Certain Studies Relating to Design of Acceptance Sampling Plans Using Weighted Poisson Distribution

Geetha, S

(12PMA005)

Thesis Submitted to

Avinashilingam Institute for Home Science and Higher Education for Women,

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In Partial Fulfilment of the Requirements for the

Degree of Master of Science in Mathematics

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Signature of the Head of the Department

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INTRODUCTION

Acceptance sampling is a statistical method which enables us to make the decision of either accepting or rejecting a shipment of items for the lot. In most situations, 100 percent inspection of all items is neither desirable nor commercially feasible.

Some advantages of accepting sampling plan are

- It is more economical as against 100 percent inspection in terms of inspection costs.
- It is usually more accurate than 100 percent inspection, since it allows less opportunity for inspection fatigue, which can be responsible for mistakes.
- Less product damage occurs since it requires less handling of the product.
- Rejecting the entire lot on the basis of simple sample testing can motivate the suppliers of the product to improve their quality control standards and producers.
- It is the only approach in situations where quality is tested by destroying the item.

Inspection for acceptance purposes is carried out at many stages in manufacturing. There may be inspection of incoming materials and parts, process inspection at various points in the manufacturing operations, final inspection by a manufacturer of his own product, and ultimately inspection of the finished product by one or more purchasers.

Much of this acceptance inspection is necessarily on a sampling basis. All the acceptance tests that are destructive of the item tested must inevitably be done by sampling. In many situations, sampling inspection is used because the cost of 100 percent inspection is prohibited.

The major areas of acceptance sampling according to Dodge [4] are

- Lot-by-Lot sampling by the method of attributes in which each unit in a sample is inspected on a go-not-go basis for one or more characteristics.
- Lot-by-Lot sampling by the method of variables in which each unit in a sample is measured for a single characteristics, such as weight or strength.

- Continuous sampling of a flow of units by the method of attributes.
- Special purpose plans including chain sampling, skip-lot sampling, small sampling plans, etc…

Sampling plan, Sampling scheme and sampling system

According to American National Standards Institute/American Society, for Quality Control (ANSI/ASQC) Standard A_2[1] an acceptance sampling plan is a specific plan that states the sampling rules to be used and the associated acceptance and non-acceptance criteria and an acceptance sampling scheme is a specific set of procedures which usually consists of acceptance sampling plans in which lot sizes ,sample sizes and acceptance criteria, or the amount of 100 percent inspection and sampling and related. According to Hill [8], a sampling scheme is a whole set of sampling plans and operation included in the standard “the over-all strategy specifying the way in which sampling plans are to be used”. The MIL-STD-105D is a well known sampling scheme. Stephens and Larson [25] have described a sampling system as an assigned grouping of two or more sampling plans and the rules for using these plans for sentencing lots to achieve a blend of the advantageous features of each of the sampling plans. Tightened-Normal-Tightened sampling scheme of Calvin [2] is an example for sampling scheme.

Operating Characteristic (OC) Curve

Every sampling plan is associated with an operating characteristic curve, familiarly known as OC curve of the plan. This curve when referred to two axes, the axis of p-proportion nonconforming of the material offered for inspection and the axis of $P_a(p)$-probability of acceptance of a lot or process, is the locus of $(pap_a(p))$. The OC curve gives the practical performance of a sampling plan.

Type A OC-Curve

A curve showing, for a given sampling plan, the probability of accepting a lot as a function of the lot quality. This curve is for isolated or unique lots or lot from isolated sequences.

Type B OC-Curve

A curve showing, for a given sampling plan, the probability of accepting a lot as a function of the process average. This curve is for continuous stream of lots.

Poisson Model

This model is exact for the case of nonconforming units under Type A and Type B situations. Under situation of type A, for the case of nonconforming units, this model can be used whenever $n/N \leq 0.10$, n is large and p is small such that $np<5$. Under situations of Type B, for the case of nonconforming units, this model can be used whenever n is large and p is small such that $np<5$.

Designing Sampling Plans

In designing a sampling plan one has to accomplish a number of different purposes. According to Hamaker [7], the important ones are

1. To strike a proper balance between the consumer's requirements, the producer's capabilities, inspector's capacity.
2. To separate bad lots from good.
3. Simplicity of procedures and administration.
4. Economy in number of observations.
5. To reduce the risk of wrong decisions with increasing lot size.
6. To use accumulated sample data as a valuable source of information.
7. To exert pressure on the producer or supplier when the quality of lots received is unreliable or not up to standard and
8. To reduce sampling when the quality is reliable and satisfactory.

   According to Peach [10], the following are some of the major types of designing the plans, which are classified according to types of protection

   1. The plan is specified by reducing the OC curve to pass through (or nearly through) two fixed points.
   2. The plan is specified by fixing the one point only, the through which the OC curve is required to pass and setting up one or more conditions, not explicitly in terms of the OC curve.

3. The plan is specified by imposing upon the OC curve two or more independent conditions none of which explicitly involves the OC curve.

Acceptance Sampling Plan

A specific plan that states the sample size or sizes to be used and the associated acceptance and non-acceptance criteria.

Probability of Acceptance

The probability that a lot will not be accepted under a given sampling plan.

Probability of Rejection

The probability that a lot will not be accepted under a given sampling plan.

Acceptance Quality Level

The maximum percentage or proportion of variant units in a lot or batch that for the purpose of acceptance sampling can be considered satisfactory as a process average.

Lot Tolerance Percent Defective

Lot tolerance percent defective is defined as a maximum percentage of defective items in a lot beyond which the lot should be rejected.

Limited Quality Level

The percentage or proportion of variant units in a batch or lot for which, the purpose of acceptance sampling the consumer wishes the probability of acceptance to be restricted to a specified low value.

Consumer's Risk

For a given sampling plan, the probability of acceptance of a lot the quality of which has designated numerical value representing a level which it is generally desired to accept.

Producer's Risk

For a given sampling plan, the probability of not accepting a lot the quality of which has designated numerical value representing a level which it is generally desired to accept.

Average Sample Number

The average number of sample units per lot for making decisions (acceptance or non-acceptance).

Average Outgoing Quality

The expected quality of outgoing product following the use of an acceptance sampling plan for a given value of incoming product quality.

Average Outgoing Quality Limit

For a given acceptance sampling plan, the maximum average outgoing quality over all possible levels of incoming quality.

Average Total Inspection

The expected number of items inspected per lot to arrive at a decision in an acceptance rectification sampling, inspection plan calling for 100 percent inspection of the rejected lots is called average amount of total inspection.

Indifference Quality Level

The percentage of variant units in a batch or lot for which for purpose of acceptance sampling, the probability of acceptance to be restricted to a specific value namely 0.50. The point (IQL, 0.50) on the OC curve is also called as 'point of control'.

Maximum Allowable Percent Defective

The point of the OC curve at which the descent is steepest is called the point of inflection. The proportion non conforming corresponding to the point of inflection of the OC curve is interpreted as the maximum allowable percent defective.

Maximum Allowable Average Outgoing Quality

The maximum allowable average outgoing quality is defined as the average outgoing quality at MAPD.

i.e., AOQ = p $P_a(p)$

Thus MAAOQ = AOQ at $p = p^*$. This can be written as MAAOQ = $p^* P_a(p^*)$.

Single Sampling Plan

Sampling inspection in which the decision to accept or not to accept a lot is based on the inspection of a single sample of size 'n'.

Double Sampling Plan

Sampling inspection in which the inspection of the first sample of size 'n_1', leads to a decision to accept a lot or not to accept it, or to take a second sample of size 'n_2' and the inspection of the second sample then leads to a decision to accept or not to accept the lot.

Conditional Double Sampling Plan

The conditional double sampling plan is either a dependent double or deferred double sampling plan depending sampling plan depending on whether the past lot or future lot information is utilized on sentencing the current lot.

Mixed Sampling

If the samples are selected partly according to some laws of chance and partly according to a fixed sampling rule (no assignments of probabilities) they are termed as mixed samples and the technique of selecting such sample is known as mixed sampling.

Glossary of Symbols:

P – Quality of Submitted Lot

P* - Maximum Allowable Percent Defective (MAPD)

n – Sample Size

c - Acceptance number

$P_a(p)$ - Probability of acceptance of the lot quality

d - Number of defectives counted

R - Ratio of MAAOQ to MAPD

Pt - The point at which the inflection tangent of the OC curve cuts the 'p' axis

P_1 - The submitted quality level such that $P_a(p_1) = 0.95$

P_0 - The submitted quality level such that $P_a(p_0) = 0.50$

h* - Relative slope at p*

n_1 – Sample size for the variable sampling plan

n_2 – Sample size for the attribute sampling plan

c_1 – First attributes acceptance number.

c_2 – Second attributes acceptance number.

c_3 – Third attributes acceptance number.

β_j – Probability of acceptance for lot quality 'p_j'

β_J □ -Probability of acceptance assigned to second stage for percent defective P_j

OC – Operating Characteristic Curve

ASP – Acceptance Sampling Plan

AQL – Acceptable Quality Level

IQL – Indifference Quality Level

LQL – Limiting Quality Level

MAPD – Maximum Allowable Percent Defective

MAAOQ – Maximum Allowable Average Outgoing Quality

CRGS – Conditional Repetitive Group Sampling Plan

MSP – Mixed Sampling Plan

WPD – Weighted Poisson Distribution

This thesis is devoted to the study of some acceptance sampling plans using weighted Poisson distribution.

The first chapter provides operating procedure for the construction of Single Sampling Plan (SSP) through Maximum Allowable Average Outgoing Quality (MAAOQ) and Maximum Allowable Percent Detective (MAPD) with conditional Weighted Poisson Distribution as a basic distribution.

The second chapter discusses about the conditional Repetitive Group Sampling Plan which is constructed with Weighted Poisson Distribution (WPD) as the basic distribution indexed through Maximum Allowable Percentage Defective (MAPD) and Maximum Allowable Average Outgoing Quality (MAAOQ). The above plans are compared with the Conditional Repetitive Group Sampling (CRGS) plans having the Poisson distribution. Tables are constructed for the easy selection of the plans.

