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A STOCHASTIC PROCESS CONTROL PLAN FOR THREE QUALITY CLASSES

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ABSTRACT:

In this paper the idea of deferred sampling inspection plan is enlarged for three attribute classes with two phase inspection. This paper presents a two-phase inspection to maintain high quality level of the production processes which are not well-behaved and/or subject to some deterioration. OC and other performance characteristics have been derived and illustrated numerically. Lastly, Poisson unity values have been tabulated to facilitate the operation and construction of the plan.

Key-Words: Deferred sampling plan, Two-Phase Inspection, OC function, ASN function, GERT.

1. INTRODUCTION:

In many industrial experimentation and quality control applications the attribute of some measurable characteristic within the lot or process is used as the sampling statistic to determine whether the product or the process meets the given specification. A production process, and for that matter any other process, generally tends to lose some of its efficiency in service because of deterioration of machines and equipments as time elapses. As a consequence, the quality of products from the process decreases in time and therefore some corrective action should be taken. Not having full information of the actual state of the process, the decision is to be based on some partial information obtained for instance by sampling. Possible corrective actions are (minimal) repairs, adjustments, renewals which all can be perform action of the after the detection of the state of deterioration or as preventive actions.

Stephens and Dodge [11] developed two-phase inspection plans with deferent sample sizes in two stages of inspection. Calvin [2] introduced the concept of Tightened-Normal-Tightened (TNT) inspection scheme which utilizes two $c = 0$ single sampling plans of different sample sizes together with switched rules to build up the shoulder of the OC curve. The idea of using what is known as deferred sampling plan is due to R. Vearst [12]. Shankar [5] studied two-phase inspection Repetitive Group Sampling (RGS) plan using the concept of Tightened and normal inspection, and taking different sample sizes at two-phase of inspection simultaneously. Shankar and Srivastava [10] proposed a two-phase deferred sampling plan in which the decision of the acceptance and rejection of a lot is dependent on the inspection results of the succeeding lots.

The development of corrective action plans with two-phase inspection has attracted several authors. Some references may be made to Srivastava [10] and Shankar and Chandrakar (2002). Shankar and

Sahu [8] modeled a two-phase inspection process control plan using deferred sentencing scheme where quality characteristic is classified in two attribute classes. In this paper, a two-phase inspection corrective action plan is proposed using deferred sentencing for three attribute classes characterized by good, marginal and bad.

The formulae for Operating Characteristic (OC), Average Sample Number (ASN) and Average Length of Inspection cycle have been derived by GERT methodology during one inspection cycle (i.e. from initial in-control to out-of-control or deterioration state) of the process. Poisson unity values have been tabulated to facilitate the operation and construction of the plan. Lastly, numerical examples have been included to illustrate the mathematical findings. A segment on OC surface is graphically shown to study the effect of the marginal quality products on the performance of the process. The graphical study concludes that it is the marginal quality that matters more than the bad quality performance to control deterioration.

2. Operating Characteristics:

Now, the following notations and concepts similar to those of Bray et al [1], the proposed plan proceeds as follows:

Step (1): Draw a random sample of size n_1 successive units for normal inspection from the production line at more or less regular intervals of time, and determine the number of good, marginal and bad quality units found therein.

Step (2): At any stage of sampling inspection, if

(a) $d_1 \le c_1$ and $d_2 \le c_2$, continue production. The process is in-control.

(b) $d_1 > c_1 + b_1$ **or** $d_2 > c_2 + b_2$, stop the process, and hunt for potential assignable causes. The process is out-of-control.

(c) Otherwise, switch to step (3) for tightened inspection.

Step (3): Draw another sample of n_2 ($> n_1$) successive units from the production line for tightened inspection, and determine the number of good, marginal and bad quality items found therein. If

(a) $d_1 \le c_1$ and $d_2 \le c_2$, continue production. The process is in-control.

(b) $d_1 > c_1 + b_1$ **or** $d_2 > c_2 + b_2$, stop the process, and hunt for potential assignable causes. The process is out-of-control.

(c) If **either** $c_1 < d_1 \le c_1 + b_1$ and $d_2 \le c_2$

or $d_1 \le c_1 + b_1$ and $c_2 < d_2 \le c_2 + b_2$,

defer the decision of corrective action until next (i-1) samples also alarm the state of corrective action, i.e. in each of the (i-1) succeeding samples either $c_1 < d_1 \le c_1 + b_1$ **&** $d_2 \le c_2$ or $d_1 \le c_1 + b_1$ **&** $c_2 < d_2 \le c_2 + b_2$. Otherwise, repeat the step (3).

