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# A DESIGN OF TWO SIDED COMPLETE CHAIN SAMPLING PLANS (TSCCHSP-1) USING FUZZY PARAMETER

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## Abstract

The two-sided complete chain sampling plan using fuzzy parameter is studied. This new plan protects the customer while putting additional pressure on the manufacturer. Tables are constructed for FOC values of the above plan. The parameters are designed to satisfy the conditions at specified quality levels. Total risks is minimized for optimum value of sample size. Illustration is also given for easy selection of the plan.

## 1. Introduction

Quality is characterized as qualification for reason. The product and manufacturer can fulfill certain requirements of the clients. [13] Quality Control is a methodical control of different elements that influence the nature of the item. Dr. Walter A. Shewart an American scientist in 1924 developed Statistical Quality Control. It gives more information in surveying and controlling item quality. [11] A few applications of daily life problem unable to solve using acceptance sampling plan. Zadeh [18] introduced the idea of Fuzzy Set. It is assuming a significant part to manage the issues having

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unclearness, suspicious information, etc, which can't be settled with the assistance of accessible traditional techniques [19]. Dubois and Prade [6] defined the fuzzy numbers as a subset of fuzzy set and its operations. Fuzzy numbers are applied in various fields like trial science, mathematics, PC programming, statistics etc.

The operating procedure of ChSP-1 and ChSP $(0, 1)$ are one sided chaining and based on the past lots the result is decided about the current lot. Dodge [4] proposed chain sampling inspection plan (ChSP-1). Clark [2] studied OC curves for ChSP-1. Frishman and Fred [7] (1960) prolonged chain sampling plans. Dodge and Stephens [3] developed Chsp $(0, 1)$. It is an extension of chsp-1. Dodge and Stephens [5] described a general family of chain sampling approach. Soundararajan [15] (1978) constructed procedure and tables for selection of ChSP-1 part I and II. Govindaraju and Subramani [8] provided selection of ChSP-1 and ChSP-$(0, 1)$ for given AQL and LQL. Deva Arul and Edna [3] designed and developed two sided complete Chain sampling plans. It is new chaining technique where the preceding $i$ lots and succeeding $j$ lots applied to get result from current lot. Fuzzy acceptance sampling plans developed by Kahraman and Kaya [10]. The outcome demonstrates that fuzzy parameters give greater flexibility and usefulness. Jamkhaneh and Sadeghpour Gildeh [1] created a (ChSP-1) chain sampling scheme using fuzzy probability theory. Turanoglu, Kaya and Kahraman [18] was studied OC curve using fuzzy parameters in acceptance sampling. Milky Mathew and Rajeswari [10] compared two sided modified chsp-1 with others chsp-1 plans using small samples. Vijila and Deva Arul [17] constructed and selected two sided CCHSP $(0, 1)$ indexed through AOQL. Vijila and Deva Arul [18] designed and selected CChSP $(0, 1)$ indexed through inflection point.

In this work basic definitions like fuzzy number, trapezoidal fuzzy number, operating procedure for two sided complete chain sampling plan and its flow chart are included. OC Curve values are calculated using fuzzy parameter. The sample size is determined to satisfy the conditions of risks. Minimized the total risks for $n$ values and the results are presented in tables.

## 2. Definitions

Fuzzy number (Zadeh [18] and Dubis and Prade [6]) "Fuzzy set that are characterized on the arrangement of real numbers having the structure $E : \Re$ tends to $[0, 1]$ are known as fuzzy number. A fuzzy number $\breve{E}$ will be a fuzzy set in the real line that fulfills the state of both normal and convexity".

Trapezoidal fuzzy number (Zadeh [18] and Dubis and Prade [6]): "If trapezoidal fuzzy numbers (TrFNs) are $\breve{E} = (e_1, e_2, e_3, e_4)$ and its membership function as"

$$TrFN = \begin{cases} 0, & \text{otherwise} \\ \dfrac{y - e_1}{e_2 - e_1}, & e_1 \le y \le e_2 \\ 1, & e_2 \le y \le e_3 \\ \dfrac{e_4 - y}{e_4 - e_3}, & e_3 \le y \le e_4 \\ 0, & \text{otherwise} \end{cases} \tag{1}$$

"The interval of confidence of trapezoidal fuzzy number defined by $\gamma$ cuts can be written as follows"

$$\breve{E}[\gamma] = [e_1 + (e_2 - e_1)\gamma,\ e_4 - (e_4 - e_3)\gamma] \tag{2}$$

## 3. Operating Procedure for TSCChSP-1

"According to Deva Arul and Edna [3] and Milky Mathew and Rajeswari [10] the operating procedure as follows

