**International Journal of Nanotechnology and Application (IJNA)**
**ISSN: 2277–4777**
**Vol.2, Issue 1 Mar 2012 1-9**


# NANO QUALITY LEVELS IN THE CONSTRUCTION OF DOUBLE SAMPLING PLAN OF THE TYPE DSP- (0,1)

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## ABSTRACT

Motorola (1980) introduced the concept of six sigma as a quality philosophy and a management strategy, which when adopted in a system of organization will reduce wastages and increase the profit to the management, in enhancing the satisfaction of the customer. If this concept of Six Sigma is adopted in an organization it can results in 3.4 or lower number of defects per million opportunities in the long run. In recent days many companies in developed and developing countries started working beyond Six Sigma level and thereby the performance level increases with number of defectives reduced to near zero level. In those situations a more stringent quality level than six sigma quality level, a concept of the 21st century is required to construct the sampling plan. In this paper a procedure for the construction of Double Sampling Plan of the type DSP-(0,1) indexed through producer's Nano quality level (PNQL) and consumer's Nano quality level (CNQL) is presented and suitable tables are also provided for the easy selection of the plans.

## KEYWORDS

Nano Quality Level, Poisson distribution, Double Sampling Plan, Operating Characteristic curve.

## 1. INTRODUCTION

Vijayaraghavan (1990) mentioned the situations for which DSP-(0,1) can be used and presented for the selection of DSP-(0,1) under Poisson and Binomial conditions. The Double Sampling Plan designated as DSP-(0,1) has the following properties :

1. Fixing $n_1$ = n and $n_2$ = (i)(n), (i>0), the OC function of DSP-(0,1) is identical to the OC function of ChSP-1 plan.
2. When i = 0 and i = ∞, the OC function of DSP-(0,1) reduces to the OC function of the single sampling plans with c = 1 and c = 0 respectively.
3. The OC curve of DSP-(0,1) lie between the OC curve of single sampling plan with c=0 and c=1.

Although DSP-(0,1) is valid under general conditions for applications of attributes sampling inspection, the plan will specially be useful to product characteristics involving costly or destructive testing. Radhakrishnan and Sekkizhar (2007) constructed sampling plans for second quality lots. Many companies such as General Electric, Allied signals have followed the success mechanism of Motorola in adopting six sigma concepts in their organization and came out with great success. Radhakrishnan and Sivakumaran (2008) introduced the concept of six sigma quality level and constructed Single Sampling Plan with Poisson distribution as the base line distribution. Radhakrishnan (2009) constructed six sigma based sampling plan with Intervened Random effect Poisson distribution and weighted Poisson distribution as the base line distribution. Norio Taniguchi (1974) introduced the concept of Nano Technology in manufacturing and other areas. Radhakrishnan and Vinotha (2011a, 2011b, 2011c, 2011d and 2011e) introduced the concept of Nano Quality Level (NQL) in the construction of sampling plans.

In the construction of sampling plans the Nano Quality Level (NQL) can be classified under two types such as Producer's Nano Quality Level (PNQL) and Consumer's Nano Quality Level (CNQL) similar to Producer's Risk and Consumer's Risk suggested by Dodge (1969). These quality levels can be used by the companies which are practicing Six Sigma initiatives for longer period of time. In this paper a procedure for the construction and selection of Double Sampling Plan of the type DSP-(0,1) indexed through Producer's Nano Quality Level (PNQL) and Consumer's Nano Quality Level (CNQL) are presented. Tables are also constructed and presented for the easy selection of plans.

### 1.1. Producer's Nano Quality Level and Consumer's Nano Quality Level

The proportion defective corresponding to the probability of acceptance $1-\gamma_1$, $\gamma_1=10^{-9}$ in the OC (Operating Characteristic) curve is termed as Producer's Nano Quality Level (PNQL). The new sampling plan is constructed with a point on the OC curve (PNQL, $1-\gamma_1$), similar to (AQL, $1-\alpha$), $\alpha=0.05$ suggested by Dodge and Romig (1942) and (SSQL-1, $1-\alpha_1$), $\alpha_1=3.4\text{x}10^{-6}$ suggested by Radhakrishnan and Sivakumaran (2008) and Radhakrishnan (2009). Similarly a new Sampling plan can be constructed with a point on the OC curve (CNQL,$\gamma_2$), $\gamma_2=2\gamma_1$ is similar to (LQL, $\beta$), $\beta=2\alpha$ suggested by Dodge and Romig (1942) and (SSQL-2, $\beta_1$), $\beta_1=2\alpha_1$ suggested by Radhakrishnan and Sivakumaran (2008) and Radhakrishnan (2009).