Thus, the proposed plan is characterized by seven parameters, namely, n_1, n_2, c_1, c_2, b_1, b_2 and i. Here, it may be noted that the inspection process is automatically switched to normal inspection (step-1) following a corrective action or due improvement of the process over out-of-control situation.

A schematic diagram of production line is shown below:

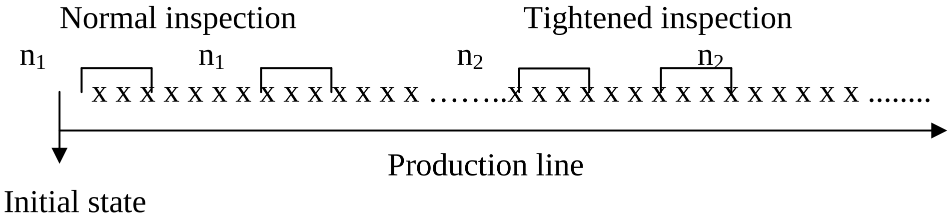

Fig.(1): A schematic diagram of production line

2. GERT Analysis of the Plan:

The possible states of the inspection system may be defined as follows:

S_0 : Initial state of the plan.
S_1 : State in which normal inspection is performed.
$S_2[k]$: State in which k^{th} (k = 0, 1, 2, …….., i-1) succeeding samples alarm a state of corrective measure under tightened inspection.
S_{CA} : State in which corrective action is performed.
S_R : State in which process is interrupted for serious assignable causes.

The above states enable us to construct GERT network representation of the inspection system as shown in Fig. (2). In this paper, however, attention has been paid to the following quantities which give important information on the process control plan:

(1) Sample size n (parameter θ),
(2) Transition time t (parameter s).

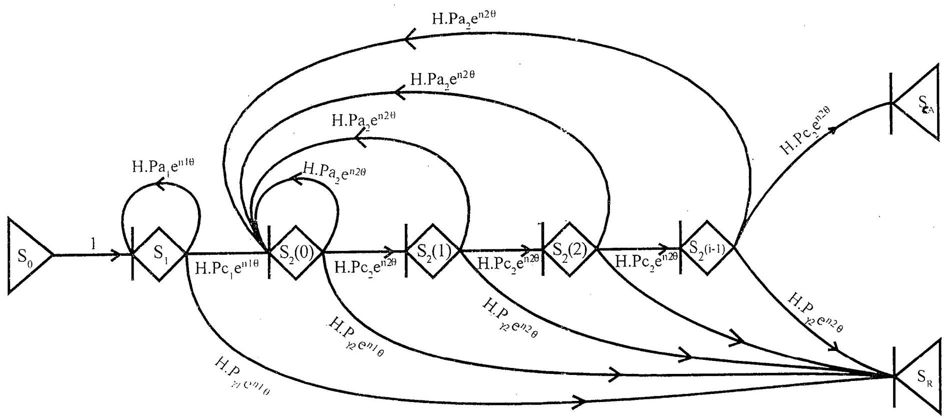

Fig. (2): GERT Network of Two – Phase Inspection Process Control Plan

The W–function from initial node S_0 to the terminal nodes S_{CA} and S_R are, respectively, obtained by applying the Mason's (1953) rule on GERT network representation as follows:

$$W_{CA}(\theta,s) = \left[H^{i+1} P_{c_1} P_{c_2}{}^{i} e^{(i.n_2+n_1)} \left(1 - H P_{c_2} e^{n_2\theta}\right)\right] \; / \; G \qquad (3.1)$$

$$W_R(\theta, s) = \left[\left(H P_{r_1} e^{n_1\theta}\right) \left\{1 - H P_{c_2} e^{n_2\theta} - H / P_{a_2} e^{n_2\theta} \left(1 - \left(H P_{c_2} e^{n_2\theta}\right)^{i}\right)\right\}\right] / G \qquad (3.2)$$

where $G = \left(1 - H P_{a_1} e^{n_1\theta}\right) \left[1 - H P_{c_2} e^{n_2\theta} - H P_{a_2} e^{n_2\theta} \left\{1 - \left(H P_{c_2} e^{n_2\theta}\right)^{i}\right\}\right]$

$$H = \lambda / (\lambda - s)$$

The symbols $P_{a_1}, P_{a_2}, P_{c_1}, P_{c_2}$ etc. are defined as follows:

$$P_{a_1} = P[d_1 \le c_1 \quad \text{and} \quad d_2 \le c_2]$$

$$= \sum_{i=0}^{c_1 - j} \sum_{j=0}^{c_2} m_{ij}(n_1)$$

$$P_{c_{11}} = P[c_1 < d_1 \le c_1 + b_1 \quad \text{and} \quad d_2 \le c_2]$$

$$= \sum_{i=0}^{c_1+b_1-j} \sum_{j=0}^{c_2} m_{ij}(n_1) - \sum_{i=0}^{c_1-j} \sum_{j=0}^{c_2} m_{ij}(n_1)$$