**Step 1.** Select a random sample of $n$ units from each lot.

**Step 2.** Count the number of defectives (d).

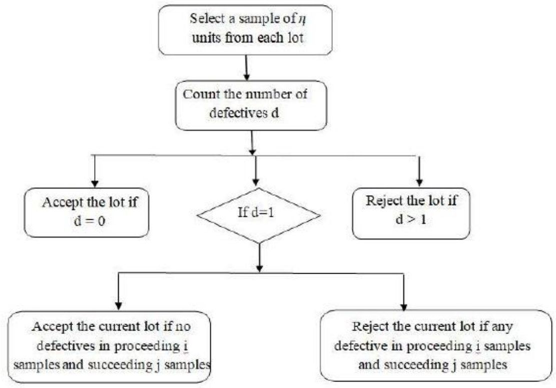
**Step 3.** If $d = 0$ accept the current lot.

**Step 4.** If $d$ is greater than one reject the current lot.

**Step 5.** if $d$ is equal to one proceed to succeeding step.

**Step 6.** If $d = 0$ in preceding $i$ samples and succeeding $j$ samples then accept the current lot."

**Flow chart for TSCChSP-1 Plan**




## 4. Fuzzy Probability of Acceptance (FPA) and Fuzzy Proportion of Defective (FPrD)

Fuzzy probability of acceptance is calculated using binomial distribution. $\gamma$ cut of trapezoidal fuzzy number is used to solve two sided complete chain sampling plan such that $\breve{\wp}_s = (s, e_2 + s, e_3 + s, e_4 + s)$. Where $e_j = b_i - b_1$, $i = 2, 3, 4$ and $s \in [0, 1 - e_4]$ $\breve{\wp}_s[\gamma] = [s + e_2\gamma, e_4 + s - (e_4 - e_3)\gamma]$ and taking $\gamma = 0, 1$ then we get fuzzy interval of proportion defective $\breve{\wp}_s[\gamma] = [\breve{\wp}_s^{lb}, \breve{\wp}_s^{ub}]$ and interval value of fuzzy probability of acceptance $\mathcal{L}(\breve{\wp}_s)[\gamma] = [\mathcal{L}(\breve{\wp}_s^{lb}), \mathcal{L}(\breve{\wp}_s^{ub})]$.

The probability of acceptance two sided complete chain sampling plan using fuzzy parameter is given by

**Case** (i) For $i = j$

$$\mathcal{L}(\breve{\wp}_s^{lb})[\gamma] = \min\{(1 - \breve{\wp}_s)^n + n\breve{\wp}_s(1 - \breve{\wp}_s)^{(n(2i+1)-1)}\} \tag{3}$$

$$\mathcal{L}(\breve{\wp}_s^{ub})[\gamma] = \max\{(1 - \breve{\wp}_s)^n + n\breve{\wp}_s(1 - \breve{\wp}_s)^{(n(2i+1)-1)}\} \tag{4}$$

$$\mathcal{L}(\breve{\wp}_{as})[\gamma] = [(1 - \breve{\wp}_s^{ub})^n + n\breve{\wp}_s^{ub}(1 - \breve{\wp}_s^{ub})^{(n(2i+1)-1)}, (1 - \breve{\wp}_s^{lb})^n + n\breve{\wp}_s^{lb}(1 - \breve{\wp}_s^{lb})^{(n(2i+1)-1)}]$$

**Case** (ii) For $i \neq j$

$$\mathcal{L}(\breve{\wp}_s^{lb})[\gamma] = \min\{(1-\breve{\wp}_s)^n + n\breve{\wp}_s(1-\breve{\wp}_s)^{(n(i+j+1)-1)}\} \quad (5)$$

$$\mathcal{L}(\breve{\wp}_s^{ub})[\gamma] = \max\{(1-\breve{\wp}_s)^n + n\breve{\wp}_s(1-\breve{\wp}_s)^{(n(i+j+1)-1)}\} \quad (6)$$

$$\mathcal{L}(\breve{\wp}_{as})[\gamma] = [(1-\breve{\wp}_s^{ub})^n + n\breve{\wp}_s^{ub}(1-\breve{\wp}_s^{ub})^{(n(i+j+1)-1)}, (1-\breve{\wp}_s^{lb})^n + n\breve{\wp}_s^{lb}(1-\breve{\wp}_s^{lb})^{(n(i+j+1)-1)}]$$