## 2. CONDITIONS FOR APPLICATION

- Production is continuous, so that results of the past, present and future lots are broadly the indicative of a continuous process.
- Lots are submitted sequentially.
- Inspection is by attributes, with the lot quality level defined as the proportion defective.

- Human involvement is to be minimum in the manufacturing process.
- The companies are to have sufficient experience in adopting Six Sigma initiatives in their process to ensure the system has the potentiality to produce nearly zero defectives.

## 3. OPERATING PROCEDURE OF DSP-(0,1)

**Step 1 :** Select a random sample of size '$n_1$' from a lot of size 'N'.

**Step 2 :** Inspect all the articles included in the sample. Let '$d_1$' be the number of non-conformities in the sample.

**Step 3 :** If $d_1 = 0$, accept the lot.

**Step 4 :** If $d_1 > 1$, reject the lot.

**Step 5 :** If $d_1 = 1$, draw a second sample of size '$n_2$' ($= in_1$) and observe the number of non-conformities '$d_2$'.

**Step 6 :** If $d_2 = 0$, accept the lot

**Step 7 :** If $d_2 \geq 1$ reject the lot.

## 4. OPERATING CHARACTERISTIC FUNCTION

Under Poisson Model the OC function of the DSP-(0,1) is given by

$$P_a(p) = e^{-np} + npe^{-np\,(i+1)} \qquad \ldots\ldots\ldots\ldots..\ (1)$$

where $n = n_1$ and $n_2 = (n_1)(i)$, $(i>0)$.

In DSP-(0,1) by attributes the lot acceptance procedure is Characterized by the Parameters $n_1$, $n_2$, $c_1=0$, $c_2=1$ and i

## 5. CONSTRUCTION OF DSP-(0,1) INDEXED THROUGH (PNQL, CNQL)

By fixing the probability of acceptance of the lot, $P_a$ (P) as $1\text{-}10^{-9}$ with Poisson distribution as the basic distribution and from equation (1), the values of nPNQL and nCNQL are obtained for various combinations of 'i' using Excel package and are presented in Table-1.

For a specified PNQL and CNQL values, calculate the Ratio R=CNQL/PNQL (CNQL>PNQL). Select the nearest R value from Table-1 and the sample size '$n_1$'is obtained using $n_1$ = nPNQL/PNQL and $n_2 = (n_1)$ (i). Then the parameters of the DSP-(0,1) are $n_1$,$n_2$ and i are obtained for the specified values of PNQL and CNQL.

The sigma levels of the process are calculated using the Process Sigma Calculator (http://www.isixsigma.com/) by providing the sample size and acceptance number.

**Example 1**

For a given PNQL = $1.3\text{x}10^{-8}$ and CNQL=0.0093, calculate the ratio R = CNQL/PNQL = 715384.6. Then the nearest R value selected from Table-1 as 716264.29 and the corresponding sample size $n_1$ is computed as $n_1$ = 0.0000280/0.000000013 = 2154 and $n_2$ = (2154) (0.75) = 1616 which are associated with 4.7 and 4.9 sigma levels respectively. Hence the parameters of DSP-(0,1) are $n_1$ =2154, $n_2$ =1616 and i = 0.75 for a specified PNQL =$1.3\text{x}10^{-8}$ and CNQL = 0.0093.

**Practical Application**

In a biscuit manufacturing company, if the producer fixes the quality level as PNQL = $1.3\text{x}10^{-8}$ (13 non-confirming biscuit packets out of one million packets) and the distributer fixes the quality as CNQL = 0.0093 (93 non-confirming units out of ten thousand packets) for a lot, then take a sample of

2154 packets from the manufactured lot of a particular day and count the number of non-conformities ($d_1$). If $d_1 = 0$ accept the biscuits manufactured in that day and if $d_1 > 1$, reject the biscuits manufactured in that day and inform the management for the corrective action. If $d_1 = 1$, take a second sample of 1616 packets from the same lot of the day and count the number of non-confirming packets ($d_2$). If $d_2 = 0$ accept the biscuits manufactured in the day, and if $d_2 \geq 1$, reject the biscuits manufactured in that day and inform the management for corrective action.