Chapter three deals with the procedure for the construction and selection of Mixed Sampling Plan with MAPD as a quality standard and Link Sampling Plan as attribute plan using weighted Poisson distribution. The plans are constructed indexed through MAPD and IQL and also compared.

The fourth chapter provides the procedure for the construction and selection of Mixed Sampling Plan with MAPD as a quality standard and Conditional Double Sampling Plan as attribute plan using Weighted Poisson Distribution as a base line distribution. The plans are constructed indexed through MAPD and AQL and also compared.

Chapter five provides the procedure for finding the Multiple Deferred State – 1 (MDS – 1) (c_1, c_2) sampling plan involving minimum sum of producer's and consumer's risks for specified Acceptable Quality Level and Limiting Quality Level using weighted Poisson distribution.

Review of Literature

Review of literature

Acceptance sampling is a statistical method which enables us to make the decision of either accepting or rejecting a shipment0f items for the lot. A specific plan that states the sample size or sizes to be used and the associated acceptance and non – acceptance criteria.

It is the usual practice to use Poisson distribution or binomial distribution to evaluate OC curves. To fix the operating characteristic curve (OC) curve in accordance with desired degree of discrimination.

In the construction of acceptance sampling plan, size – biased version of random variable about defectives play an important role. The weighted distributions are more suitable distributions than the classical distributions like Binomial, Poisson and Negative Binomial. The weighted Poisson distribution plays an important role in acceptance sampling, mainly in the construction of sampling plans. Each outcome (number of defectives) is specific but can be assigned different weights based on its importance or usage.

Golub [5] has given a method of finding a single sampling plan involving a minimum sum of producer's and consumer's risks for given AQL and IQL where the sample size n is fixed due to the economic, administrative or practical factors. Guenther [6] proposed an iterative procedure to determine the parameters of the single sampling plans by attribute for two points on the OC curve, namely $(p_1, 1-\alpha)$ and (p_2, β) where p_1, p_2, α and β represent respectively producer's quality level, consumer's quality level, producer's risk and consumer's risk.

Radhakrishnan and Mohanapriya [16] constructed the single and double sampling plans using conditional weighted Poisson distribution. Subramani and Haridoss [29] have constructed table for selecting single sampling attributes plan for given AQL and LQL with minimum sum of risks using weighted Poisson distribution. Sherman [22] has proposed a new type of sampling plan namely repetitive group sampling (RGS) plan. The operation of the plan is similar to that of the sequential sampling plan. Sudeswari [30] studied the designing of sampling plan using weighted Poisson distribution as the basic distribution. Subramani and Haridoss [28] have constructed table for selecting repetitive group sampling (RGS) plan for given AQL and LQL with minimum sum of risks using weighted Poisson distribution.

The mixed sampling plan has been designed under two cases of significant interest. In the first case sample size n_1 is fixed and a point on the OC curve is given. In the second case plans are designed when two points on the OC curve are given. The procedure for designing the mixed sampling plans to satisfy the above mentioned conditions was provided by Schilling [21]

Devaarul [3] has constructed tables for mixed sampling plans (independent case) having various sampling plans as attribute plans. Sampath kumar [18] has constructed mixed sampling plan with various sampling plan as attribute plans using weighted Poisson distribution as a base line distribution. Schilling [21] has given the following procedure for the independent mixed sampling plan with upper specification limit (U) and standard deviation (σ).

Sudeswari [30] studied the construction of mixed sampling plans using weighted Poisson distribution as a base line distribution. Soundarajan and Raju [24] presented tables for selecting MDS plans for given p_1, p_2, $\alpha(0.05,0.01)$ and

$\beta(0.10, 0.05, 0.01)$ for fixed values of $c_1 = 0$ and $c_2 = 2$. Subramani and Govindaraju [26]have developed tables for the selection of multiple deferred state sampling MDS - 1plan with minimum sum of risks for given acceptance and limiting quality levels using Poisson distribution. Soundarajan and Vijyaraghavan [23] extended this approach to multiple deferred sampling plan of type MDS – 1 (0, 2) limiting to the acceptance a numbers at 0 and 2.

Rao [11] introduced the concept of weighted distribution when the samples recorded without a sampling frame that enables random sample to be drawn.

Chapter – I

CHAPTER – I

SELECTION OF SINGLE SAMPLING PLAN USING CONDITIONAL WEIGHTED POISSON DISTRIBUTION

In this chapter "Selection of Single Sampling Plan Using Conditional Weighted Poisson Distribution" by R. Radhakrishnan and L. Mohanapriya [16] have been reviewed.

The proportion defective corresponding to the inflection point of the OC curve is interpreted as MAPD (p*). One of the desirable properties of an OC curve is that the decrease of $P_a(p)$ should be slower for lesser values of p and steeper for larger values of p, which provides a better overall discrimination. If p* is considered as a standard quality measure then the above property of a desirable OC curve is exactly followed. As p* corresponds to the inflection point of the OC curve, it implies that, where $P_a(p)$ is the probability of acceptance at quality level p fraction defective. Taking into consideration, the criticism leveled at AOQL by several authors, and corresponding importance of the MAPD as a quality measure, procedures and table for the selection of Single Sampling Plan using conditional Weighted Poisson Distribution for $\alpha = 1$ are provided.

1.1 Operating Procedure of Single Sampling Plan

The operating procedure of Single Sampling Plan (SSP) is as follows.

Step 1:

From each of the submitted lots, select a sample of size n and observe the number of non-conformities (d).

Step 2:

Accept the current lot if $d \leq c$ and reject the lot if $d > c$

1.3 Construction of Tables

The probability mass function of SSP using weighted Poisson distribution is given by,

The OC function of SSP using conditional weighted Poisson distribution for α = 1 is given by

$P_a(p) = \sum_{x=0}^{c} P(X: \lambda, \alpha)$

$P_a(a) = \sum_{x=0}^{c} e^{-np} (np)^{x-1} / (x-1)!$ x = 1,2,3,..................

where p is the proportion defective of the lot. Table 1.1 is constructed for various possible combinations of n and c with α = 1 using search procedure.

1.4 Selection of the Sampling Plan for Specified MAAOQ and MAPD

Table 1.1 is used to construct the plan when the MAPD and MAAOQ are specified. One can find the ratio R = MAPD/MAAOQ which is a function of c alone and strictly increasing and find the value in Table 1.1under the column R which is equal to or just greater than the specified ratio the corresponding valued of c is noted. From this, one can determine the parameters n and c for the conditional weighted Poisson distribution.

Example 1.1

Given MAAOQ = 0.00439 and MAPD = 0.0065 the ratio R= MAPD/ MAAOQ=1.48, and locate the nearest value R from Table 1.1, corresponding value of n = 308, c=3. Then the SSP with conditional weighted Poisson distribution is n =308, c = 3for α = 1 with the specified MAAOQ = 0.00439 and MAPD = 0.0065.

Example1.2

Given MAAOQ = 0.0037 and MAPD = 0.0065 the ratio R = MAPD / MAAOQ=1.76, and locate the nearest value R from the Table 1.1, corresponding value of n =2307,c=16. Then the SSP with conditional weighted Poisson distribution is n = 2307, c=16 for α = 1 with specified MAAOQ = 0.0037 and MAPD = 0.0065.

Table 1.1: parameters of the single sampling plan conditional weighted

Poisson distribution $\alpha = 1$

	MAPD % ==>	0.25	0.4	0.5	0.65	1	1.5	2.5	4	6.5	10
	C	n values									
1.48	3	802	501	401	308	200	134	80	50	31	20
1.54	4	1396	748	698	460	299	200	120	75	46	30
1.6	5	1610	1006	805	619	402	268	160	101	62	40
1.62	6	1996	1247	998	767	499	333	200	125	77	50
1.65	7	2400	1501	1200	924	600	400	240	150	92	60
1.67	8	2800	1750	1400	1077	700	467	280	175	108	70
1.69	9	3204	2003	1602	1233	801	534	320	200	123	80
1.7	10	9594	2247	1797	1383	899	599	359	225	138	90
1.72	11	4012	2740	2006	1686	1096	731	439	274	169	110
1.73	12	4408	2989	2204	1839	1196	797	478	299	184	120
1.74	13	4810	3241	2405	1994	1296	864	518	324	199	130
1.75	14	5214	3494	2607	2150	1398	932	559	350	215	140
1.76	16	6000	3749	3000	2307	1500	1000	600	375	231	150
1.77	17	6411	4007	3205	2466	1603	1068	641	401	246	160
1.78	19	7206	4504	3603	2771	1801	1201	721	450	277	180
1.79	21	8006	5004	4003	3079	2001	1334	800	500	308	200
1.8	24	9193	5746	4597	3536	2298	1532	920	575	354	230
1.81	26	10008	6255	5004	3849	2502	1668	1000	625	385	250

The work results provided in this chapter helps the floor engineer to decide about the size of the sample if the incoming quality (MAPD) and the outgoing quality (MAAOQ) are specified. This will help the management in taking quick decisions

Chapter - II

CHAPTER – II

COMPARISON OF CRGS PLANS USING POISSON AND WEIGHTED POISSIN DISTRIBUTION

In this chapter "Comparison of CRGS plans are using Poisson and Weighted Poisson Distribution" by R. Radhakrishnan and L. Mohana Priya [17] have been reviewed.

In this chapter the Conditional Repetitive Group Sampling (CRGS) plan is constructed with the Weighted Poisson Distribution as the basic distribution indexed through MAPD &MAAOQ. These plans are compared with the CRGS plans having Poisson distribution as the basic distribution.

2.1 Conditions for the application of CRGS with WPD in the product control

- Production is steady, so that results of past, present and future lots are broadly is indicative of a continuing process.
- Lot submitted may be isolated or series.
- Inspection is by attributes, with the lot quality defined as the proportion defective.
- Variation in the lot quality may exist.
- Lot has at least one defective unit.
- Lots submitted for inspection may be of second quality.