**Table 1.** Fuzzy probability of acceptance with $n = 20$ and $i = 1$, $j = 1$.

| $\breve{\wp}_s = (s, e_2 + s, e_3 + s, e_4 + s)$ | $\breve{\wp}_s[\gamma = 0]$ | $\mathcal{L}(\breve{\wp}_{as})[\gamma = 0]$ | $\breve{\wp}_s[\gamma = 1]$ | $\mathcal{L}(\breve{\wp}_{as})[\gamma = 1]$ |
|---|---|---|---|---|
| (0.000, 0.001, 0.002, 0.003) | [0.000 0.003] | [1.0000 0.9890] | [0.001 0.002] | [0.9987 0.9949] |
| (0.001, 0.002, 0.003, 0.004) | [0.001 0.005] | [0.9990 0.9719] | [0.003 0.004] | [0.9890 0.9813] |
| (0.002, 0.003, 0.004, 0.005) | [0.002 0.007] | [0.9963 0.9493] | [0.005 0.006] | [0.9719 0.9612] |
| (0.003, 0.004, 0.005, 0.006) | [0.003 0.009] | [0.9919 0.9227] | [0.007 0.008] | [0.9493 0.9364] |
| (0.004, 0.005, 0.006, 0.007) | [0.004 0.011] | [0.9861 0.8934] | [0.009 0.010] | [0.9227 0.9083] |
| (0.005, 0.006, 0.007, 0.008) | [0.005 0.013] | [0.9790 0.8622] | [0.011 0.012] | [0.8934 0.8780] |
| (0.006, 0.007, 0.008, 0.009) | [0.006 0.015] | [0.9707 0.8300] | [0.013 0.014] | [0.8622 0.8462] |
| (0.007, 0.008, 0.009, 0.01) | [0.007 0.017] | [0.9614 0.7974] | [0.015 0.016] | [0.8300 0.8138] |
| (0.008, 0.009, 0.01, 0.011) | [0.008 0.019] | [0.9512 0.7649] | [0.017 0.018] | [0.7974 0.7811] |
| (0.009, 0.010, 0.011, 0.012) | [0.009 0.021] | [0.9402 0.7327] | [0.019 0.020] | [0.7649 0.7487] |
| (0.010, 0.011, 0.012, 0.013) | [0.010 0.023] | [0.9284 0.7011] | [0.021 0.022] | [0.7327 0.7168] |
| (0.011, 0.012, 0.013, 0.014) | [0.011 0.025] | [0.9161 0.6703] | [0.023 0.024] | [0.7011 0.6856] |
| (0.012, 0.013, 0.014, 0.015) | [0.012 0.027] | [0.9032 0.6406] | [0.025 0.027] | [0.6703 0.6553] |
| (0.013, 0.014, 0.015, 0.016) | [0.013 0.029] | [0.8899 0.6118] | [0.027 0.028] | [0.6406 0.6261] |
| (0.014, 0.015, 0.016, 0.017) | [0.014 0.031] | [0.8762 0.5842] | [0.029 0.030] | [0.6118 0.5979] |
| (0.015, 0.016, 0.017, 0.018) | [0.015 0.033] | [0.8621 0.5577] | [0.031 0.032] | [0.5842 0.5708] |

**Table 2.** Fuzzy probability of acceptance with $n = 20$ and $i = 1$, and $j = 2$.

| $\breve{\wp}_s = (s, e_2 + s, e_3 + s, e_4 + s)$ | $\breve{\wp}_s[\gamma = 0]$ | $\mathcal{L}(\breve{\wp}_{as})[\gamma = 0]$ | $\breve{\wp}_s[\gamma = 1]$ | $\mathcal{L}(\breve{\wp}_{as})[\gamma = 1]$ |
|---|---|---|---|---|
| (0.000, 0.001, 0.002, 0.003) | [0 .000 0.003] | [1.0000 0.9919] | [0.001 0.002] | [0.9990 0.9963] |
| (0.001, 0.002, 0.003, 0.004) | [0.001 0.005] | [0.9990 0.9790] | [0.003 0.004] | [0.9919 0.9861] |

