

# Designing of MATLAB Program for Various Fuzzy Quality Regions in CSP-MLP-T-3 Sampling plan

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**Abstract**— In this paper, an optimal designing methodology is proposed to determine the parameters for Multi-Level Continuous Sampling Plans CSP-MLP-T-3, when the lifetime of the product follows generalized exponential distribution. The two points on the operating characteristic curve approach are used to find the optimal parameters for the proposed plan. The plan parameters are determined through Quality Decision Region.

**Keywords**- Consumer risk, Producer risk, Fuzzy Quality Regions, Continuous sampling plan

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## I. INTRODUCTION

Fordice (1972) proposed a tightened three level continuous sampling plan designated as CSP –T, which is included in MIL-STD 1235C (1988). Brugger (1972) presented a simplification of the Markov chain approach to continuous formulation. Using this approach, Fordice (1972) derived AOQ and AFI functions for the CSP –T plan, which is a special case of MLP –T plan with three sampling inspection levels  $f_1 = f$ ,  $f_2 = 1/2f$  and  $f_3 = 1/4f$ . Recently Suresh and Nirmala (2015) and presented Construction and Selection of Continuous Sampling Plan (CSP-1) Indexed through Quality Decision Regions. This paper provides new structure quality regions for Modified Tightened 3 level Continuous sampling plan (modified MLP – T – 3).

## II. OPERATING PROCEDURE

1. The procedure starts with 100% inspection of units in the order of production.
  - a) If the first  $i$  consecutive units are found non-conforming discontinue 100% inspection and switch to sampling inspection at level 2, where only a pre specified fraction  $f_2$  of the units are inspected.
  - b) Otherwise continue 100% inspection until any run of  $i$  successive units found non-conforming and then proceed to sampling inspection at level 1, where only a pre-specified fraction  $f_1$  of the units are inspected.
2. If sampling inspection is on level 1, then continue inspection until a non-conforming unit is found. When this occurs revert immediately to 100% inspection and then continue as in (1).
3. If sampling inspection is on level 2 or level 3, then continue the inspection until a non-conforming unit is

found. When this occurs revert immediately to 100% inspection and then:

- a) If the first  $i$  consecutive units are found conforming then discontinue 100% inspection and switch to sampling inspection at level 3, where a pre-specified fraction  $f_3$  of the units is inspected.
- b) Otherwise continue as in 1(b).

Repair all non-conforming units found or replace them with conforming units.

An important feature of the modified MLP – T – 3 plan compared with MLP – T – 3 plan is that one cannot go from one level of sampling inspection to another without going back to 100% inspection. This property might give some reassurance in practice that the higher levels of inspections can be adopted only when good process quality has been confirmed by 100% inspection. Thus, this feature could be essential when selecting an appropriate sampling plan.

## III. SELECTION PROCEDURE

The Performance Measures of Modified MLP – T – 3 Plan.

If one employs a modified MLP –T –3 plan for a process fraction non-conforming  $p$ , the following performance measures are obtained. The average number of units passed under the sampling inspection is given by,

$$v = \frac{f_2 f_3 (1 - q^i) + f_1 f_3 q^i (1 - q^i) + f_1 f_2 q^{2i}}{f_1 f_2 f_3 p}$$

The average fraction of total produced units inspected in the long run is,

$$F = \frac{f_1 f_2 f_3}{f_1 f_2 f_3 (1 - q^i) + f_2 f_3 q^i (1 - q^i) + f_1 f_3 q^{2i} (1 - q^i) + f_1 f_2 q^{3i}}$$

The average outgoing quality limit (AOQL), the maximum of the AOQ for all values of  $p$ , may be found graphically using the AOQ function.

#### IV. QUALITY DECISION REGION (QDR)

It is an interval of quality ( $p_1 < p < p_*$ ) in which product is accepted at engineer's quality average. The quality is reliably maintained up to  $p_*$  (MAPD) and sudden decline in quality is expected. This region is also called Reliable Quality Region (RQR).

Quality Decision Region is denoted as  $d_1 = (p_* - p_1)$  is derived from the average probability of acceptance,

$$P_a(p_1 < p < p_*) = P_a(p) \text{ for } (p_1 < p < p_*)$$

Where  $P_a(p)$  is the mean value for the product quality  $p$ .