$$P_{c_{12}} = P[\, d_1 \le c_1 + b_1 \quad \text{and} \quad c_2 < d_2 \le c_2 + b_2]$$

$$= \sum_{i=0}^{c_1+b_1-j} \sum_{j=0}^{c_2+b_2} m_{ij}(n_1) - \sum_{i=0}^{c_1+b_1-j} \sum_{j=0}^{c_2} m_{ij}(n_1)$$

$$P_{c_1} = P_{c_{11}} + P_{c_{12}} \quad , \qquad P_{r_1} = 1 - P_{a_1} + P_{c1}$$

$$= P[d_1 \le c_1 \quad \text{and} \quad d_2 \le c_2]$$

$$P_{a\,2} = \sum_{i=0}^{c_1-j} \sum_{j=0}^{c_2} m_{ij}(n_2)$$

$$P_{c_{21}} = P[\, c_1 < d_1 \le c_1 + b_1 \quad \text{and} \quad d_2 \le c_2]$$

$$= \sum_{i=0}^{c_1+b_1-j} \sum_{j=0}^{c_2} m_{ij}(n_2) - \sum_{i=0}^{c_1-j} \sum_{j=0}^{c_2} m_{ij}(n_2)$$

$$P_{c_{22}} = P[\, d_1 \le c_1 + b_1 \quad \text{and} \quad c_2 < d_2 \le c_2 + b_2]$$

$$= \sum_{i=0}^{c_1+b_1-j} \sum_{j=0}^{c_2+b_2} m_{ij}(n_2) - \sum_{i=0}^{c_1+b_1-j} \sum_{j=0}^{c_2} m_{ij}(n_2)$$

$$P_{c_2} = P_{c_{21}} + P_{c_{22}} , \quad P_{r_2} = 1 - P_{a_2} + P_{c_2}$$

where $m_{ij}(n) = \dfrac{n!}{i!\, j!\, (n-i-j)!}\, p_0^{\,n-i-j}\, p_1^{\,i}\, p_2^{\,j}$.

Now, from the definition of W-function, we obtain

$$P_{CA} = \frac{P_{c_1} P_{c_2}{}^{i} \left(1 - P_{c_2}\right)}{\left(1 - P_{a_1}\right)\left(P_{r_2} + P_{a_2} P_{c_2}{}^{i}\right)} \tag{3.3}$$

$$P_R = \frac{P_{r_1}\left(P_{r_2} + P_{a_2} P_{c_2}{}^{i}\right) + P_{c_2} P_{r_2}\left(1 - P_{c_2}{}^{i}\right)}{\left(1 - P_{a_1}\right)\left(P_{r_2} + P_{a_2} P_{c_2}{}^{i}\right)} \tag{3.4}$$

$$= 1 - P_{CA}$$

For further characterization of the plan, ASN function is found to be

$$E(n) = P_{CA}\left[\frac{d}{d\theta} M_A(\theta)\right]_{\theta=0} + P_R\left[\frac{d}{d\theta} M_R(\theta)\right]_{\theta=0}$$

$$= \frac{n_1\left(P_{r_2} + P_{a_2} P_{c_2}{}^{i}\right) + n_2\, P_{c_1} P_{c_2}{}^{i}}{\left(1 - P_{a_1}\right)\left(P_{r_2} + P_{a_2} P_{c_2}{}^{i}\right)} \tag{3.5}$$

where $M_A(\theta) = \dfrac{W_{CA}(\theta, 0)}{W_{CA}(0, 0)}$ and $M_R(\theta) = \dfrac{W_R(\theta, 0)}{W_R(0, 0)}$

Here, it may be noted that ASN describes the expected number of items inspected for corrective action / termination of the process for variation in process level p_1 and p_2.

Proceeding in the same way as above, the Average Length of Inspection cycle, E (t), is found as

$$E(t) = P_{CA}\left[\frac{d}{d\theta} M_{1A}(s)\right]_{s=0} + P_R\left[\frac{d}{d\theta} M_{1R}(s)\right]_{s=0}$$

$$E(t) = \frac{(P_{c_2} + P_{a_2} P_{c_2}{}^{i}) + P_{c_1}(1 - P_{c_2}{}^{i})}{\lambda\,[(1 - P_{a_1})\,(P_{c_2} + P_{a_2} P_{c_2}{}^{i})]} \qquad (3.6)$$

where, $M_{1A}(s) = \dfrac{W_{CA}(0,s)}{W_{CA}(0,0)}$ and $M_{1R}(s) = \dfrac{W_R(0,s)}{W_R(0,0)}$