| | | | | |
|---|---|---|---|---|
| (0.002, 0.003, 0.004, 0.005) | [0.002 0.007] | [0.9963 0.9614] | [0.005 0.006] | [0.9790 0.9707] |
| (0.003, 0.004, 0.005, 0.006) | [0.003 0.009] | [0.9919 0.9402] | [0.007 0.008] | [0.9614 0.9512] |
| (0.004, 0.005, 0.006, 0.007) | [0.004 0.011] | [0.9861 0.9161] | [0.009 0.010] | [0.9402 0.9284] |
| (0.005, 0.006, 0.007, 0.008) | [0.005 0.013] | [0.9790 0.8899] | [0.011 0.012] | [0.9161 0.9032] |
| (0.006, 0.007, 0.008, 0.009) | [0.006 0.015] | [0.9707 0.8621] | [0.013 0.014] | [0.8899 0.8762] |
| (0.007, 0.008, 0.009, 0.01) | [0.007 0.017] | [0.9614 0.8333] | [0.015 0.016] | [0.8621 0.8478] |
| (0.008, 0.009, 0.01, 0.011) | [0.008 0.019] | [0.9512 0.8039] | [0.017 0.018] | [0.8333 0.8187] |
| (0.009, 0.010, 0.011, 0.012) | [0.009 0.021] | [0.9402 0.7742] | [0.019 0.020] | [0.8039 0.7891] |
| (0.010, 0.011, 0.012, 0.013) | [0.010 0.023] | [0.9284 0.7445] | [0.021 0.022] | [0.7742 0.7593] |
| (0.011, 0.012, 0.013, 0.014) | [0.011 0.025] | [0.9161 0.7150] | [0.023 0.024] | [0.7445 0.7297] |
| (0.012, 0.013, 0.014, 0.015) | [0.012 0.027] | [0.9032 0.6858] | [0.025 0.027] | [0.7150 0.7003] |
| (0.013, 0.014, 0.015, 0.016) | [0.013 0.029] | [0.8899 0.6573] | [0.027 0.028] | [0.6858 0.6715] |
| (0.014, 0.015, 0.016, 0.017) | [0.014 0.031] | [0.8762 0.6294] | [0.029 0.030] | [0.6573 0.6433] |
| (0.015, 0.016, 0.017, 0.018) | [0.015 0.033] | [0.8621 0.6023] | [0.031 0.032] | [0.6294 0.6157] |
| (0.016, 0.017, 0.018, 0.019) | [0.016 0.035] | [0.8478 0.5759] | [0.033 0.034] | [0.6023 0.5890] |
| (0.017, 0.018, 0.019, 0.02) | [0.017 0.037] | [0.8333 0.5505] | [0.035 0.036] | [0.5759 0.5631] |
| (0.018, 0.019, 0.02, 0.021) | [0.018 0.039] | [0.8187 0.5259] | [0.037 0.038] | [0.5505 0.5381] |
| (0.019, 0.02, 0.021, 0.022) | [0.019 0.041] | [0.8039 0.5022] | [0.039 0.040] | [0.5259 0.5140] |

The acceptance value for fuzzy probability and defective value for fuzzy proportion is calculated for various values and is provided in Table 1 and Table 2.

**Example 1.** Let us consider that $\breve{\wp}_s = (0.002, 0.003, 0.004, 0.005)$ where $i = j = 1$ and $n = 20$. Then from the Table 1 $\breve{\wp}_s[\gamma = 0] = [0.0020\ 0.0070]$ and $\breve{\wp}_s[\gamma = 1] = [0.0050\ 0.0060]$ FPrD values are calculated and acceptance value for fuzzy probability is obtained as $\mathcal{L}(\breve{\wp}_{as})[\gamma = 0] = [0.9936\ 0.9614]$ and $\mathcal{L}(\breve{\wp}_{as})[\gamma = 1] = [0.9790\ 0.9707]$.

**Example 2.** Suppose $\breve{\wp}_s = (0.002, 0.003, 0.004, 0.005)$ where $i = 1$, $j = 2$ and $n = 20$. From Table 2 defective value for fuzzy proportion is obtained as $\breve{\wp}_s[\gamma = 0] = [0.0020\ 0.0070]$ and $\breve{\wp}_s[\gamma = 1] = [0.0050\ 0.0060]$ and acceptance value for fuzzy probability is calculated as $\mathcal{L}(\breve{\wp}_{as})[\gamma = 0]$

$= [0.9949\ 0.9493]$ and $\mathcal{L}(\breve{\wp}_{as})[\gamma = 1] = [0.9719\ 0.9612]$.

## 5. Fuzzy Operating Characteristic (FOC) curve

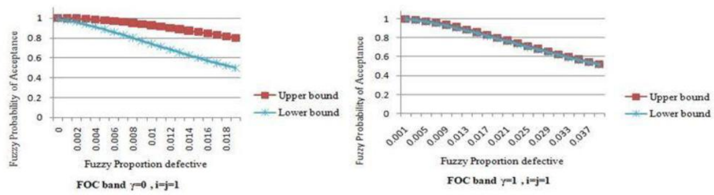



**Figure 1** and Figure 2 Fuzzy Operating Characteristic curve for TSCChSP-1 Plan.

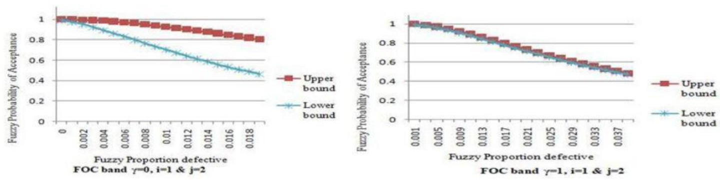



**Figure 3** and Figure 4 Fuzzy Operating Characteristic curve for TSCChSP-1 Plan.

In the above Figures, OC Curve has upper bound and lower bound therefore it is called FOC curve. One can observe that FOC band value become closer when $\gamma$ value increases from 0 to 1 in both cases where $i = j = 1$ and $i = 1$ and $j = 2$.

