 | 0.0029 | 0.0023 | 0.0019 | 0.0016 | 0.0015 | 0.0013 | 0.0012 |
| 3 | 0.0099 | 0.0049 | 0.0033 | 0.0025 | 0.002 | 0.0016 | 0.0014 | 0.0012 | 0.0011 | 0.001 |
| 4 | 0.0086 | 0.0043 | 0.0029 | 0.0022 | 0.0017 | 0.0014 | 0.0012 | 0.0011 | 0.001 | 0.0009 |
| 5 | 0.0079 | 0.0039 | 0.0026 | 0.002 | 0.0016 | 0.0013 | 0.0011 | 0.001 | 0.0009 | 0.0008 |
| 6 | 0.0073 | 0.0036 | 0.0024 | 0.0018 | 0.0014 | 0.0012 | 0.001 | 0.0009 | 0.0008 | 0.0007 |
| 7 | 0.0068 | 0.0034 | 0.0022 | 0.0017 | 0.0013 | 0.0011 | 0.001 | 0.0008 | 0.0007 | 0.0007 |
| 8 | 0.0064 | 0.0031 | 0.0021 | 0.0016 | 0.0013 | 0.0011 | 0.0009 | 0.0008 | 0.0007 | 0.0006 |
| 9 | 0.006 | 0.003 | 0.002 | 0.0015 | 0.0012 | 0.001 | 0.0009 | 0.0007 | 0.0007 | 0.0006 |
| ∞ | 0.0041 | 0.002 | 0.0014 | 0.001 | 0.0008 | 0.0007 | 0.0006 | 0.0005 | 0.0005 | 0.0004 |

Table 1: Indexed By Six Sigma Quality Levels Values of $n_T p_1$ For Given $(i,r)$

| i | r=0.1 | r=0.2 | r=0.3 | r=0.4 | r=0.5 | r=0.6 | r=0.7 | r=0.8 | r=0.9 | r=1 |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 12.882 | 12.248 | 12.011 | 11.935 | 11.9 | 11.899 | 11.891 | 11.889 | 11.88 | 11.868 |
| 1 | 12.398 | 11.999 | 11.923 | 11.902 | 11.888 | 11.886 | 11.885 | 11.884 | 11.862 | 11.862 |
| 2 | 12.283 | 11.985 | 11.907 | 11.898 | 11.875 | 11.874 | 11.872 | 11.872 | 11.858 | 11.853 |
| 3 | 12.253 | 11.98 | 11.9 | 11.895 | 11.869 | 11.868 | 11.866 | 11.865 | 11.847 | 11.844 |
| 4 | 12.249 | 11.975 | 11.881 | 11.88 | 11.852 | 11.851 | 11.851 | 11.841 | 11.836 | 11.829 |
| 5 | 12.247 | 11.966 | 11.793 | 11.791 | 11.783 | 11.78 | 11.779 | 11.778 | 11.777 | 11.775 |
| 6 | 12.238 | 11.952 | 11.79 | 11.788 | 11.78 | 11.777 | 11.769 | 11.766 | 11.764 | 11.762 |
| 7 | 12.226 | 11.898 | 11.778 | 11.777 | 11.763 | 11.761 | 11.755 | 11.754 | 11.752 | 11.752 |
| 8 | 12.193 | 11.878 | 11.69 | 11.688 | 11.675 | 11.674 | 11.671 | 11.671 | 11.668 | 11.662 |
| 9 | 12.187 | 11.86 | 11.686 | 11.677 | 11.668 | 11.664 | 11.663 | 11.661 | 11.654 | 11.652 |
| ∞ | 12.176 | 11.852 | 11.673 | 11.669 | 11.655 | 11.653 | 11.652 | 11.65 | 11.641 | 11.641 |

Table 2: Indexed By Six Sigma Quality Levels Values of $N_tp_2$for Given (I, R)

In equation (6) explains the values of $n_T p_1$ for α =0.9999966 and for different (i,r). Equation (7) reveals that the values of $n_T p_2$ for different combinations of (i,r).The operating ratios attainable by a QSS-1 $(rn_T, n_T; i)$ system are put into a Table 3. Operating ratios in the range 3-13 are not attainable by a QSS-1$(n_N, n_T; 0)$ system. Where, Table3 explains that the method of chaining lot results can attain for instance small operating ratios.