2.2 Operating procedure of Conditional Repetitive Group Sampling Plan

Step.1

From each of the submitted lots, select a sample of size n and observe the number of non-conformities (say d)

Step .2

Accept the current lot if $d \leq c_1$, reject the lot, if $d > c_2$

Step .3

If $c_1 < d \leq c_2$, utilize the information of the next proceeding lot (i.e) the current lot is accepted if the proceeding lot result shows $d \leq c_1$ in the sample, in case the proceeding lot result shows $c_1 < d \leq c_2$, then utilize the next proceeding lot and checkup whether $d < c_1$ or $d > c_2$ continue utilizing the proceeding lot results till satisfying $d < c_1$ or $d > c_2$.

2.3 Operating characteristic function

The probability mass function of Weighted Poisson Distribution is given by,

$$P(X: \lambda, \alpha) = \frac{X^{\alpha} P(X, \lambda)}{\sum X^{\alpha} P(X, \lambda)}, \qquad X = 0, 1, \text{ where } \lambda = np$$

The probability mass function of Weighted Poisson Distribution for $\alpha = 1$ is given by

$$P(x : \lambda) = P(X : \lambda, \alpha) \qquad \alpha = 1$$

$$= \frac{e^{-np} (np)^{x-1}}{(x-1)!}, \qquad x = 1,2,3,\ldots\ldots\ldots\ldots$$

$$P_a(p) = P_1 / (1 - P_1 P_3)$$

Where $P_1 = \sum_{x=1}^{c_1} \frac{e^{-np} (np)^{x-1}}{(x-1)!}$

$$P_2 = 1 - \sum_{x=1}^{c_2} \frac{e^{-np} (np)^{x-1}}{(x-1)!}$$

The AOQ function for conditional Repetitive Group Sampling Plan is given by

$$AOQ(p) = p.P_a(p)$$

$$MAAOQ = AOQ(p^*)$$

2.4 Constructions of the plans

The value of MAPD (p*) is obtained using $d^2P_a(p)/dp^2 \neq 0$, at p = p* and $d^3P_a(p)/dp^3 \neq 0$, at p = p*. The value of n MAPD = np* and n MAAOQ = $np^*P_a(p)$, where $P_a(p)$ is the probability of acceptance at $p = p*$ and R=MAPD/MAAOQ have been calculated for different possible combinations of c_1 and c_2 are presented in Table 2.1.

For a specified MAPD and MAAOQ =AOQL, Table 2.3 is used to construct the plan. $R = MAPD/MAAOQ$ and $R_1 = MAPD/AOQL$ are found out. The value nearer to the calculated value is obtained. The corresponding values of $c_1 = c_2$ are noted. From this one can find the parameters of CRGS.

2.5 Selection of sampling plan through MAPD and MAAOQ

Table 2.1 is used to construct the plan when the MAPD and MAAOQ are specified. One can find the ratio R=MAPD/MAAOQ which is the function of c_1 and c_2 and the values are obtained from the column R in Table 2.1. The corresponding values of c_1 and c_2 are noted, and hence the parameter of n, c_1 and c_2 for the repetitive group sampling plan is determined.

Table 2.1 Certain parametric (n MAPD, n MAAOQ) values for CRGS plan

c_1	c_2	n MAPD	nMAAOQ	R
1	2	0.4822	0.36236	1.326
1	3	0.5842	0.4525	1.376
1	4	0.6030	0.4366	1.381
2	2	1.000	0.7358	1.359
2	3	1.3971	0.9668	1.445
2	4	1.5712	1.0587	1.484
2	5	1.6548	1.0967	1.508
3	3	2.0000	1.3534	1.478
3	4	2.3468	1.5547	1.509
3	5	2.5448	1.6645	1.529
3	6	2.6656	1.7239	1.546
3	7	2.7276	1.7498	1.559
4	4	3.0000	1.9416	1.545
4	5	3.3115	2.1402	1.547
4	6	3.5190	2.2509	1.563
4	7	3.6616	2.3336	1.569
4	8	3.7490	2.3647	1.585
5	5	4.0000	2.5152	1.590
5	6	4.2848	2.7095	1.581
5	7	4.4956	2.8447	1.580
5	8	4.6518	2.9313	1.587
5	9	4.7580	2.9677	1.603
6	6	5.0000	3.08	1.623
6	7	5.2636	3.2915	1.599
6	8	5.4746	3.4261	1.597
6	9	5.6396	3.5212	1.602
6	10	5.7598	3.5707	1.613
7	7	6.0000	3.6378	1.649
7	8	6.2461	3.8495	1.623
7	9	6.4558	4.0026	1.612
7	10	6.6269	4.1023	1.615

Example 2.1:

Given MAPD = 0.0196 & MAAOQ = 0.0142 the ratio R = MAPD/MAAOQ = 1.381and the corresponding value of n, c_1 and c_2 of the sampling plans are respectively n=31, c_1=1 & c_2=4. Then the CRGS with the weighted Poisson distribution is n =31, c_1 = 1 & c_2=4 with specified MAPD = 0.0196 and MAAOQ = 0.0142. The OC curve for the plan is presented in figure 2.1 more examples are provided in Table 2.2

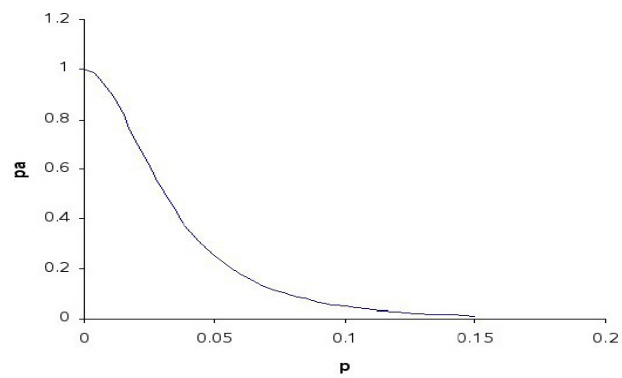

Figure 2.1 OC curve of the CRGS using WPD for n = 31, $c_1 = 1$ **&** $c_2 = 4$.

Table 2.2 CRGS plans for specified MAPD and MAAOQ

MAPD	MAAOQ	n	c_1	c_2
0.03	0.0207	47	2	3
0.026	0.019	22	1	3
0.044	0.0296	36	2	4
0.022	0.0149	91	3	3
0.040	0.026	67	3	6
0.065	0.042	51	4	5
0.015	0.0096	234	4	6
0.025	0.0154	200	6	6
0.081	0.051	57	5	8
0.037	0.0234	116	5	6

2.6 Selection of the plan through MAPD and AOQL

For a specified MAPD and MAAOQ = AOQL, Table 2.3 is used to construct the plan. R =MAPD/MAAOQ and R=MAPD/AOQL are found out. The value nearer to the calculated value is obtained. The corresponding values c_1 and c_2 noted, and hence the parameters n, c_1 and c_2 for the CRGS plan is determined.

Table 2.3 Parameters (nMAAOQ, n AOQL) of CRGS using Weighted Poisson Distribution $(\alpha = 1)$

c_1	c_2	nMAAOQ	nAOQL	R=MAPD/MAAOQ	R_1=MAPD/AOQL
1	2	0.3636	0.4302	1.326	1.121
1	3	0.4245	0.4668	1.376	1.251
1	4	0.4366	0.4788	1.381	1.259
2	2	0.7358	0.8400	1.359	1.190
2	3	0.9668	0.9733	1.445	1.435
2	4	1.0587	1.0610	1.484	1.481
2	5	1.0967	1.1007	1.508	1.502
3	3	1.3534	1.3711	1.478	1.459
3	4	1.5547	1.5615	1.509	1.503
3	5	1.6645	1.6943	1.529	1.504
3	6	1.7239	1.7651	1.546	1.510
3	7	1.7498	1.7957	1.559	1.519
4	4	1.9416	1.9424	1.545	1.544
4	5	2.1402	2.1794	1.547	1.519
4	6	2.2509	2.3511	1.563	1.497
4	7	2.3336	2.4524	1.569	1.493
4	8	2.3647	2.5023	1.585	1.498
5	5	2.5152	2.5435	1.590	1.573
5	6	2.7095	2.8196	1.581	1.519
5	7	2.8447	3.0253	1.580	1.486
5	8	2.9313	3.1553	1.587	1.474
5	9	2.9677	3.2250	1.603	1.475
6	6	3.08	3.1682	1.623	1.578
6	7	3.2915	3.4770	1.599	1.514
6	8	3.4261	3.7133	1.597	1.474
6	9	3.5212	3.8698	1.602	1.457
6	10	3.5707	3.9611	1.613	1.454
7	7	3.6378	3.8120	1.649	1.574
7	8	3.8495	4.1506	1.623	1.505
7	9	4.0026	4.1136	1.612	1.569
7	10	4.1023	4.5941	1.615	1.442

Example 2.2

Given MAPD = 0.0326 and MAAOQ = AOQL = 0.0216 compute the ratio R = MAPD/ MAAOQ = 1.509 and R_1 = MAPD/AOQL = 1.509. And from Table 2.3, the nearest value of 1.509 is R = 1.509 with $c_1 = 3$, $c_2 = 4$, nMAAOQ = 1.5547 and $c_1 = 3$, $c_2 = 6$ n AOQL =n AOQL /MAAOQ = 1.5547/0.0126 = 72, and n = n AOQL/AOQL = 1.7651/0.0126 = 82. Hence the repetitive group sampling plans are specified MAPD = 0.0326 and MAAOQ = 0.0216 and n=72, c_1= 3, c_2 = 4 and the CRGS plan for specify MAPD = 0.036 and AOQL = 0.0216 is n = 82, c_1 = 3, c_2= 6. The OC curves are presented in figure 2.1.