**Example 2**

For a given PNQL = 0.000000013 and CNQL=0.0071, calculate the ratio R = CNQL/PNQL = 0.0071/0.000000013 = 546153.84. Then the nearest R value selected from Table-1 as 545135.14 and the corresponding sample size $n_1$ is computed as $n_1$ = 0.0000370/0.000000013 = 2846 and $n_2$ = (2846) (0.25) = 712 which are associated with 4.7 and 5.0 sigma levels respectively. Hence the parameters of DSP-(0,1) are $n_1$ = 2846, $n_2$ =712 and i = 0.25 for a specified PNQL = 0.000000013 and CNQL = 0.0071.

The OC curves of the plans provided in Example 1 and Example 2 are presented in Figure 1.

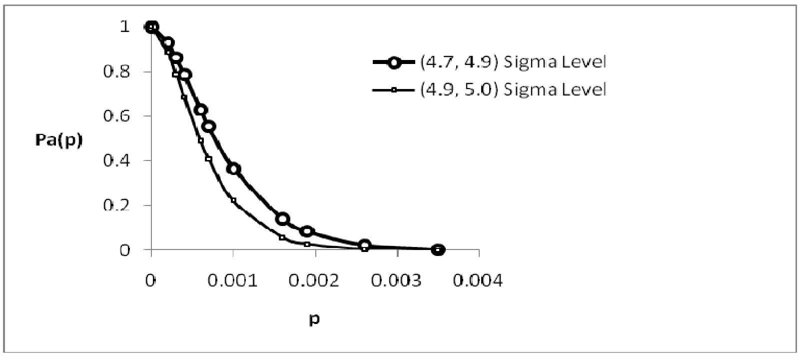


***Figure 1. OC curves for the plan $n_1$ =2154, $n_2$ =1616 and i = 0.75 & $n_1$ =2846, $n_2$ =0712 and i = 0.25***

***Table 1. Parameters of DSP-(0,1) for a specified PNQL and CNQL***

| i | nPNQL | nCNQL | R |
|---|---|---|---|
| 0.25 | 0.0000370 | 20.1700 | 545135.14 |
| 0.50 | 0.0000320 | 20.0563 | 626759.38 |
| 0.75 | 0.0000280 | 20.0554 | 716264.29 |
| 1.00 | 0.0000260 | 20.0554 | 771361.54 |
| 1.25 | 0.0000240 | 20.0554 | 835641.67 |
| 1.50 | 0.0000220 | 20.0554 | 911609.09 |
| 1.75 | 0.0000210 | 20.0554 | 955019.05 |
| 2.00 | 0.0000200 | 20.0554 | 1002770.00 |
| 2.25 | 0.0000190 | 20.0554 | 1055547.37 |
| 2.50 | 0.0000180 | 20.0554 | 1114188.89 |
| 2.75 | 0.0000179 | 20.0554 | 1120413.41 |
| 3.00 | 0.0000173 | 20.0554 | 1159271.68 |
| 3.25 | 0.0000167 | 20.0554 | 1200922.16 |
| 3.50 | 0.0000162 | 20.0554 | 1237987.65 |
| 3.75 | 0.0000157 | 20.0550 | 1277388.54 |
| 4.00 | 0.0000152 | 20.0550 | 1319407.89 |
| 4.25 | 0.0000148 | 20.0550 | 1355067.57 |
| 4.50 | 0.0000144 | 20.0550 | 1392708.33 |
| 4.75 | 0.0000141 | 20.0550 | 1422340.43 |
| 5.00 | 0.0000138 | 20.0550 | 1453260.87 |

## 6. CONCLUSION

In this paper a concept Nano Quality with two quality levels such as Producer's Nano Quality Level (PNQL) and Consumer's Nano Quality Level (CNQL) is introduced and the procedure for constructing Double Sampling Plan of the type DSP-(0,1) indexed through these quality levels with Poisson distribution as the base line distribution are also presented. The procedure indicated in this paper can replace the existing quality levels adopted in the construction of sampling plans because more organizations have specialized in adopting Six Sigma initiatives in their system and are willing to shift towards Nano Technology that will results in nearly zero non-conformities. So it is necessary for those companies to adopt the Nano quality levels in the construction of the plan suggested in this paper. This will increase the confidence of the producer in providing a better sampling inspection procedure in enhancing the satisfaction of the consumers. The procedure outlined in this paper can be used for other plans also.

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