Figure. 1 is drawn using the MATLAB software and the program is described below

Program for Fuzzy QDR:

```
>> x=(0:0.001:0.10);
>> y=trimf(x,[0.02,0.05,0.08]);
>> plot(x,y);% Given x & y values,
>> X lable ('FQDR');
>> Y label ('Pa(p)');
```

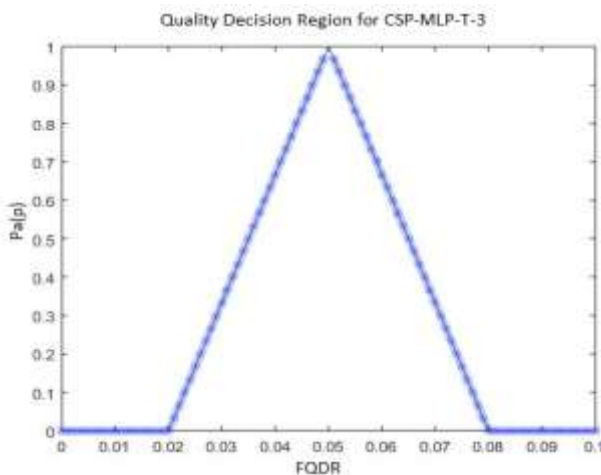


Figure 1: Fuzzy Quality Decision Region for CSP-MLP-T-3

#### V. PROBABILISTIC QUALITY REGION (PQR)

It is an interval of quality ( $p_1 < p < p_2$ ) in which product is accepted with a minimum probability 0.10 and maximum probability 0.95.

Probabilistic Quality Region denoted as  $d_2 = (p_2 - p_1)$  is derived from the average probability of acceptance,

$$P_a(p_1 < p < p_2) = P_a(p) \text{ for } (p_1 < p < p_2)$$

Figure .2 is drawn using the MATLAB software and the program is described below

Program for Fuzzy PQR:

```
>> x=(0:0.001:0.10);
>> y=trimf(x,[0.02,0.04,0.06]);
>> plot(x,y);% Given x & y values,
>> X lable ('FPQR');
>> Y label ('Pa(p)');
```

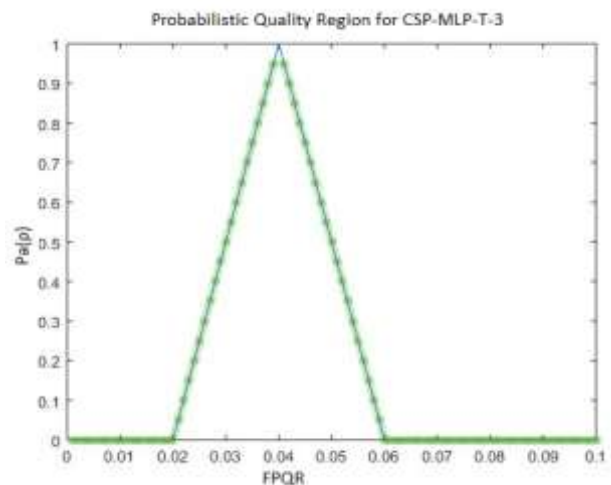


Figure 2: Fuzzy Probabilistic Quality Region for CSP-MLP-T-3

#### VI. LIMITING QUALITY REGION (LQR)

It is an interval of quality ( $p_* < p < p_2$ ) in which product is accepted with a minimum probability 0.10 and maximum probability 0.95.

Limiting quality range denoted as  $d_3 = (p_2 - p_*)$  is derived from the Average probability of acceptance,

$$P_a(p_* < p < p_2) = P_a(p) \text{ for } (p_* < p < p_2)$$

Figure .3 is drawn using the MATLAB software and the program is described below

Program for Fuzzy LQR:

```
>> x=(0:0.001:0.10);
>> y=trimf(x,[0.05,0.07,0.09]);
```

```
>> plot(x,y);% Given x & y values,
>> X lable ('FLQR');
>> Y lable ('Pa(p)')
```

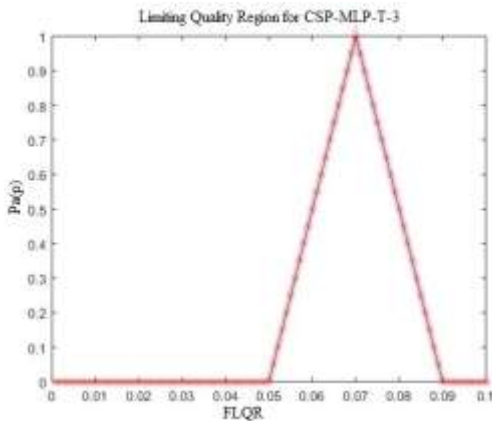


Figure .3: Fuzzy Limiting Quality Region for CSP-MLP-T-3

## VII. INDIFFERENCE QUALITY REGION (IQR)

It is an interval of quality ( $p_1 < p < p_0$ ) in which product is accepted with a minimum probability 0.50 and maximum probability 0.95.