(1) We shall now consider the case when i = 1. Now putting i = 1 in (3.3), (3.5) and (6), we have

$$P_{CA} = \frac{P_{c_1}\, P_{c_2}}{(1 - P_{a_1})\,(1 - P_{a_2})} \quad , \quad E(n) = \frac{n_1(1 - P_{a_2}) + n_2 P_{c_1}}{(1 - P_{a_1})\,(1 - P_{a_2})}$$

$$E(t) = \frac{(1 + P_{a_1} - P_{a_2})}{\lambda\,(1 - P_{a_1})\,(1 - P_{a_2})}.$$

These results are agreed with Srivastava [10].

(2) It may be noted that in the case of normal inspection only. The state $S_2[k]$ is treated as corrective state S_{CA} (i.e. $P_{a_2} = P_{c_2} = P_{c_2} = 0$ and $n_2 = 0$) and thus, resulting plan reduced to Shankar`s [6] model. The respective expression comes out to be

$$P_{CA} = P_{c_1} / (1 - P_{a_1}) \quad , \quad E(n) = n_1 / (1 - P_{a_1})$$

$$E(t) = 1 / \lambda\,(1 - P_{a_1})$$

These results are agreed with Shankar's [10] model.

4 A Particular Case:

Bray et. al (1973) pointed out that the number of three-class plan is admittedly large, and the most useful subset of such plans is one for which the bad quality items is zero. We shall now consider the case when $c_2 = b_2 = 0$. The probabilities $P_{a_1}, P_{a_2}, P_{c_1}, P_{c_2}$ etc. are respectively given as

$$P_{a_1} = P[d_1 \le c_1 \text{ and } d_2 = 0]$$

$$= \sum_{i=0}^{c_1} \binom{n_1}{i} p_0^{\,n_1 - i}\, p_1^{\,i}$$

$$P_{c_{11}} = P[\, c_1 < d_1 \le c_1 + b_1 \text{ and } d_2 = 0]$$

$$= \sum_{i=0}^{c_1+b_1} \binom{n_1}{i} p_0^{\,n_1 - i}\, p_1^{\,i} - \sum_{i=0}^{c_1} \binom{n_1}{i} p_0^{\,n_1 - i}\, p_1^{\,i}$$

$$P_{c_1} = P_{c_{11}} + P_{c_{12}} \quad , \quad P_{r_1} = 1 - P_{a_1} + P_{c1}$$

$$P_{a_2} = P[d_1 \le c_1 \text{ and } d_2 = 0]$$

$$= \sum_{i=0}^{c_1} \binom{n_2}{i} p_0^{\,n_1 - i}\, p_1^{\,i}$$

$$P_{c_{21}} = P[\, c_1 < d_1 \le c_1 + b_1 \text{ and } d_2 = 0]$$

$$= \sum_{i=0}^{c_1+b_1} \binom{n_2}{i} p_0^{n_1-i} p_1^{i} - \sum_{i=0}^{c_1} \binom{n_2}{i} p_0^{n_1-i} p_1^{i}$$

$$P_{c_2} = P_{c_{21}} \quad , \quad P_{r_2} = 1 - P_{a_2} + P_{c_2}$$

Bray et. al [1] further remarked that there are many ways of studying and presenting three-class plans. This part develops procedures and tables for construction and selection of three-class corrective action plan when (c_1, b_1), i and γ are given. Using the procedures and tables one may very easily

(1) Select a corrective action plan when one point (p_1, p_2, P_{CA}) on the OC surface and (c_1, b_1), i and γ are given.

(2) Plot the OC surface of the plan where sample size n, (c_1, b_1), i and γ are given.

4.1 Illustration and Evaluation of the Plan:

For construction and Evaluation of the plan, unity values $\lambda_1 = n_1p_1$ presented in Table (3.1) were derived by using the theory of unity values due to Duncan [3]. These tables may be used to construct plans whose OC surface passes through the point (p_1, p_2, P_{CA}) for pre-specified values of (c_1, b_1), i and γ. The steps to be followed are the following:

(1) Compute the discriminating ratio $m = p_1 / p_2$.

(2) Read the values of $\lambda_1=n_1p_1$ against m and P_{CA} from the corresponding table of (c_1, b_1), i and γ.

(3) Determine the sample sizes as $n_1 = n_1p_1 / p_1$ and $n_2 = n_1 \gamma$. Round up in determining the sample sizes.

Example (1): Suppose a three-class deferred corrective action plan is desired to have 80% probability of corrective action at $p_1 = 0.02$, $p_2 = 0.001$ with $c_1 = 0$, $b_1 = 2$, i = 2 and $\gamma = 1.50$. We have

(1) The discriminating ratio $m = p_1 / p_2 = 0.02 / 0.001 = 20$.