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| i | r=0.1 | r=0.2 | r=0.3 | r=0.4 | r=0.5 | r=0.6 | r=0.7 | r=0.8 | r=0.9 | r=1 |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 4.93 | 9.38 | 14.07 | 18.58 | 22.94 | 27.65 | 31.99 | 36.85 | 40.95 | 45.84 |
| 1 | 8.227 | 15.99 | 23.8 | 31.27 | 39.55 | 48.01 | 55.59 | 63.59 | 71.07 | 79.03 |
| 2 | 10.59 | 20.61 | 30.35 | 40.36 | 51.39 | 61.74 | 72.3 | 81.76 | 92.42 | 102 |
| 3 | 12.37 | 24.34 | 35.99 | 48.21 | 60.84 | 72.63 | 84.4 | 96.54 | 107.6 | 120.5 |
| 4 | 14.2 | 27.79 | 41.3 | 54.05 | 68.35 | 82.36 | 98.02 | 110 | 123.1 | 137.3 |
| 5 | 15.46 | 30.81 | 45.48 | 60.19 | 75.58 | 89.86 | 104.8 | 119.8 | 134.8 | 150.8 |
| 6 | 16.75 | 33.18 | 49.31 | 64.59 | 81.58 | 97.66 | 114 | 130.2 | 147.6 | 162.7 |
| 7 | 17.95 | 34.98 | 53.06 | 69.15 | 87.65 | 105.4 | 122.2 | 139.9 | 157.2 | 174.4 |
| 8 | 19.09 | 38.07 | 55.16 | 73 | 92.73 | 110.8 | 130.7 | 147.5 | 166.1 | 184.4 |
| 9 | 20.26 | 40.12 | 58.81 | 77.21 | 98.63 | 118.1 | 136.7 | 157.8 | 175.4 | 195.9 |
| ∞ | 29.93 | 58.59 | 85.96 | 115.9 | 143.2 | 171.7 | 199.9 | 229.2 | 257.3 | 283.2 |

Table 3: Indexed By Six Sigma Quality Levels Operating Ratios $\frac{p_2}{p_1}\%$ For Given (I, R)

| i | r = 0.1 | r=0.2 | r=0.3 | r =0.4 | r=0.5 | r=0.6 | r=0.7 | r=0.8 | r=0.9 | r=1 |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 9.068 | 8.304 | 7.97 | 7.801 | 7.699 | 7.657 | 7.63 | 7.615 | 7.607 | 7.603 |
| 1 | 8.476 | 7.917 | 7.728 | 7.655 | 7.624 | 7.609 | 7.605 | 7.602 | 7.601 | 7.6 |
| 2 | 8.302 | 7.851 | 7.705 | 7.648 | 7.622 | 7.608 | 7.604 | 7.6 | 7.6 | 7.599 |
| 3 | 8.234 | 7.838 | 7.703 | 7.647 | 7.622 | 7.605 | 7.603 | 7.6 | 7.599 | 7.598 |
| 4 | 8.204 | 7.835 | 7.702 | 7.646 | 7.621 | 7.604 | 7.602 | 7.598 | 7.598 | 7.597 |
| 5 | 8.192 | 7.834 | 7.7 | 7.645 | 7.619 | 7.603 | 7.601 | 7.597 | 7.596 | 7.595 |
| 6 | 8.186 | 7.833 | 7.699 | 7.644 | 7.618 | 7.602 | 7.601 | 7.596 | 7.595 | 7.594 |
| 7 | 8.182 | 7.832 | 7.698 | 7.643 | 7.617 | 7.602 | 7.6 | 7.589 | 7.584 | 7.583 |
| 8 | 8.181 | 7.831 | 7.696 | 7.64 | 7.616 | 7.601 | 7.6 | 7.588 | 7.583 | 7.582 |
| 9 | 8.181 | 7.83 | 7.694 | 7.64 | 7.615 | 7.6 | 7.599 | 7.587 | 7.582 | 7.582 |
| ∞ | 8.18 | 7.83 | 7.693 | 7.638 | 7.614 | 7.599 | 7.598 | 7.586 | 7.582 | 7.581 |

Table 4: Indexed By Six Sigma Quality Levels Values of $X_0$ For Given N(I, R)