## 6. Fuzzy Probability of Acceptance When the Sample Size Varies

Let us consider that $\breve{\wp}_s = (0.002, 0.003, 0.004, 0.005)$ and the sample size $n$ varies from 5 to 50 then $\gamma$ cut of trapezoidal fuzzy number is used to calculate the interval of fuzzy proportion defective $\breve{\wp}_s[\gamma = 0] = [0.0020\ 0.0070]$, $\breve{\wp}_s[\gamma = 1] = [0.0050\ 0.0060]$ and fuzzy probability of acceptance value as shown in the Table 3.

**Table 3.** Fuzzy probability of acceptance for different sample size where $i = j$ and $i \neq j$.

| n | $i = j$ | $\mathcal{L}(\breve{\wp}_{as})[\gamma = 0]$ | $\mathcal{L}(\breve{\wp}_{as})[\gamma = 1]$ | $i \neq j$ | $\mathcal{L}(\breve{\wp}_{as})[\gamma = 0]$ | $\mathcal{L}(\breve{\wp}_{as})[\gamma = 1]$ |
|---|---|---|---|---|---|---|

| | | | | | | |
|---|---|---|---|---|---|---|
| 5 | $i = 1, j = 1$ | [0.9998 0.9972] | [0.9986 0.9979] | $i = 1, j = 2$ | [0.9997 0.9961] | [0.9980 0.9971] |
| 10 | | [0.9991 0.9893] | [0.9943 0.9920] | | [0.9987 0.9854] | [0.9922 0.9890] |
| 15 | | [0.9979 0.9771] | [0.9877 0.9827] | | [0.9971 0.9694] | [0.9834 0.9768] |
| 20 | | [0.9963 0.9614] | [0.9790 0.9707] | | [0.9719 0.9612] | [0.9963 0.9614 ] |
| 25 | | [0.9943 0.9430] | [0.9685 0.9564] | | [0.9583 0.9430] | [0.9943 0.9430 ] |
| 30 | | [0.9919 0.9224] | [0.9564 0.9402] | | [0.9430 0.9228] | [0.9919 0.9224 ] |
| 35 | | [0.9892 0.9000] | [0.9430 0.9224] | | [0.9263 0.9010] | [0.9892 0.9000 ] |
| 40 | | [0.9861 0.8764] | [0.9285 0.9033] | | [0.9085 0.8782] | [0.9861 0.8764 ] |
| 45 | | [0.9827 0.8519] | [0.9130 0.8833] | | [0.8898 0.8547] | [0.9827 0.8519 ] |
| 50 | | [0.9790 0.8267] | [0.8968 0.8625] | | [0.8705 0.8307] | [0.9790 0.8267] |
| 5 | $i = 1, j = 2$ | [0.9996 0.9951] | [0.9974 0.9963] | $i = 1, j = 3$ | [0.9995 0.9940] | [0.9969 0.9956] |
| 10 | | [0.9983 0.9818] | [0.9902 0.9863] | | [0.9883 0.9837] | [0.9983 0.9818] |
| 15 | | [0.9963 0.9624] | [0.9793 0.9713] | | [0.9756 0.9664] | [0.9963 0.9624] |
| 20 | | [0.9936 0.9388] | [0.9655 0.9527] | | [0.9597 0.9452] | [0.9936 0.9388] |
| 25 | | [0.9902 0.9122] | [0.9494 0.9314] | | [0.9415 0.9215] | [0.9902 0.9122] |
| 30 | | [0.9862 0.8837] | [0.9315 0.9082] | | [0.9215 0.8961] | [0.9862 0.8837] |
| 35 | | [0.9817 0.8542] | [0.9122 0.8838] | | [0.9005 0.8698] | [0.9817 0.8542] |
| 40 | | [0.9768 0.8242] | [0.8921 0.8585] | | [0.8787 0.8430] | [0.9768 0.8242] |
| 45 | | [0.9713 0.7943] | [0.8713 0.8329] | | [0.8565 0.8163] | [0.9713 0.7943] |
| 50 | | [0.9655 0.7647] | [0.8501 0.8072] | | [0.8342 0.7898] | [0.9655 0.7647] |

From the above Table 3 one can observe that when the sample size value decreases the width of FOC curve decreases. In Fuzzy probability of acceptance values for $i = j$ and $i \neq j$ where $\gamma = 0$ is having better value than $\gamma = 1$.

## 7. Determination of Sample Size

"Let producer's risk is denoted as $\widetilde{\alpha_f}$ and consumer's risk is denoted as $\widetilde{\beta_h}$. The rejecting the good lot is called producer's risk and accepting the bad lot is called Consumer's risk. Accepting quality level $(\widetilde{AQL})$ denoted by $\breve{\wp}_{1f}$ and Limiting quality level $(L\breve{Q}L)$ denoted by $\breve{\wp}_{2h}$. Here two sided complete chain sampling plan is used to design the parameter sample size $n$ to satisfy the following two inequalities for $\mathcal{L}(\breve{\wp}_{1f})$ and $\mathcal{L}(\breve{\wp}_{2h})$ simultaneously.