Indifference Quality range denoted as  $d_0 = (p_1 - p_0)$  is derived from the average probability of acceptance,

$$P_a(p_1 < p < p_0) = Pa(p) \text{ for } (p_1 < p < p_0)$$

Figure .4 is drawn using the MATLAB software and the program is described below

Program for Fuzzy IQR:

```
>> x=(0:0.001:0.10);
>> y=trimf(x,[0.02,0.045,0.07]);
>> plot(x,y);% Given x & y values,
>> X lable ('FIQR');
>> Y label ('Pa(p)');
```

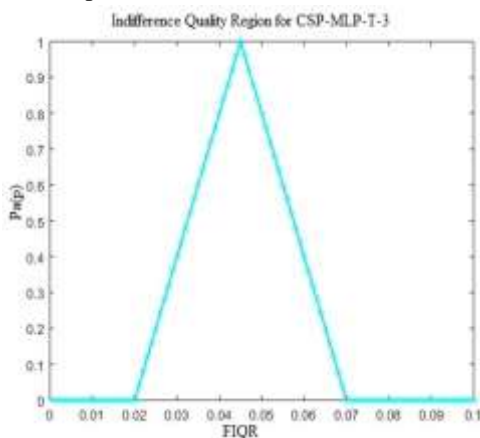


Figure .4: Fuzzy Indifference Quality Region for CSP-MLP-T-3

## VIII. SELECTION OF THE SAMPLING PLAN

Table .1 gives unique values of T for different values of 'f', 'c' and 'i'. Here operating ratio  $= \frac{d_1}{d_2}$ , where

$d_1 = (p_* - p_1)$  and  $d_2 = (p_2 - p_1)$  is used to characterize the sampling plan. For any given values of 'i', 'f' and corresponding ranges  $d_1 = \text{QDR}$ ,  $d_2 = \text{PQR}$ . One can find the ratio  $T = \frac{d_1}{d_2}$ , find the value in the table 1 under the column

T, which is equal to or just less than the specified ratio corresponding 'i', 'c' and 'f' values are noted. From this ratio, one can determine the parameter for the continuous sampling plan.

## IX. NUMERICAL EXAMPLES

In petroleum company producing various oils and lubricants, 1% defects are seen in QDR and 5% defects are seen in LQR. Then 'i' = 2, x = 1,  $f_1 = 1/5$ ,  $f_2 = 1/10$  and  $f_3 = 1/20$ .

Given  $d_1 = 0.01$ , i = 2, x = 1,  $f_1 = 1/5$ ,  $f_2 = 1/10$  and  $f_3 = 1/20$ ,  $p_* = 0.6246$ ,  $p_0 = 0.5811$ ,  $p_1 = 0.0608$ , and  $p_2 = 0.7010$  from the given equation; compute the values of  $d_0 = p_0 - p_1$ ; IQR = 0.52.  $d_1 = p_* - p_1$ ; QDR = 0.5637,  $d_2 = p_2 - p_1$ ; PQR = 0.6402 and  $d_3 = p_2 - p_0$ ; LQR = 0.0764. Then compute T,  $T_1$  and  $T_2$ . Select the respective values from given equation. The nearest values are  $T = 0.8806$ ,  $T_1 = 7.3769$  and  $T_2 = 1.0836$  with respect to i and f. Given  $R_1 = p_0/p_* = 0.9304$  and  $R_2 = p_2/p_1 = 11.528$  can be compute.

## X. FOR SPECIFIED QDR, PQR, IQR AND LQR

Table 2 is used to construct the plans when the QDR and PQR are specified. For any given values of the QDR ( $d_1$ ), PQR ( $d_2$ ), IQR( $d_0$ ) and LQR( $d_3$ ) one can find the ratio  $T_1 = d_1/d_2$  which is a monotonic increasing function in 'f', and can find the value in table 2 under the column  $T_1$  which is equal to or just less than the specified ratio. Then the corresponding value of 'f' is noted. From this, one can determine the parameters 'i', 'x' and 'f' for continuous sampling plan.

## XI. CONCLUSION

In this paper, a new procedure is developed, when the lifetime of the product follows the generalized exponential distribution under the conditions of AQL and LQL. QDR are designed for selected sampling plan. Which is a key measure assessing to what degree of inflection point empowers the OC curve to discriminate between good and bad lots. The present development would be valuable addition to the literature and a useful device for quality control practitioners under industrial applications.

#### AUTHORS PROFILE

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