(2) The value of $\lambda_1 = n_1p_1$ corresponding to m = 20, $P_{CA} = 0.80$, i = 2 and $\gamma = 1.50$ is found as 0.7757. [From Table (3.2)]

(3) The sample sizes are: $n_1 = n_1p_1 / p_1 = 0.7757 / 0.02 = 38.785 \cong 39$.

$n_2 = n_1 \gamma = 38.785 \times 1.50 = 58.177 \cong 58$.

Thus, the desired plan consists of

$$n_1 = 39,\ n_2 = 58,\ c_1 = 0,\ b_1 = 2,\ c_2 = b_2 = 0 \text{ and } i = 2.$$

The OC surface of the plan characterized by the sample size n_1, the acceptance constants (c_1, b_1), i and γ can be constructed through the following steps:

(a) Choose the probability of corrective action P_{CA} .

(b) Read the values of $\lambda_1=n_1p_1$ against the values of m and P_{CA} from the corresponding table of i, (c_1, b_1) and γ.

(c) Determine $p_1 = \lambda_1 / n_1$ and $p_2 = \lambda_2 / n_2$. Thus, one point (p_1, p_2, P_{CA}) on the OC surface is obtained.

(d) Repeat the steps (b) to (d) to obtain other points on the OC surface taking other values of m with the same value of P_{CA}.

(e) Repeat the steps (a) to (e) taking other values of P_{CA}.

Example (2): For proposed corrective action plan for three attribute classes with two-phase inspection calling for a sample size n_1 =15, c_1 = 0, b_1 = 2, i = 2 and γ = 1.50, some point on OC surface may be shown below [Table (4.1)]:

Table (4.1): Some Points on OC Surface

p_1	p_2	P_{CA}
0.04358	0.004358	0.80
0.05171	0.002585	0.80
0.05562	0.001854	0.80
0.04553	0.004553	0.70
0.05294	0.002684	0.70
0.05586	0.001862	0.70
0.04733	0.004733	0.60
0.05515	0.002757	0.60
0.05814	0.001938	0.60
0.04971	0.004971	0.50
0.05802	0.002901	0.50
0.06117	0.006117	0.50
0.05302	0.005302	0.40
0.06190	0.003095	0.40
0.06524	0.002174	0.40

In order to study the properties of marginal and bad quality performance of the process, we consider the plan with n_1=10, c_1 = 0, b_1 = 2, c_2 = b_2 = 0, i =2 and γ = 1.50. The OC curve (a segment of OC surface) showing the relationship between p_1 and P_{CA} have been drawn in Fig. (3). It is observed from the figure that for fixed p_2, the probability of corrective action increases gradually to certain extent, and then it decreases as p_1 value increases. Therefore, a step of corrective action is useful and necessary only to a certain increase in the proportion p_1 of marginal quality performance of the process, and thereafter (or otherwise), process becomes out-of-control. The nature of bad quality performance shown in Fig. (4) reveals that for fixed p_1, the probability of corrective action decreases slowly to certain extent, and then it decreases sharply with the increasing proportion p_2 of bad quality performance of the process. Thus, bad quality performance of the process can not be controlled because of continuous force of deterioration. It is also interesting to observe from figure that the OC curve of larger values of p_1 cuts the OC curve formed by the initial lower values of p_1 due to the shift of control line towards out-of-control region.

5. Construction of Tables:

If the sample size is assumed to be large, and the process level p_1 and p_2 are closed to zero, it can be seen that

$$P_a = P\left[d_1 \le c_1 \text{ and } d_2 \le c_2\right] = \sum_{i=0}^{c_1-j} \sum_{j=0}^{c_2} \frac{\lambda_1^{\,i}\, \lambda_2^{\,i}}{i!\; j!} \exp[-(\lambda_1+\lambda_2)],$$

where $\lambda_1 = n_1 p_1$ and $\lambda_2 = n_2 p_2$.