$\mathcal{L}(\breve{\wp}_{1f}) \geq 1 - \widetilde{\alpha_f}$ and $\mathcal{L}(\breve{\wp}_{1f}) \leq \widetilde{\beta_h}, \widetilde{\alpha_f} = 0.05$ and $\widetilde{\beta_h} = 0.10$ is fixed so that the interval of fuzzy probability of acceptance is satisfied the conditions $\mathcal{L}(\breve{\wp}_{1f}) \geq 0.95$ and $\mathcal{L}(\breve{\wp}_{2h}) \leq 0.10$ for different sample sizes".

**Case (i)** For $i = j$

$$\mathcal{L}(\breve{\wp}_{1f}) = (1 - \breve{\wp}_{1f})^n + n\breve{\wp}_{1f}(1 - \breve{\wp}_{1f})^{(n(2i+1)-1)} \geq 0.95 \tag{7}$$

$$\mathcal{L}(\breve{\wp}_{2h}) = (1 - \breve{\wp}_{2h})^n + n\breve{\wp}_{2h}(1 - \breve{\wp}_{2h})^{(n(2i+1)-1)} \geq 0.10 \tag{8}$$

**Case (ii)** For $i \neq j$

$$\mathcal{L}(\breve{\wp}_{1f}) = (1 - \breve{\wp}_{1f})^n + n\breve{\wp}_{1f}(1 - \breve{\wp}_{1f})^{(n(i+j+1)-1)} \geq 0.95 \tag{9}$$

$$\mathcal{L}(\breve{\wp}_{2h}) = (1 - \breve{\wp}_{2h})^n + n\breve{\wp}_{2h}(1 - \breve{\wp}_{2h})^{(n(i+j+1)-1)} \leq 0.10 \tag{10}$$

**Table 4.** Optimum value of the parameter $n$ for $i = j$, $\mathcal{L}(\breve{\wp}_{1f}) \geq 0.95$ and $\mathcal{L}(\breve{\wp}_{2h}) \leq 0.10$.

| $i = j$ | ($\widetilde{AQL}$) | ($L\breve{Q}L$) | $n$ |
|---|---|---|---|
| $i = 1$, $j = 1$ | (0.001,0.0011,0.0012,0.0013) | (0.05,0.051,0.052,0.053) | 85 |
| | | (0.06,0.061,0.062,0.063) | 80 |
| | | (0.07.0.071,0.072,0.073) | 75 |
| | | (0.08,0.081,0.082,0.083) | 70 |
| | | (0.09,0.091,0.092,0.093) | 65 |
| | (0.002,0.0021,0.0022,0.0023) | (0.05,0.051,0.052,0.053) | 70 |
| | | (0.06,0.061,0.062,0.063) | 65 |
| | | (0.07.0.071,0.072,0.073) | 60 |
| | | (0.08,0.081,0.082,0.083) | 55 |
| | | (0.09,0.091,0.092,0.093) | 50 |
| $i = 1$, $j = 2$ | (0.001,0.0011,0.0012,0.0013) | (0.05,0.051,0.052,0.053) | 85 |
| | | (0.06,0.061,0.062,0.063) | 80 |
| | | (0.07.0.071,0.072,0.073) | 75 |

| | | | |
|---|---|---|---|
| | | (0.08,0.081,0.082,0.083) | 70 |
| | | (0.09,0.091,0.092,0.093) | 65 |
| | (0.002,0.0021,0.0022,0.0023) | (0.05,0.051,0.052,0.053) | 50 |
| | | (0.06,0.061,0.062,0.063) | 46 |
| | | (0.07.0.071,0.072,0.073) | 40 |
| | | (0.08,0.081,0.082,0.083) | 35 |
| | | (0.09,0.091,0.092,0.093) | 30 |

**Table 5.** Optimum value of the parameter $n$ for $i \neq j$, $\mathcal{L}(\breve{\wp}_{1f}) \geq 0.95$ and $\mathcal{L}(\breve{\wp}_{2h}) \leq 0.10$.