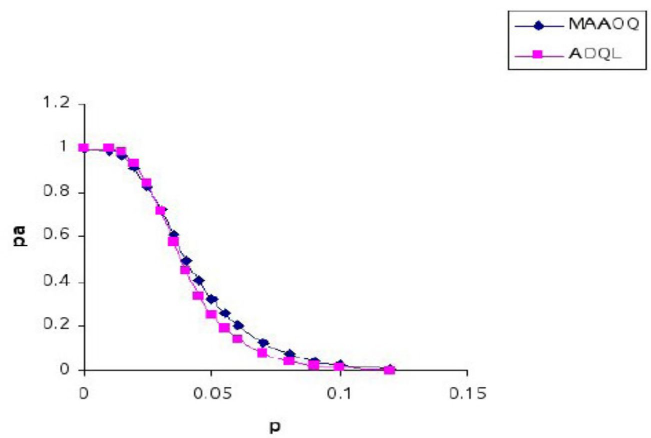

Figure 2.2 OC curves for the plans indexed through MAAOQ and AOQL

2.7 Comparison of CRGS plan indexed through Poisson and Weighted Poisson Distribution

The CRGS plans indexed through Poisson distribution Radhakrishnan [13] is compared with CRGS plan indexed through Weighted Poisson Distribution. For the different values of (MAPD, MAAOQ) and (MAPD, AOQL) the values of n, c_1, c_2 (indexed through Poisson) n, c_1, c_2 (indexed through Weighted Poisson Distribution) are presented in Table 2.4.

Table 2.4: Comparison of CRGS plans

Given values			Poisson distribution (Radhakrishnan, 2002)			Weighted Poisson distribution		
MAPD	MAAOQ	AOQL	n	c_1	c_2	n	c_1	c_2
0.09	0.058	-	0	2	5	26	3	6
0.09	-	0.058	34	3	3	32	4	4
0.0326	0.022	-	48	1	3	43	2	3
0.0326	-	0.022	48	1	3	44	2	3

2.8 Construction of OC curve

In constructing OC curves for the plans 'np' and $P_a(p)$ values are calculated for different values of 'p' for the plans n = 30, $c_1 = 2, c_2 = 5$ (indexed through Poisson) and n = 26, $c_1 = 3, c_2 = 6$ (indexed through Weighted Poisson Distribution) and presented in figure 2.3

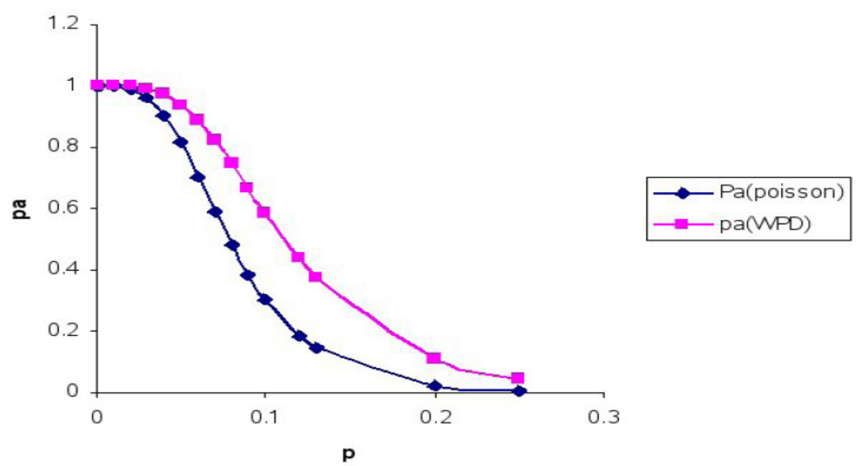

Figure 2.3 OC curves for CRGS

It is concluded from the study that the size of the sample is less in the construction of the sampling plans indexed through MAAOQ than the indexed through AOQL irrespective of the basic distribution whether it is Poisson or weighted Poisson distribution

Chapter – III

CHAPTER – III

CONSTRUCTION OF MIXED SAMPLING PLANS INDEXED THROUGH MAPD AND IQL WITH LINK SAMPLING PLAN AS ATTRIBUTE PLAN USING WEIHGTED POISSON DISTRIBUTION

In this chapter "construction of mixed sampling plans indexed through MAPD and IQL with Link Sampling Plan as attribute plan using Weighted Poisson Distribution " by R.Sampath Kumar, R.Kruthika and R.Radhakrishnan [20].have been reviewed.

Mixed sampling plan consist of two stages of rather different nature. During the first stage the given lot is considered as a sample from the respective production process and a criterion by variables is used to check process quality. If process quality is judged to be sufficiently good, the lot quality is checked directly by means of an attribute sampling plan.

There are two types of mixed sampling plans called independent and dependent plans. If the first stage sample results are not utilized in the second stage, then the plan is said to be independent otherwise dependent. The principal advantage of a mixed sampling plan over pure attribute sampling plans is a reduction in sample size for a similar amount of production.

It is the usual practice that while selecting a sampling inspection plan, to fix the operating characteristic curve in accordance with the desired degree of discrimination. The sampling plan is in turn fixed through suitably chosen parameters. One of the desired properties of an OC curve is that the decrease of $P_a(p)$ should be slower for lesser values of 'p' and faster for greater values of 'p'. If we set p_* as the quality standard, the above property of the OC curve is obtained. Since p_* corresponds to the inflection point of the OC curve and hence

$$d^2 P_a(p)/dp^2 = 0 \qquad \text{for } p = p_*$$

$$d^2 P_a(p)/dp^2 < 0 \qquad \text{for } p < p_*$$

$$d^2 P_a(p)/dp^2 > 0 \qquad \text{for } p > p_*$$

The mixed sampling plan has been designed under two cases of significant interest. In the first case sample size n_1 is fixed and a point on the OC curve is given. In the second case plans are designed when two points on the OC curve are given.

The weighted Poisson distribution plays an important role in the acceptance sampling, mainly in the construction of sampling plans. Each outcome (number of defectives) is specific but can be assigned with different weights based on its importance or usage. In using weighted Poisson distribution with weights X^{α}, $\alpha = 1$ the range of the distribution curtailed to 1, 2, 3……. From 0, 1, 2…… this distribution can be viewed as a truncated at X = 0. It will be more useful to the industries which concentrate on second's quality lots and also the industries which has at least one defective in the majority of the manufacturing lots. Even though the modern technologies aim at zero defective/ defects but practically it is very difficult to make the lot as zero defective lot.

In this chapter, mixed sampling plan (independent case) with the link sampling plan as attribute plan constructed using weighted Poisson distribution as a base line distribution is studied.

3.1 Operating procedure of mixed sampling plan having link sampling plan as attribute plan

Schilling [21] has given the following procedure for the independent mixed sampling plan with upper specification limit (U) and standard deviation (σ).

1. Determine the parameters of the mixed sampling plan n_1, n_2, k, c_1, c_2, and $c_{3.}$
2. Take a random sample of size n_1 from the lot.
3. If a sample average $\overline{X} \le A = U - k\sigma$, accept the lot.

4. If the sample average $\overline{X} > A = U - k\sigma$, take another sample of size n_2 from the lot 'i' and count the number of defectives d_i there i.
5. If the number of defectives $d_i \le c_1$, accept the lot.
6. If the number of defectives $d_i < c_3$, reject the lot.
7. If $c_1 < D_i \le c_3$, combine the total number of defectives from the immediate part and future lots, $D_i = d_{i-i} + d_i + d_{i+1}$.
8. If $D_i \le c_2$, accept the lot 'i' and reject the lot if $D_i > c_3$

The OC function of the mixed sampling plan, suggested by schilling [ ]for single sampling plan is

$$P_a(p) = P_{n_1}(\overline{x} \le A)\sum_{j=0}^{c} P(j;n_2) \text{ .... } (3.1)$$

Equation (3.1) can be expressed as $\beta_j = \beta_j^{'} + \left(1-\beta_j^{'}\right)\beta_j^{''}$.

By taking the link sampling plan as attribute plan, equation (3.1) can be written as

$$P_a(p) = P_{n_1}(\overline{x} \le A) + P_{n_1}(\overline{x} > A)\left(\sum_{i=1}^{c_1} P_{ri} + P_{c_i+1}\sum_{i=1}^{c_3-c_1-1} q_{ri} + P_{c_i+2}\sum_{i=1}^{c_3-c_1-2} q_{ri} + \text{........} + P_{c_2}\sum_{i=1}^{c_3-c_2} q_{ri}\right) \text{........(3.2)}$$

Where $P_{ri} = \dfrac{e^{-np}(np)^{ri-1}}{(ri-1)!}, ri = 1,2,\text{........}c_2$

$$q_{ri} = \frac{e^{-knp}(knp)^{ri-1}}{(ri-1)!}, ri = 1,2,\text{.........}c_3 - (c_1 + 1)$$

In this chapter, the probability mass function of the link sampling plan is used for $k = 2$.

3.2 Construction of mixed sampling plan having link sampling plan as attribute plan using weighted Poisson distribution

In this chapter the construction mixed sampling plan having link sampling as attribute plan using weighted Poisson distribution indexed through MAPD is given below:

1. Assume that the mixed plan is independent
2. Decide the sample size n_1 (for the sampling plan) to be used.
3. Calculate the acceptance limit for the variable sampling plan as $A = U - [z(p_*) + \{z(\beta_*^{'}) / \sqrt{n_1}\}]\sigma,$ where z is standard normal variate corresponding to 't' such that $t = \int_{z(t)}^{\infty} \frac{1}{\sqrt{2\pi}} e^{\frac{-u^2}{2}} du$
4. Split the probability of acceptance β_* as $\beta_*^{'}$ and $\beta_*^{''}$ such that $\beta_* = \beta_*^{'} + (1 - \beta_*^{'})\beta_*^{''}$. Fix the value of $\beta_*^{'}$.
5. Determine $\beta_*^{''}$, the probability of acceptance assigned to the attribute plan associated with the second stage sample as $\beta_*^{''} = (\beta_* - \beta_*^{'}) / (1 - \beta_*^{'})$.
6. Determine the appropriate second stage sample of n_2 from the relation

$$\beta_*^{''} = \sum_{i=1}^{c_1} P_{ri} + P_{c_i+1} \sum_{i=1}^{c_3-c_1-1} q_{ri} + P_{c_i+2} \sum_{i=1}^{c_3-c_1-2} q_{ri} + \dots\dots\dots\dots + P_{c_2} \sum_{i=1}^{c_3-c_2} q_{ri}$$

Where $P_{ri} = \frac{e^{-np}(np)^{ri-1}}{(ri-1)!}, ri = 1,2,\dots\dots\dots c_2$

$$q_{ri} = \frac{e^{-knp}(knp)^{ri-1}}{(ri-1)!}, ri = 1,2,\dots\dots\dots c_3 - (c_1 + 1)$$

Using the above procedure, tables have been constructed to facilitate easy selection of mixed sampling plan using link sampling plan as attribute plans indexed through MAPD.