The OC function of the plan is given in equation (3.3.5). Now, for $c_2 = b_2 = 0$ the probabilities P_{a_1}, P_{c1}, P_{r_1} etc. under the poison approximation come out to be:

$$P_{a_1} = \sum_{i=0}^{c_1} \frac{\lambda_1^{\,i}}{i!} \exp\left(-\lambda_1 - \lambda_2\right) = \sum_{i=0}^{c_1} \frac{\lambda_1^{\,i}}{i!} \exp\left(-k\lambda_1\right)$$

$$P_{c_1} = \sum_{i=0}^{c_1+b_1} \frac{\lambda_1^{\,i}}{i!} \exp\left(-k\lambda_1\right) - \sum_{i=0}^{c_1} \frac{\lambda_1^{\,i}}{i!} \exp\left(-k\lambda_1\right)$$

$$P_{r_1} = 1 - P_{a_1} - P_{c_1}$$

and

$$P_{a_2} = \sum_{i=0}^{c_1} \frac{(\gamma\lambda_1)^i}{i!} \exp\left(-k\gamma\lambda_1\right)$$

$$P_{c_2} = \sum_{i=0}^{c_1+b_1} \frac{(\gamma\lambda_1)^i}{i!} \exp\left(-k\gamma\lambda_1\right) - \sum_{i=0}^{c_1} \frac{(\gamma\lambda_1)^i}{i!} \exp\left(-k\gamma\lambda_1\right)$$

$$P_{r_2} = 1 - P_2 - P_2$$

where $m = \lambda_1 / \lambda_2$, $k = (1 + m) / m$ and $\gamma = n_2 / n_1$.

Since the probability of corrective action P_{CA} can be shown a function of $\lambda_1 = n_1p_1$ for given values of (c_1, b_1), i and γ, therefore, following arguments presented by Schilling [1982, pp. 151], the discriminating ratio m may be used to generate unity values. A wide range of m values have been considered to develop the tables of unity values. Only the tables for $(c_1, b_1) = (0, 2)$ and γ=1.25, 1.50 and 1.75 have been presented in Tables (3.1, 3.2 and 3.3).

Glossary of Symbols

The following symbols and definitions are customarily used in three-class plans similar to those of Bray et. al (1973):

n	:	Sample size; the number of items drawn from the process and examined.
p_0	:	Good quality level of the process, Process is in in-control state.
p_1	:	Marginal quality level of the process. Process is in marginal-control state.
$p_2 = 1 - p_0 - p_1$	:	Bad quality level of the process. Process is in out-of-control state.
m	:	The value of the characteristic separating good quality from marginal quality.
M	:	The value of the characteristic separating marginal quality from bad quality (m < M).

d_1 : The number of items of either marginal quality or bad quality in the sample; i. e. such that characteristic > m.

d_2 : The number of items of bad quality in the sample; i. e. such that characteristic > M.

c_1 : The maximum allowable number for the sum of marginal quality and bad quality items in the sample.

c_2 : The maximum allowable number for the bad quality items in the sample.

b_1 : The additional allowable number for the sum of marginal and bad quality items in the sample.

b_2 : The additional allowable number for bad quality items in the sample.

i : Acceptance criterion, the number of succeeding samples to be considered for deferred decision.

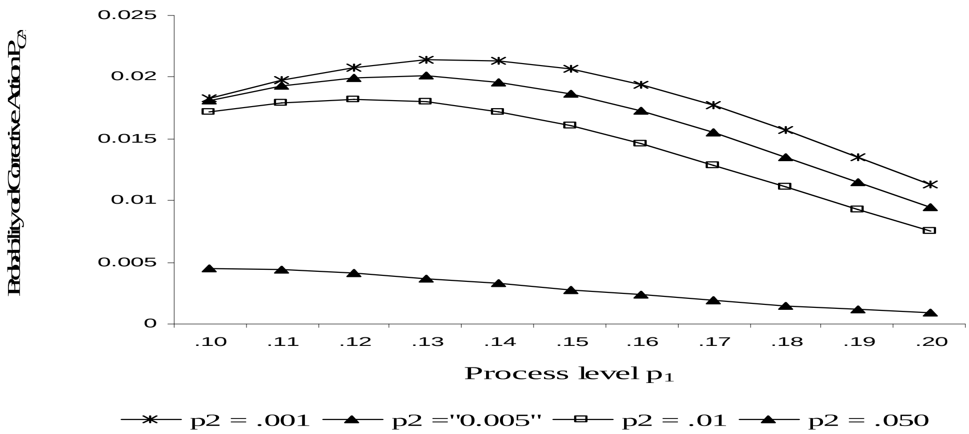

Fig. (3): A segment of OC surface (p_1 versus P_{CA})
$n_1 = 10$, $c_1 = 0$, $b_1 = 2$, $c_2 = b_2 = 0$, $i = 2$ and $\gamma = 1.50$.