In 1950, Hamaker [4] presented an alternative method for calculating the power of difference between good and bad lots realized by a sampling plan. Let $p_0$ be the indifference quality level (IQL), the quality level at which the probability of acceptance and rejection are both equal to 50%. The "relative" slope of the OC curve at $p_0$ is described as

$$h_0 = -\left(\frac{p}{P_a(p)}\frac{dP_a(p)}{dp}\right)_{p=p_0} = -\left(2np\frac{dP_a(p)}{d(np)}\right)_{p=p_0}$$

$$= -\left(2np\frac{e^{-x_0}}{1-e^{-rx_0}-rx_0e^{-rx_0(i+1)}+e^{-x_0}}dx_0\right)-2$$

$$\frac{\frac{x_0\,(i+1)\,r^2}{e^{r\,x_0\,(i+1)}}-\frac{r}{e^{r\,x_0\,(i+1)}}+\frac{r}{e^{r\,x_0}}-\frac{1}{e^{x_0}}}{e^{x_0}\left(-\frac{r\,x_0}{e^{r\,x_0\,(i+1)}}-\frac{1}{e^{r\,x_0}}+\frac{1}{e^{x_0}}+1\right)^2}-\frac{1}{e^{x_0}\left(-\frac{r\,x_0}{e^{r\,x_0\,(i+1)}}-\frac{1}{e^{r\,x_0}}+\frac{1}{e^{x_0}}+1\right)} \quad \text{........ (9)}$$

The relative slope $h_0$ is a direct measure of difference attained by a sampling plan. Used for the ChQSS-1 $(rn_T, n_T; i)$ system, the "unity" value $x_T = n_T p_0 = (= x_0 say)$ equivalent to the IQL can be obtained by equations (6) to 0.5 and solving for $x_0$. The relative slope $h_0$ can be calculated using (6) and (7). From the Tables 4 and 5 explain $x_0$ and $h_0$ values, correspondingly, for the $(i, r)$ arrangements revealed in

Table 1-3. From Table-5 verifies that the $h_0$ values for the ChQSS-1 $(rn_T, n_T; i)$ systems are larger than the $h_0$ of the QSS-1 $(n_N, n_T; 0)$ systems. This denotes that the method of chaining normal inspection sample outcomes directs to developed difference good and bad lots.

| i | r=0.1 | r=0.2 | r=0.3 | r=0.4 | r=0.5 | r=0.6 | r=0.7 | r=0.8 | r=0.9 | r=1 |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0.0105 | 0.0094 | 0.0087 | 0.0083 | 0.0081 | 0.0079 | 0.0078 | 0.0077 | 0.0077 | 0.0076 |
| 1 | 0.0096 | 0.0086 | 0.0081 | 0.0078 | 0.0077 | 0.0077 | 0.0076 | 0.0076 | 0.0076 | 0.0076 |
| 2 | 0.0092 | 0.0083 | 0.008 | 0.0078 | 0.0077 | 0.0077 | 0.0076 | 0.0076 | 0.0076 | 0.0076 |
| 3 | 0.009 | 0.0083 | 0.008 | 0.0078 | 0.0077 | 0.0077 | 0.0076 | 0.0076 | 0.0076 | 0.0076 |
| 4 | 0.0089 | 0.0083 | 0.008 | 0.0078 | 0.0077 | 0.0077 | 0.0076 | 0.0076 | 0.0076 | 0.0076 |
| 5 | 0.0089 | 0.0082 | 0.008 | 0.0078 | 0.0077 | 0.0077 | 0.0077 | 0.0076 | 0.0076 | 0.0076 |
| 6 | 0.0089 | 0.0082 | 0.008 | 0.0078 | 0.0077 | 0.0077 | 0.0077 | 0.0077 | 0.0076 | 0.0076 |
| 7 | 0.0089 | 0.0083 | 0.008 | 0.0078 | 0.0077 | 0.0077 | 0.0077 | 0.0077 | 0.0077 | 0.0077 |
| 8 | 0.0088 | 0.0083 | 0.008 | 0.0078 | 0.0077 | 0.0077 | 0.0077 | 0.0077 | 0.0077 | 0.0077 |
| 9 | 0.0088 | 0.0083 | 0.008 | 0.0079 | 0.0078 | 0.0077 | 0.0077 | 0.0077 | 0.0077 | 0.0077 |
| ∞ | 0.0088 | 0.0083 | 0.008 | 0.0079 | 0.0078 | 0.0077 | 0.0077 | 0.0077 | 0.0077 | 0.0077 |

Table -5: Indexed By Six Sigma Quality Levels Values of $h_0$ For Given $n(i, r)$

## III. CONCLUSION

This reveals that the discriminatory power of a quick switching system including the zero acceptance number reference plan is developed when preceding lot results are chained chqss-1 systems are considered to control the producer's and consumer's risks or to minimise the sampling inspection effort.

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