3.3 Construction of tables

The OC function of weighted Poisson distribution for single sampling plan is given by,

$$P_a(p) = \frac{x^{\alpha} p(x, \alpha)}{\sum_{x=0}^{\infty} x^{\alpha} p(x; \alpha)}; X = 0,1,2 \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (3.3)$$

The probability of acceptance for link sampling plan under weighted Poisson distribution when $\alpha = 1$ is used in this chapter for determining the second stage probabilities and is given by

$$P_a(p) = \sum_{i=1}^{c_1} P_{ri} + P_{c_i+1} \sum_{i=1}^{c_3-c_1-1} q_{ri} + P_{c_1+2} \sum_{i=1}^{c_3-c_1-1} q_{ri} + \ldots\ldots\ldots\ldots\ldots + P_{c_2} \sum_{i=1}^{c_3-c_2} q_{ri} = \beta_j' \;\ldots\ldots\ldots \; (3.4)$$

Where $p_{ri} = \dfrac{e^{-knp}(knp)^{ri-1}}{(ri-1)!}$, ri = 1, 2, ……….. c_2

$$q_{ri} = \frac{e^{-knp}(knp)^{ri-1}}{(ri-1)!}, \text{ri} = 1, 2\ldots\ldots\ldots\ldots c_3 - (c_1 + 1)$$

Using the equation (3.4) the inflection point (p_*) is obtained by using $\dfrac{d^2 P_a(p)}{dp^2} = 0$ and $\dfrac{d^3 P_a(p)}{dp^3} \neq 0$. The relative slope of the OC curve h_* is given by, $h_* = \left(\dfrac{-p}{P_a(p)}\right)\dfrac{dp_a(p)}{dp}$ at $p = p_*$.

The inflection tangent of the OC curve cuts 'p' axis at $p_t = p_* + (p_* / h_*)$. The values of $n_2 p_*$, h_*, $n_2 p_t$ and $R = p_t / p_*$ are calculated for the specified $\beta_*' = 0.25$

3.4 Selection of the plan

Table (3.1) is used to construct the plans when MAPD (p_*) and tangent intercept (p_t) are given. For any given values of c_1, c_2, p_t and p_* one can find the ratio $R = p_t / p_*$. Corresponding to the value of c_1 and c_2 find the value in Table (3.1) under the column R which is equal to or just greater than the specified ratio, the corresponding value of c_3 is noted. From this c_1,c_2 and c_3 values one can determine the value of 'n' using $n_2 = n_2 p_* / p_*$.

Example 3.1:

Given $c_1 = 4$, $c_2 = 8$, $p_* = 0.06$, and $\beta_*' = 0.25$. Find the ratio $R = p_t / p_* = 2.5$. Using Table 3.1, corresponding to $c_1 = 4$, $c_2 = 8$ select the value of

R equal to or just greater than this ratio is 2.6239 which is associated with c_1 = 4, c_2 = 8, c_3 = 12 an $n_2 = n_2 p_* / p_* = (3.6448/0.06) = 61$. The mixed sampling plan with link sampling plan as attribute plan is n_2 = 61, c_1 = 4, c_2 = 8 and c_3 = 12 and the OC curve is presented in figure 3.1

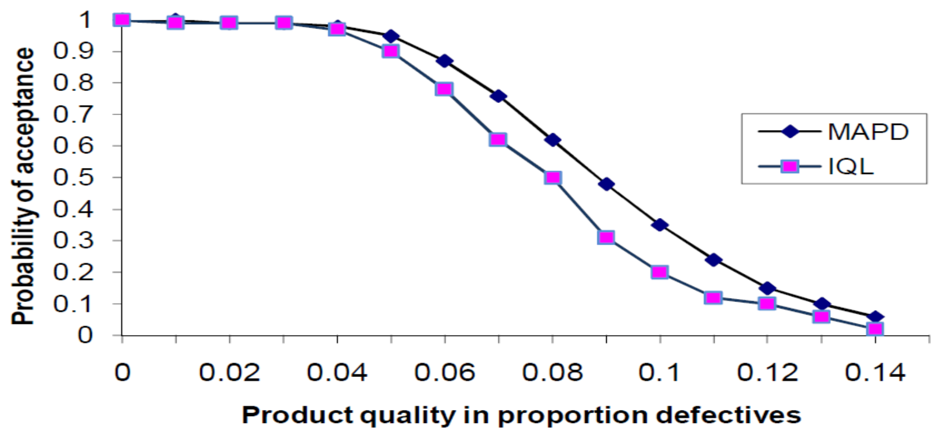

Figure 3.1 OC curves for LSP with n = 61 (MAPD),

n = 70 (IQL) $c_1 = 4,\ c_2 = 8,\ c_3 = 12$

3.5 Selection of mixed sampling plan having link sampling plan as attribute plan indexed through IQL

The general procedure given above is used for designing the mixed sampling plan having link sampling plan as attribute plan indexed through IQL (p_0). For the specified values of $\beta_0 = 0.50$ and $\beta_0' = 0.25$, the $n_2 p_0$ values are calculated for different values of c_1, c_2 and c_3

3.5.1 Selection of the plan

Table 3.1 is used to construct the plans when IQL (p_0), c_1, c_2, c_3 values are given. For any specified values of (p_0), c_1, c_2 and c_3 one can determine n_2 value using $n_2 = n_2 p_0 / p_0$.

Table 3.1: Various characteristics of the mixed sampling plan when (p_*, β_*) and (p_0, β_0) are known for specified $\beta_*^{'} = 0.25, \beta_0 = 0.50$ and $\beta_0^{'} = 0.25$

c_1	c_2	c_3	$n_2 p_0$	β_*	$\beta_*^{''}$	$n_2 p_*$	h_*	$n_2 p_t$	$R = p_t / p_*$
1	2	2	1.0989	0.6618	0.5491	0.5944	0.2006	3.5874	5.9849
1	2	3	1.2020	0.5976	0.4635	0.9068	0.2116	5.1922	5.7258
1	3	4	1.5459	0.6933	0.5911	1.0422	0.2696	4.9079	4.7092
1	3	5	1.8861	0.8042	0.7389	1.1314	0.2188	0.3023	5.5703
1	3	6	2.2274	0.9161	0.8881	1.1740	0.2450	5.9658	5.0816
1	4	5	2.0451	0.7523	0.6697	1.3902	0.4267	4.6482	3.3435
1	4	6	2.4879	0.7924	0.7232	1.7437	0.6538	4.4107	2.5295
1	4	7	2.9182	0.8023	0.7364	2.1483	0.9899	4.3185	2.0102
2	4	5	2.3975	0.6984	0.5979	1.6104	0.2832	5.6864	3.5310
2	4	6	2.5734	0.7619	0.6825	1.6383	0.3414	6.4370	3.9291
2	4	7	2.8132	0.8601	0.8135	1.6063	0.3010	6.9428	4.3222
2	5	5	2.4242	0.8409	0.7879	1.1667	0.3074	4.9621	4.2531
2	5	6	2.6465	0.8623	0.8164	1.3947	0.3374	5.5283	3.9637
2	5	7	2.9546	0.9016	0.8688	1.6291	0.3950	5.7534	3.5316
2	5	8	3.3108	0.9230	0.8973	1.9697	0.3601	7.4355	3.7749
3	5	8	3.6153	0.7869	0.7159	2.3840	0.3533	7.1011	2.9786
3	5	9	3.7841	0.8768	0.8357	2.1789	0.3192	9.0050	4.1328
3	6	8	3.6962	0.7788	0.7051	2.4299	0.3666	9.0581	3.7278
3	6	9	3.9011	0.7963	0.7284	2.6705	0.4991	8.0211	3.0036
3	7	8	3.7115	0.7799	0.7065	2.4610	0.3719	9.0784	3.6889
3	7	9	3.9713	0.8037	0.7383	2.7154	0.4960	8.1899	3.0161
3	7	10	4.3102	0.8227	0.7636	3.0587	0.6999	7.4288	2.4287
3	7	11	4.6764	0.8345	0.7793	3.4498	0.9661	7.0207	2.0351
4	7	11	4.8788	0.9570	0.9427	2.5273	0.3456	9.8400	3.8934
4	7	12	5.0991	0.8191	0.7588	3.6097	0.6546	9.1241	2.5277
4	8	11	4.9386	0.8241	0.7655	3.3503	0.5679	9.2498	2.7608
4	8	12	5.1995	0.8406	0.7875	3.6448	0.6158	9.5636	2.6239
4	8	13	5.5141	0.8499	0.7999	4.0137	0.8478	8.7479	2.1795

Example 3.2

Given $p_0 = 0.07$, $c_1 = 4$, $c_2 = 7$, $c_3 = 11$ and $\beta_0' = 0.25.$ using Table 3.1, find $n_2 = n_2 p_0 / p_0 = 4.8788/0.07 = 70.$ For a fixed $\beta_0' = 0.25.$ the mixed sampling plan with link sampling plan as attribute plan is $n_2 = 70$, $c_1 = 4$, $c_2 = 7$ and $c_3 = 11$.