| $i \neq j$ | $(\widetilde{AQL})$ | $(L\breve{Q}L)$ | $n$ |
|---|---|---|---|
| $i = 1,\ j = 2$ | (0.001,0.0011,0.0012,0.0013) | (0.05,0.051,0.052,0.053) | 95 |
| | | (0.06,0.061,0.062,0.063) | 90 |
| | | (0.07.0.071,0.072,0.073) | 85 |
| | | (0.08,0.081,0.082,0.083) | 80 |
| | | (0.09,0.091,0.092,0.093) | 75 |
| | (0.002,0.0021,0.0022,0.0023) | (0.05,0.051,0.052,0.053) | 60 |
| | | (0.06,0.061,0.062,0.063) | 55 |
| | | (0.07.0.071,0.072,0.073) | 50 |
| | | (0.08,0.081,0.082,0.083) | 45 |
| | | (0.09,0.091,0.092,0.093) | 40 |
| $i = 1,\ j = 3$ | (0.001,0.0011,0.0012,0.0013) | (0.05,0.051,0.052,0.053) | 85 |
| | | (0.06,0.061,0.062,0.063) | 80 |
| | | (0.07.0.071,0.072,0.073) | 75 |
| | | (0.08,0.081,0.082,0.083) | 70 |
| | | (0.09,0.091,0.092,0.093) | 65 |
| | (0.002,0.0021,0.0022,0.0023) | (0.05,0.051,0.052,0.053) | 48 |
| | | (0.06,0.061,0.062,0.063) | 45 |
| | | (0.07.0.071,0.072,0.073) | 42 |

| | | | |
|---|---|---|---|
| | | (0.08,0.081,0.082,0.083) | 39 |
| | | (0.09,0.091,0.092,0.093) | 35 |

From the above Table 4 and Table 5 one can observe that when the value of $i$ and $j$ increases AQL and LQL values satisfying the condition is decreased.

## 8. Minimizing the Sum of Risks

The sample size is calculated so as to minimize the sum of the risks and it is presented in Table 6 and Table 7. The mathematical expression to minimize the sum of risk is $\widetilde{\alpha_f} + \widetilde{\beta_h} = 1 - \mathcal{L}(\breve{\wp}_{1f}) + \mathcal{L}(\breve{\wp}_{2h})$. The sum of risks is obtained as interval of fuzzy.

**Case (i)** For $i = j$

$$\widetilde{\alpha_f} + \widetilde{\beta_h} = 1 - \mathcal{L}(\breve{\wp}_{1f}) + \mathcal{L}(\breve{\wp}_{2h})$$

$$= 1 - \{(1 - \breve{\wp}_{1f})^n + n\breve{\wp}_{1f}(1 - \breve{\wp}_{1f})^{(n(2i+1)-1)}\}$$

$$+ \{(1 - \breve{\wp}_{2h})^n + n\breve{\wp}_{2h}(1 - \breve{\wp}_{2h})^{(n(2i+1)-1)}\}$$

**Case (ii)** For $i \neq j$

$$\widetilde{\alpha_f} + \widetilde{\beta_h} = 1 - \{(1 - \breve{\wp}_{1f})^n + n\breve{\wp}_{1f}(1 - \breve{\wp}_{1f})^{(n(i+j+1)-1)}\}$$

$$+ \{(1 - \breve{\wp}_{2h})^n + n\breve{\wp}_{2h}(1 - \breve{\wp}_{2h})^{(n(i+j+1)-1)}\}$$

**Table 6.** Optimum parameter $n$ for $i = j$ and minimizes sum of risks when $\widetilde{\alpha_f} \cong 0.05$ and $\widetilde{\beta_h} \cong 0.10$.

| $i = j$ | n | $\breve{\wp}_{1f}[\gamma = 0]$ | $\mathcal{L}(\breve{\wp}_{1f})[\gamma = 0]$ | $\breve{\wp}_{2h}[\gamma = 0]$ | $\mathcal{L}(\breve{\wp}_{1f})[\gamma = 0]$ | $\widetilde{\alpha_f} + \widetilde{\beta_h}$ |
|---|---|---|---|---|---|---|
| $i = 1, j = 1$ | 85 | [0.001 0.0013] | [0.9844 0.9747] | [0.05 0.053] | [0.0128 0.0098] | [0.0284 0.0351] |
| | 80 | [0.001 0.0013] | [0.9861 0.9774] | [0.06 0.063] | [0.0071 0.0055] | [0.0210 0.0281] |
| | 75 | [0.001 0.0013] | [0.9877 0.9799] | [0.07 0.073] | [0.0043 0.0034] | [0.0166 0.0235] |
| | 70 | [0.001 0.0013] | [0.9892 0.9823] | [0.08 0.083] | [0.0029 0.0023] | [0.0137 0.0200] |
| | 65 | [0.001 0.0013] | [0.9906 0.9846] | [0.09 0.093] | [0.0022 0.0018] | [0.0116 0.0172] |

| | | | | | | |
|---|---|---|---|---|---|---|
| | 70 | [0.002 0.0023] | [0.9614 0.9506] | [0.05 0.053] | [0.0277 0.0221] | [0.0663 0.0715] |
| | 65 | [0.002 0.0023] | [0.9661 0.9566] | [0.06 0.063] | [0.0179 0.0146] | [0.0518 0.0580] |
| | 60 | [0.002 0.0023] | [0.9707 0.9623] | [0.07 0.073] | [0.0129 0.0106] | [0.0422 0.0483] |
| | 55 | [0.002 0.0023] | [0.9749 0.9678] | [0.08 0.083] | [0.0102 0.0085] | [0.0353 0.0407] |
| | 50 | [0.002 0.0023] | [0.9790 0.9728] | [0.09 0.093] | [0.0090 0.0076] | [0.0300 0.0348] |