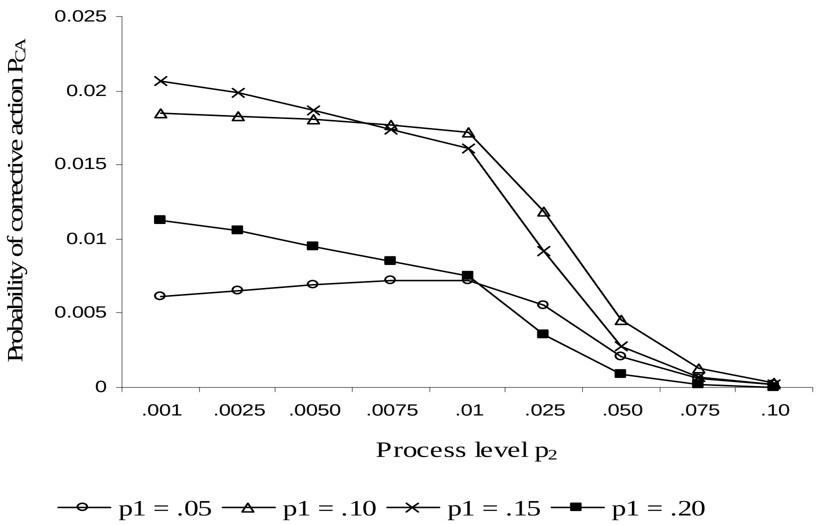

Fig. (4): A segment of OC surface (p_2 versus P_{CA})
$n_1 = 10$, $c_1 = 0$, $b_1 = 2$, $c_2 = b_2 = 0$, $i = 2$ and $\gamma = 1.50$.

T A B L E (1)

Unity Values for Construction and Selection of Corrective Action Plan

$c_1 = 0$, $b_1 = 2$, $c_2 = b_2 = 0$, $i = 2$ and $\gamma = 1.25$.

Probability of Corrective Action

m	0.80	0.75	0.70	0.65	0.60	0.55	0.50	0.45	0.40	0.35	0.30
5	0.4983	0.5037	0.5114	0.5208	0.5318	0.5450	0.5608	0.5802	0.6043	0.6349	0.674
10	0.6464	0.6689	0.6863	0.7038	0.7235	0.7462	0.7728	0.8044	0.8423	0.888	0.9448
15	0.7304	0.7507	0.7697	0.7901	0.8131	0.8396	0.8703	0.9062	0.9485	0.9991	1.0663
20	0.6960	0.7734	0.8103	0.8372	0.8634	0.8921	0.9248	0.9628	1.0072	1.0598	1.1231
25	0.7208	0.8015	0.8403	0.8685	0.8958	0.9256	0.9595	0.9986	1.0442	1.0980	1.1624
30	0.7388	0.8214	0.8613	0.8903	0.9183	0.9488	0.9835	1.0233	1.0696	1.1242	1.1893
35	0.7529	0.8363	0.8768	0.9063	0.9348	0.9658	1.0010	1.0413	1.0882	1.1432	1.2088
40	0.7643	0.8479	0.8887	0.9185	0.9474	0.9788	1.0143	1.0551	1.1023	1.1577	1.2236
45	0.7734	0.8571	0.8981	0.9282	0.9574	0.9891	1.0248	1.0659	1.1134	1.1691	1.2353
50	0.7805	0.8644	0.9057	0.9360	0.9654	0.9973	1.0334	1.0746	1.1223	1.1782	1.2446
55	0.7858	0.8704	0.9119	0.9425	0.9721	1.0042	1.0404	1.0818	1.1297	1.1858	1.2524
60	0.7901	0.8753	0.9171	0.9479	0.9776	1.0099	1.0462	1.878	1.1359	1.1921	1.2588
65	0.7947	0.8798	0.9217	0.9525	0.9824	1.0148	1.0512	1.0930	1.1412	1.1975	1.2643

T A B L E (2)

Unity Values for Construction and Selection of Corrective Action Plan

$c_1 = 0$, $b_1 = 2$, $c_2 = b_2 = 0$, $i = 2$ and $\gamma = 1.50$.