3.6 Comparison of plans indexed through MAPD and AQL

The mixed sampling plan with link sampling plan as attribute plan indexed through MAPD is compared with the mixed sampling plan with link sampling plan as attribute plan indexed through IQL by fixing the parameters c_1, c_2, and β_0'. For the specified values of p_* and p_t with the assumption $\beta_*' = 0.25$ one can find the values of c_3 and n_2 indexed through MAPD. By fixing the values of c_1, c_2 and n_2, find the value of p_1 by equating $P_a(p) = \beta_0 = 0.50.$ Using $\beta_0' = 0.25,$ c_1, c_2 and p_0 one can find the value of n_2 using $n_2 = n_2 p_0 / p_0$ form the Table 3.1. For different combinations of c_1, c_2, and p_* and p_t, the values of n_2, c_3 (indexed through MAPD) and n_2, c_3 (indexed through IQL) are calculated and presented in Table 3.2.

p_t

Table 3.2: Comparison of plans

Given values				Through MAPD n_2, c_3	Through IQL n_2, c_3
c_1	c_2	p_*	p_t		
1	3	0.02	0.10	59,6	70,6
1	4	0.04	0.08	54,7	62,7
2	5	0.04	0.14	41,7	49,7
3	5	0.05	0.14	48,8	58,8
3	7	0.06	0.12	58,11	65,11
4	8	0.06	0.15	61,12*	70,12*

It is concluded from the study that the second sample size required for mixed sampling plan with link sampling plan as attribute plan indexed through MAPD is less than that of the second stage sample size of the mixed sampling plan with link sampling indexed through IQL, justified. These plans definitely helps the producers, because of the lesser sampling cost and indirectly reduces the total cost of the product. The different sampling plans can also be constructed by changing first stage probabilities ($\beta_*^{\prime}$ and $\beta_0^{\prime}$) and can be compared for their efficiency.

Chapter - IV

CHAPTER – IV

CONSTRUCTION OF MIXED SAMPLING PLANS INDEXED THROUGH MAPD AND AQL WITH CONDITIONAL DOUBLE SAMPLING PLAN AS ATTRIBUTE PLAN USING WEIGHTED POISSON DISTRIBUTION

In this chapter “construction of Mixed Sampling Plans indexed through MAPD and AQL with conditional double sampling plan as attribute plan using Weighted Poisson Distribution” by R.Sampath kumar, R.Kiruthika and R.Radhakrishnan [19] has been reviewed.

It is the usual practice that while selecting a sampling inspection plan, to fix the operating characteristic curve in accordance with the desired degree of discrimination. The sampling plan is in turn fixed through suitably chosen parameters. One of the desired properties of an OC curve is that the decrease of $P_a(p)$ should be slower for lesser values of ‘p’ and faster for greater values of ‘p’. If we set p_* as the quality standard, the above property of the OC curve is obtained. Since p_* corresponds to the inflection point of the OC curve and hence

$$d^2P_a(p)/dp^2 = 0 \qquad \text{for } p = p_*$$

$$d^2P_a(p)/dp^2 < 0 \qquad \text{for } p < p_*$$

$$d^2P_a(p)/dp^2 > 0 \qquad \text{for } p > p_*$$

The mixed sampling plan has been designed under two cases of significant interest. In the first case sample size n_1 is fixed and appoint on the OC curve is given. In the second case plans are designed when two points on the OC curve are given. The weighted Poisson distribution plays an important role in the acceptance sampling, mainly in the construction of sampling plans. Each outcome (number of defectives) is specific but can be assigned with different weights based on its importance or usage.

4.1 Operating procedure of Mixed Sampling Plan having Conditional Double Sampling Plan as attribute plan

Schilling [21] has given the following procedure for the independent mixed sampling plan with upper specification limit (U) and standard deviation (σ).

1. Determine the parameters of the mixed sampling plan n_1, $n_{1,2}$, $n_{2,2}$, k, c_1, c_2, and c_3.
2. Take a random sample of size n_1 from the lot.
3. If a sample average $\overline{X} \le A = U - k\sigma$, accept the lot.
4. If the sample average $\overline{X} > A = U - k\sigma$, take a second sample of size $n_{1,2}$ and count the number of defectives $'d_1'$ in the sample.
5. If the number of defectives $d_1 \le c_1$, accept the lot.
6. If $c_1 + 1 \le d_1 \le c_3$, take a second sample of size $n_{2,2}$ from the remaining lot and find the number of defectives $'d_2'$
7. If $d_2 \le c_2$ or $d_1 + d_2 \le c_3$ accept the lot, otherwise reject the lot.

4.2 Construction of mixed sampling plan having conditional double sampling plan as attribute plan using weighted Poisson distribution

The detailed procedure for the construction of mixed sampling plan having conditional double sampling as attribute plan using weighted Poisson distribution indexed through MAPD is given below:

1. Assume that the mixed plan is independent.
2. Decide the sample size n_1 (for variable sampling plan) to be used.
3. Calculate the acceptance limit for the variable sampling plan as $A = U - \left[z(p_*) + \left\{ z(\beta_*^{\prime}) / \sqrt{n_1} \right\} \right] \sigma$, where z is standard normal variate corresponding to 't' such that $t = \int_{z(t)}^{\infty} \frac{1}{2\pi} e^{\frac{-u^2}{2}} du$

4. Split the probability of acceptance β_* as $\beta_*^{'}$ and $\beta_*^{''}$ such that $\beta_* = \beta_*^{'} + (1-\beta_*^{'})\beta_*^{''}$. Fix the value of $\beta_*^{'}$
5. Determine $\beta_*^{''}$, the probability of acceptance assigned to the attribute plan associated with the second stage sample as $\beta_*^{''} = (\beta_* - \beta_*^{'})/(1-\beta_*^{'})$.
6. Determine the appropriate second stage sample of n_2 from the relation $\beta_*^{''} = \sum_{i=1}^{c_1} P_i + P_{c_i+1} \sum_{i=1}^{c_3-c_1-1} q_i + P_{c_1+2} \sum_{i=1}^{c_3-c_1-2} q_i + \ldots\ldots\ldots + P_{c_2} \sum_{i=1}^{c_3-c_2} q_i$

where $P_i = \dfrac{e^{-np}(np)^{i-1}}{(i-1)!}$, $q_i = \dfrac{e^{-mnp}(mnp)^{i-1}}{(i-1)!}$

Using the above procedure, tables have been constructed to facilitate easy selection of mixed sampling plan using conditional Double Sampling Plan as attribute plans indexed through MAPD.

4.3 Construction of tables

The OC function of the weighted Poisson distribution is given by,

$$P_a(p) = \frac{x^{\alpha} p(x,\alpha)}{\sum_{x=0}^{\infty} x^{\alpha} p(x;\alpha)};\ X = 0,1,2 \ldots\ldots\ldots\ldots$$

The probability of acceptance for conditional double sampling plan under weighted Poisson distribution when $\alpha = 1$ is used in this chapter for determining the second stage probabilities and is given by

$$P_a(p) = \sum_{i=1}^{c_1} P_i + P_{c_1+1} \sum_{i=1}^{c_3-c_1-1} q_i + P_{c_1+2} \sum_{i=1}^{c_3-c_1-2} q_i + \ldots\ldots\ldots\ldots + P_{c_2} \sum_{i=1}^{c_3-c_2} q_i$$

where $P_i = \dfrac{e^{-np}(np)^{i-1}}{(i-1)!}$,

$$q_i = \frac{e^{-mnp}(mnp)^{i-1}}{(i-1)!},\ m \geq 1.$$

In this chapter, the probability mass function of the conditional double sampling plan is used for m =1.

For $n_{1,2} = n_{2,2} = n$ (say) the inflection point (p_*) is obtained by using and $\frac{d^2 P_a(p)}{dp^2} = 0$ and $\frac{d^3 P_a(p)}{dp^3} \neq 0.$

The relative slope of the OC curve h_* is given by ,

$$h_* = \left(\frac{-p}{P_a(p)} \right) \frac{dP_a(p)}{dp} \text{ at } p = p_*.$$

The inflection point OC curve cuts the 'p' axis at $p_t = p_* + \left(\frac{p_*}{h_*} \right)$. The values of $n_2 p_*$, h_*, $n_2 p_t$ and $R = p_t / p_*$ are calculated for the specified $\beta_*' = 0.35$ and presented in Table 4.1.

Table 4.1 Various characteristics of mixed sampling plan when (p_*, β_*) and (p_1, β_1) are known for a specified $\beta_*' = 0.35$, $\beta_1 = 0.95$, $\beta_1' = 0.35$ c_1 c_2 c_3 np_1 β_* β_*'' h_* np_t

c_1	c_2	c_3	np_1	β_*	β_*''	np_*	h_*	np_t	$R = p_t / p_*$
1	2	2	0.0801	0.5702	0.3388	1.0825	1.0825	2.0825	1.9238
1	3	4	0.5157	0.4854	0.2983	2.2772	2.5329	3.1762	1.3948
1	4	5	0.8080	0.4601	0.1694	2.9967	3.2811	3.9100	1.3048
1	4	6	1.0972	0.4788	0.1982	3.3807	3.3906	4.3778	1.2949
2	4	5	0.8895	0.5215	0.2638	2.9583	2.4116	4.1850	1.4147
2	5	5	0.8859	0.5088	0.2443	3.0519	2.5151	4.2653	1.3976
3	5	7	1.5831	0.5345	0.2838	4.0955	2.7617	5.5785	1.3621
3	6	7	1.6038	0.5285	0.2746	4.1573	2.8324	5.6251	1.3531
3	7	7	1.6038	0.5177	0.2580	4.2482	2.9299	5.6981	1.3413
3	7	8	1.9133	0.4940	0.2215	4.8063	3.5344	6.1662	1.2829
3	7	9	2.2441	0.4835	0.2054	5.3250	4.0205	6.6495	1.2487
4	7	9	2.3638	0.5268	0.2720	5.3768	3.2410	7.0358	1.3085
4	7	10	2.6594	0.5161	0.2555	5.7914	3.6548	7.3760	1.2736
4	7	12	3.1905	0.5038	0.2366	6.6453	4.2482	8.1964	1.2334
4	8	9	2.3691	0.5227	0.2657	5.4195	3.2869	7.0683	1.3042
4	8	10	2.6851	0.5403	0.2928	5.5837	3.4051	7.2235	1.2937
4	8	12	3.3420	0.4891	0.214	6.8937	4.6133	8.3880	1.2168
6	9	13	3.9442	0.5335	0.2823	7.6361	3.8082	9.6418	1.2627
6	10	13	3.9738	0.5284	0.2745	7.7063	3.8855	9.6896	1.2574
6	10	16	4.9142	0.4991	0.2294	9.0633	5.0758	10.8489	1.1970
7	10	16	5.0179	0.5236	0.2671	9.1506	4.4374	11.2128	1.2254
8	11	19	6.0569	0.5177	0.258	10.6257	4.9363	12.7783	1.2026
12	16	27	9.5777	0.5171	0.2571	15.1403	5.1403	17.6899	1.1684