**Table 7.** Optimum parameter $n$ for $i \neq j$ and minimizes sum of risks when $\widetilde{\alpha_f} \cong 0.05$ and $\widetilde{\beta_h} \cong 0.10$.

| $i \neq j$ | n | $\breve{\wp}_{1f}[\gamma = 0]$ | $\mathcal{L}(\breve{\wp}_{1f})[\gamma = 0]$ | $\breve{\wp}_{2h}[\gamma = 0]$ | $\mathcal{L}(\breve{\wp}_{1f})[\gamma = 0]$ | $\widetilde{\alpha_f} + \widetilde{\beta_h}$ |
|---|---|---|---|---|---|---|
| $i = 1, j = 2$ | 95 | [0.001 0.0013] | [0.9743 0.9592] | [0.05 0.053] | [0.0077 0.0057] | [0.0334 0.0465] |
| | 90 | [0.001 0.0013] | [0.9767 0.9629] | [0.06 0.063] | [0.0038 0.0029] | [0.0271 0.0400] |
| | 85 | [0.001 0.0013] | [0.9790 0.9664] | [0.07 0.073] | [0.0021 0.0016] | [0.0231 0.0352] |
| | 80 | [0.001 0.0013] | [0.9812 0.9698] | [0.08 0.083] | [0.0013 0.0010] | [0.0201 0.0312] |
| | 75 | [0.001 0.0013] | [0.9833 0.9731] | [0.09 0.093] | [0.0008 0.0007] | [0.0175 0.0276 ] |
| | 60 | [0.002 0.0023] | [0.9612 0.9506] | [0.05 0.053] | [0.0461 0.0381] | [0.0849 0.0875] |
| | 55 | [0.002 0.0023] | [0.9667 0.9574] | [0.06 0.063] | [0.0333 0.0279] | [0.0666 0.0705 ] |
| | 50 | [0.002 0.0023] | [0.9719 0.9640] | [0.07 0.073] | [0.0266 0.0226] | [0.0547 0.0586] |
| | 45 | [0.002 0.0023] | [0.9767 0.9701] | [0.08 0.083] | [0.0235 0.0203] | [0.0468 0.0502] |
| | 40 | [0.002 0.0023] | [0.9812 0.9758] | [0.09 0.093] | [0.0230 0.0202] | [0.0418 0.0444] |

**Example 3.** Consider $\breve{\wp}_{1f} = (0.0010, 0.0011, 0.0012, 0.0013)$ and $\breve{\wp}_{2h} = (0.08, 0.081, 0.082, 0.083)$ then fuzzy proportion value calculated for as $\breve{\wp}_{1f}[\gamma = 0] = [0.0010\ 0.0013]$ and $\breve{\wp}_{2h}[\gamma = 0] = [0.08\ 0.083]$ respectively and fuzzy probability of acceptance obtained for case (i) $i = j = 1$ from Table 4 and Table 6 $\mathcal{L}(\breve{\wp}_{1f})[\gamma = 0] = [0.9892\ 0.9823]$, $\mathcal{L}(\breve{\wp}_{2h})[\gamma = 0] = [0.0029\ 0.0023]$ and sum of the risks minimized is $\breve{\alpha} + \breve{\beta} = [0.0137\ 0.0200]$ and sample size calculated as 70. Case (ii) $i = 1$ and $j = 2$ from Table 5 and Table 7 $\mathcal{L}(\breve{\wp}_{1f})[\gamma = 0] = [0.9812\ 0.9698]$, $\mathcal{L}(\breve{\wp}_{2h})[\gamma = 0] = [0.0013\ 0.0010]$ sum of the risks minimized as $\breve{\alpha} + \breve{\beta} = [0.0013\ 0.0010]$ and sample size calculated satisfying the condition is 80.

## Conclusion

In this study two sided complete chain sampling plan is developed using fuzzy parameters. In this trapezoidal fuzzy number method is used to calculate the interval value of fuzzy acceptance sampling plan. FOC band is drawn from that one can conclude when $\gamma$ increases from 0 to 1 the width of FOC band becomes less. After satisfying the inequality conditions of risks then the sample size is calculated. The total risks are minimized for optimum value for $n$ and obtained as interval of fuzzy.

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