Probability of Corrective Action

m	0.80	0.75	0.70	0.65	0.60	0.55	0.50	0.45	0.40	0.35	0.30
5	0.5088	0.5151	0.5220	0.5298	0.5388	0.5494	0.5619	0.5770	0.5955	0.6185	0.6479
10	0.6537	0.6709	0.6830	0.6957	0.7100	0.7265	0.7457	0.7684	0.7954	0.8282	0.8688
15	0.7269	0.7412	0.7545	0.7690	0.7854	0.8042	0.8259	0.8513	0.8814	0.9175	0.9616
20	0.7757	0.7819	0.7946	0.8098	0.8273	0.8472	0.8703	0.8971	0.9286	0.9663	1.0121
25	0.8106	0.8085	0.8202	0.8358	0.8538	0.8745	0.8983	0.9259	0.9583	0.9969	1.0438
30	0.8343	0.8268	0.8379	0.8537	0.8722	0.8933	0.9176	0.9457	0.9787	1.0180	1.0655
35	0.8470	0.8394	0.8507	0.8668	0.8856	0.9071	0.9317	0.9602	0.9936	1.0333	1.0812
40	0.8477	0.8475	0.8602	0.8767	0.8958	0.9175	0.9424	0.9712	1.0049	1.0449	1.0932
45	0.8352	0.8516	0.8673	0.8845	0.9038	0.9258	0.9509	0.9799	1.0138	1.0541	1.1026
50	0.8084	0.8516	0.8725	0.8907	0.9103	0.9324	0.9577	0.9869	1.0210	1.0615	1.1102
55	0.8084	0.8556	0.8775	0.8959	0.9157	0.9379	0.9633	0.9927	1.0269	1.0675	1.1165
60	0.7985	0.8571	0.8813	0.9003	0.9202	0.9425	0.9681	0.9975	1.0319	1.0726	1.1217
65	0.8540	0.8706	0.8867	0.9043	0.9241	0.9465	0.9721	1.0016	1.0361	1.0770	1.1262

T A B L E (3)

Unity Values for Construction and Selection of Corrective Action Plan

$c_1 = 0$, $b_1 = 2$, $c_2 = b_2 = 0$, $i = 2$ and $\gamma = 1.75$

Probability of Corrective Action

m	0.80	0.75	0.70	0.65	0.60	0.55	0.50	0.45	0.40	0.35	0.30
5	0.5229	0.5235	0.5241	0.5243	0.5319	0.5322	0.5427	0.5423	0.5572	0.5751	0.5980
10	0.6399	0.6481	0.6451	0.6543	0.6652	0.6778	0.6925	0.7097	0.7304	0.7555	0.7866
15	0.6899	0.6975	0.7071	0.7181	0.7305	0.7447	0.7612	0.7806	0.8035	0.8311	0.8651
20	0.7254	0.7315	0.7416	0.7532	0.7664	0.7815	0.7990	0.8193	0.8434	0.8723	0.9078
25	0.7435	0.7526	0.7634	0.7755	0.7891	0.8048	0.8228	0.8437	0.8685	0.8982	0.9345

30	0.7463	0.7665	0.7783	0.7908	0.8048	0.8207	0.8391	0.8605	0.8857	0.9159	0.9528
35	0.7583	0.7774	0.7893	0.8019	0.8162	0.8324	0.8510	0.8727	0.8983	0.9288	0.9661
40	0.7708	0.7859	0.7977	0.8104	0.8249	0.8413	0.8603	0.8820	0.9078	0.9386	0.9762
45	0.7758	0.7923	0.8042	0.8172	0.8317	0.8483	0.8673	0.8894	0.9153	0.9464	0.9841
50	0.7840	0.7977	0.8096	0.8226	0.8372	0.8539	0.8731	0.8953	0.9214	0.9526	0.9906

REFERENCES:

1. Bray, D. F., Lyon, D. A. and Burr, I. W. (1973): Three-class attributes plans in acceptance sampling. Technometrics, 15, 3, 575-585.
2. Calvin, T. W. (1977): TNT Zero acceptance number sampling. ASQC Technical Conference Transactions, Philadelphia, Pennsylvania.
3. Duncan, A. J. (1986): Quality Control and Industrial Statistics. 5th ed., Richard D. Irwin, Homewood, Illinois.
4. Schilling, E. G. (1982): Acceptance Sampling in Quality Control. Marcel Dekker, Inc., New York.
5. Shankar, G. (1996): GERT analysis of repetitive group sampling plan: Two- Phase Inspection. Sankhya B, 58, 3, 431-438.
6. Shankar, G. (1999): GERT analysis of corrective action plan for the production processes. OPSEARCH, 36, 1, 85-94.
7. Shankar, G. and Chandrakar, T. K. (2002): Three class inspection corrective plan for the production processes, Gujarat Statistical Review, 29, 1 & 2, 11-24.
8. Shankar, G. and Sahu, A. K. (2002): A process control plan with two-phase inspection. Econ. Qual. Control, 17, 63-73.
9. Shankar, G. and Srivastava, R. K. (1996): GERT analysis of two-stage deferred sampling plan. Metron, LIV, 1-2, 181-193.
10. Srivastava, R. K. (1999): GERT network analysis of some quality control systems. Ph. D. Dissertation, Pt. Ravishankar Shukla University, Raipur.
11. Stephens, K. S. and Dodge, H. F. (1976): Two-stage chain sampling inspection plans with different sample sizes in the two stages. JQT, 8, 4, 209-224.
12. Vearst, R. (1980): A procedure to construct multiple deferred state sampling plans. Methods of Operations Research, 37, 477- 485.