4.4 Selection of the plan

Table 4.1 is used to construct the plans when MAPD (p_*) and the tangent intercept (p_t) are given. For any given values of c_1, c_2, p_t, and p_* one can find the ratio $R = p_t / p_*$. Corresponding to the values of c_1 and c_2 find the value in Table 4.1 under the column R which is equal to or just greater than the specified ratio, the corresponding value of c_3 is noted from this c_1, c_2 and c_3 values one can determine the value of 'n' using $n = np_* / p_*$.

Example 4.1

Given $c_1 = 6$, $c_2 = 10$, $p_* = 0.09$ $p_t = 0.11$ and $\beta_*' = 0.35$. Find the ratio $R = p_t / p_* = 1.2220$. Using Table 4.1, corresponding to $c_1 = 6, \quad c_2 = 10$ select the value of R equal to or just greater than this ratio is 1.2627which is associated with $c_1 = 6, \quad c_2 = 10, \quad c_3 = 13$ and $n = np_* / p_* = (7.6361/0.09) = 85$. The mixed sampling plan with conditional double sampling plan is $n_{1,2} = 85, \quad n_{2,2} = 85, \quad c_1 = 6, \quad c_2 = 10$ and $c_3 = 13$.

4.5 Selection of mixed sampling plan having conditional double sampling plan as attribute plan indexed through AQL

The general procedure used for designing the mixed sampling plan having conditional double sampling plan as attribute plan indexed through AQL (p_1). For $n_{1,2} = n_{2,2} = n$ (say), under the assumption $\beta_1 = 0.95$ and $\beta_1' = 0.35$ the np_1 values are calculated for different values of c_1, c_2 and c_3 and presented in Table 4.1

4.5.1 Selection of the plan

Table 4.1 is used to construct the plans when AQL (P_1), c_1, c_2 and c_3 are given. For any specified values of p_1, c_1, c_2 and c_3 one can determine n value using $n = np_1 / p_1$.

Example 4.2

Given $p_1 = 0.03$, $c_1 = 4$, $c_2 = 7$ $c_3 = 10$ and $\beta_1' = 0.35$. Using Table 4.1 , find $n = np_1 / p_1 = 2.6594/0.03 = 89$. For a fixed $\beta_1' = 0.35$, the mixed sampling plan with conditional double sampling plan as attribute plan is $n_{1,2} = 89$, $n_{2,2} = 89$, $c_1 = 4$, $c_2 = 7$ and $c_3 = 10$.

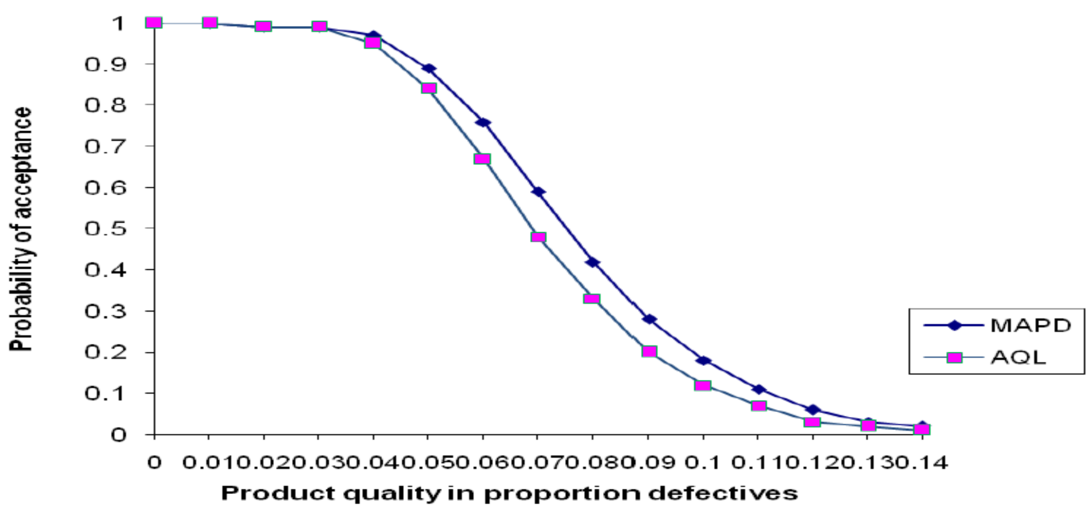

Figure 4.1 OC curves for CDSP with n = 85 (MAPD) , n = 92 (AQL) $c_1 = 6,\ c_2 = 10,\ c_3 = 13$

4.6 Comparison of plans indexed through MAPD and AQL

The mixed sampling plan with conditional double sampling plan as attribute plan indexed through MAPD is compared with mixed sampling plan with conditional double sampling plan as attribute plan indexed through AQL by fixing the parameters c_1, c_2 and β_1' .

For the specified values of p_* and p_t, one can find the values of c_1, c_2, c_3 and 'n' indexed through MAPD for $\beta_*' = 0.35$ as given. By fixing the values of c_1, c_2, c_3 and n, find the values of p_1 by equating $P_a(p) = \beta_1 = 0..95$. By fixing $\beta_1' = 0.35$ and c_1, c_2, c_3 and for the values of p_1, one can find the values of n using $n = np_1 / p_1$ from the Table 4.1, for different combinations of c_1, c_2, p_* and p_t, the values of n,

c_3 (indexed through MAPD) and n, c_3 (indexed through AQL) are calculated and presented in Table 4.2

Table 4.2 Comparison of plans

Given values				Through MAPD	Through AQL
c_1	c_2	p_*	p_t	n, c_3	n, c_3
1	4	0.10	0.12	34,6	39,6
1	2	0.05	0.07	59,5	69,5
4	7	0.10	0.12	66,12	72,12
3	7	0.10	0.13	43,7	84,7
6	10	0.09	0.11	85,13	92,13

It is concluded from the study that the second sample size required for mixed sampling plan with conditional double sampling plan as attribute plan indexed through MAPD is less than that of the second stage sample size of the mixed sampling plan with conditional double sampling plan as attribute plan indexed through AQL, justified by Sampath kumar [18]. These plans definitely help the procedures, because of the lesser sample size which directly result in lesser sampling cost and indirectly reduces the total cost of the product. The different sampling plans can also be constructed by changing the first stage probabilities.

Chapter - V

CHAPTER - V

SELECTION OF MULTIPLE DEFFERED STATE MDS-1 SAMPLING PLAN FOR GIVEN ACCEPTABLE QUALITY LEVEL AND LIMITING QUALITY LEVEL INVOLVING MINIMUM RISKS USING WEIGHTED POISSON DISTRIBUTUION

In this chapter "selection of multiple deferred state MDS-1 sampling plan for given Acceptable Quality Level and Limiting Quality Level involving minimum risks using weighted Poisson distribution" by k.Subramani and v.Haridoss [28] have been reviewed.

The practical performance of a sampling plan is revealed by its operating characteristic (OC) curve. Sampling plans are usually selected for two given points on the OC curve, viz $(p_1, 1-\alpha)$ and (p_2, β) where p_1 is the Acceptable Quality Level (AQL), α is the producers risk , p_2 is the Limiting Quality Level (LQL) and β is the consumers risk. Due to the discreteness of the parameters of the sampling plan , the conditions of fixed risks are often changed to $P_a(AQL) \geq 1-\alpha$ and $P_a(p) \leq \beta$, where $P_a(p)$ is the probability of acceptance for given lot or process quality p. Golub [5] has given a method of finding a single sampling plan involving a minimum sum of producer's and consumer's risks for given AQL and LQL where the sample size n is fixed due to the economic, administrative or practical factors. Subramani and Govindaraju [26] have developed tables for the selection of multiple deferred state MDS-1 sampling plan with minimum sum of risks for given acceptable and limiting quality levels using Poisson distribution. The original MDS plan of Wortham and Baker [31] also involving smaller producer's and consumer's risks.

5.1 MDS- 1 plan

The MDS-1 plan is applicable to the case of Type B situations where lots expected to be of the same quality are submitted for inspection seriously in the lot production. MDS-1 plans are extensions of the chain sampling plans of Dodge[4]type Chsp-1.Both the MDS-1 and chain sampling plans achieve a similar reduction in sample size when compared to the unconditional plans, such as single and double sampling plans .

5.2 The operating procedure of the MDS-1 plan

1. From each submitted lot, select a sample of n units and test each unit for conference to the specified requirements.

2. Accept the lot if d, the observed number of nonconformities, is less than or equal to c_1; reject the lot if d is greater than c_2.

3.If $c_1 < d \le c_2$ accept the lot, provided in each of the sample taken from the preceding or succeeding m lots , the number of nonconformities found is less than or equal to c_1. The lot otherwise rejected.

5.4 construction of the Table 5.1

The OC curve of the MDS-1 plan based on weighted Poisson model when k=2 is given by

$$P_a(p) = L(np_1/c_1) + [L(np/c_2) - L(np_1/c_1)][L(np/c_1)]^m \quad \ldots\ldots\ldots\ldots \quad (5.1)$$

Where

$$L(np/c_1) = \sum_{d=1}^{c_1} \frac{e^{np}(np)^{d-1}}{(d-1)!} \frac{d}{1+np} \qquad ; d = 1,2,3\ldots\ldots\ldots \quad (5.2)$$

$$L(np/c_2) = \sum_{d=1}^{c_2} \frac{e^{np}(np)^{d-1}}{(d-1)!} \frac{d}{1+np} \qquad ; d = 1,2,3\ldots\ldots\ldots \quad (5.3)$$

The expression for the sum of the producer's and consumer's risks is given by

$$\alpha + \beta = 1 - P_a(p_1) + P_a(p_2) \ldots\ldots\ldots\ldots \quad (5.4)$$

If the operating ratio p_2/p_1 and np_1 are known, then the expression for np_2 can be written as

$$np_2 = (p_2/p_1)(np_1) \ldots\ldots\ldots\ldots \quad (5.5)$$

Thus, the expression (5.4) for the minimum sum of risks can be written in terms of p_2/p_1 and np_1 as

$$\alpha+\beta=1-\{L(np_1/c_1)+[L(np_1/c_2)-L(np_1/c_1)][L(np_1/c_1)^m\}+$$
$$+L(np_1)(p_2/p_1)/c_1+[L(np_1)(p_2/p_1)/c_2]$$
$$-L[(np_1)(p_2/p_1)/c_1]L(np_1)(p_2/p_1)/c_1]^m \quad \text{...(5.6)}$$

Table 5.1 is constructed using expression (5.6). The producer's and consumer's risks are then obtained corresponding to c_1, c_2 and m values for which the sum of risks is minimum.

5.5 Selection of minimum risk MDS – 1 plan

Table 5.1 is used to select an MDS – 1 plan system using weighted Poisson distribution for given AQL (p_1) LQL (p_2) which involves minimum sum of risks. For the plan of Table 5.1, producer's and consumer's risk will be at most 10% each against fixed values of the operating ratio p_2/p_1. Table5.1 gives the parameters c_1 and c_2 and m of the MDS – 1 plan and associated producer's risk and consumer's risk (α & β respectively) in the body of table against the product of sample size (n) and AQL (np_1). With the given p_1, p_2, α and β one can find MDS – 1 plan as follows.

1. Compute the operating ratio p_2/p_1
2. With the computed value of p_2/p_1, refer to the row of Table 5.1 headed by the value of p_2/p_1 which is equal to or just smaller than the computed ratio.
3. The parameters c_1, c_2 and m of the MDS – 1 plan are obtained from the Table 5.1, one proceeds from the left to right in the row identified in step 2 such that the tabulated producer's and consumer's risks are equal to or just smaller than the desired values.

Example 5.1

If one fixes $p_1=1\%(0.01)$, $p_2=45\%(0.045)$ when $\alpha=1\%(0.01)$ and $\beta=5\%(0.05)$ one obtains a MDS – 1 plan (Weighted Poisson model) using Table 5.1 as follows:

1. $p_2/p_1=0.045/0.01=4.5$
2. Tabulated $p_2/p_1=4.5$.

3. Corresponding to $c_1 = 6$ and $c_2 = 10$ and $m = 1$ given in the body of the table of Table 5.1, one obtains $\alpha = 1\%(0.01)$ and $\beta = 2\%(0.02)$ against the desired $\alpha = 1\%$ and $\beta = 5\%$.
4. $n = np_1 / p_1 = 2.5 / 0.01 = 250.$

5.6 Selecting the plan when the sample size is fixed

Table 5.1 can be used to select an MDS – 1 plan when sample size is fixed for practical or administrative reasons. For example , if one fixes X = 60, AQL=0.01 and LQL=0.12, one gets $np_1 = 60(0.01) = 0.60$ and $p_2 / p_1 = 0.12/0.01 = 12$ .Corresponding to the value of $np_1 = 60$ and p_2 / p_1 ,one obtains the following MDS-1 plan involving minimum sum of risks from Subramani and Govindaraju[26] table(Poisson distribution)

$n = 60, c_1 = 1, c_2 = 4$ and m = 1 with $\alpha = 0.02$ and $\beta = 0.01$.

For the same conditions one obtains, the following MDS – 1 plan from Table 5.1 using weighted Poisson distribution. $n = 60, c_1 = 3, c_2 = 6$ and m = 1 with $\alpha = 0$ and $\beta = 0.01$.

5.7 Comparison with others MDS plan

Table 5.2 Comparison of MDS – 1 (c_1, c_2) sampling plans

Given values				Poisson distribution					Weighted Poisson distribution K = 2				
p_1	p_2	α	β	c_1	c_2	m	α	β	c_1	c_2	M	α	β
0.01	0.05	0.01	0.01	5	11	2	0(<0.1%)	0.02	6	11	1	0.008	0.007
0.01	0.05	0.05	0.05	2	6	1	0.04	0.03	4	7	1	0.02	0.03
0.01	0.06	0.05	0.05	2	5	2	0.01	0.06	3	6	1	0.03	0.03
0.01	0.06	0.01	0.01	8	8	1	0(<0.1%)	0.01	6	10	1	0(<0.1%)	0.01

From the above table we can see that sum of risks is minimum. The weighted Poisson distribution further reduces the sum of risks when compared to the Poisson distribution (Table 5.2). The OC curve of the multiple deferred state – 1 (c_1, c_2) plan using the Weighted Poisson model has better shoulder in comparison with Poisson model (figure 5.1)

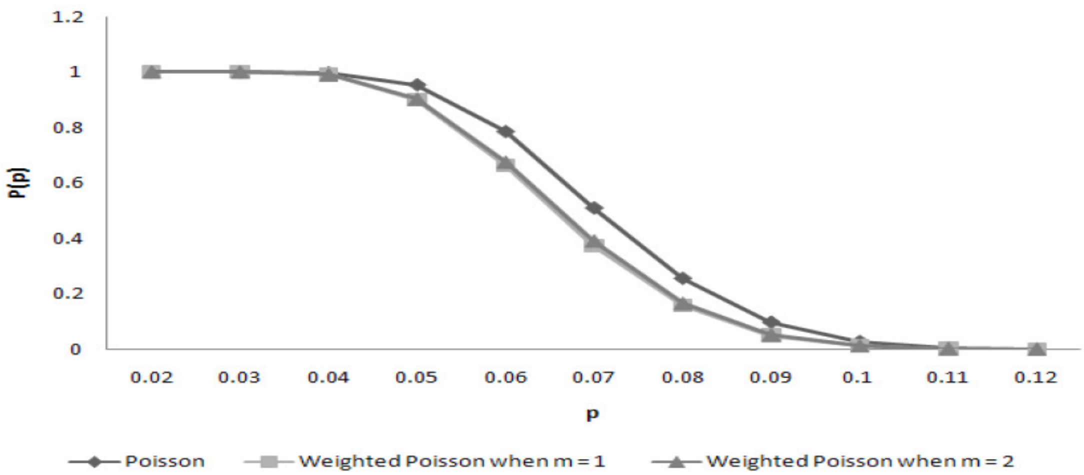

Figure 5.1 comparison of OC curves of MDS – 1 plan (Weighted Poisson model) with minimum risks

Summary and Conclusion

Summary and conclusion

First chapter deals with operating procedure for the construction of Single Sampling Plan (SSP) through Maximum Allowable Average Outgoing Quality (MAAOQ) and Maximum Allowable Percent Detective (MAPD) with conditional weighted Poisson distribution as a basic distribution. This procedure helps the floor engineer to deciding about the size of the sample if the incoming quality (MAPD) and the outgoing quality (MAAOQ) are specified. This will help the management in taking quick decisions.

Second chapter deals with the conditional Repetitive Group Sampling (CRGS) plan constructed with the WPD as the basic distribution indexed through MAPD &MAAOQ. These plans are compared with the CRGS plans having Poisson distribution as the basic distribution. It is concluded from the study that the size of the sample is less in the construction of the sample is less in the construction of the sampling plans indexed through MAAOQ than the indexed through AOQL irrespective of the basic distribution whether it is Poisson or weighted Poisson distribution.

Chapter three deals with the procedure for the construction and selection of Mixed Sampling Plan with MAPD as a quality standard and Link Sampling Plan as attribute plan using weighted Poisson distribution. The plans are constructed indexed through MAPD and IQL and also compared. It is concluded from the study that the second sample size required for mixed sampling plan with link sampling plan as attribute plan indexed through MAPD is less than that of the second stage sample size of the mixed sampling plan with link sampling indexed through IQL, justified. These plans definitely helps the producers, because of the lesser sampling cost and indirectly reduces the total cost of the product. The different sampling plans can also be constructed by changing first stage probabilities (β_*' and β_0') and can be compared for their efficiency.

The fourth chapter deals with the procedure for the construction and selection of Mixed Sampling Plan with MAPD as a quality standard and Link Sampling Plan as attribute plan using weighted Poisson distribution. The plans are constructed indexed through MAPD and IQL and also compared. It is concluded from the study that the second sample size required for mixed sampling plan with conditional double sampling plan as attribute plan indexed through MAPD is less than that of the second stage sample size of the mixed sampling plan with conditional double sampling plan as attribute plan indexed through AQL, justified by Sampath kumar [18]. These plans definitely help the procedures, because of the lesser sample size which directly result in lesser sampling cost and indirectly reduces the total cost of the product. The different sampling plans can also be constructed by changing the first stage probabilities.

Chapter five provides the procedure for finding the Multiple Deferred State-1(MDS – 1) (C_1,C_2) sampling plan involving minimum sum of producer's and consumer's risks for specified Acceptable Quality Level and Limiting Quality Level using weighted Poisson distribution. The weighted Poisson distribution further reduces the sum of risks when compared to the Poisson distribution. The OC curve of the Multiple Deferred State – 1 (c_1, c_2) plan using the weighted Poisson model has better shoulder in comparison with Poisson model.

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