International Journal of Applied Research 2016; 2(4): 104-111

ISSN Print: 2394-7500
ISSN Online: 2394-5869
Impact Factor: 5.2
IJAR 2016; 2(4): 104-111
www.allresearchjournal.com
Received: 07-02-2016
Accepted: 09-03-2016

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The construction and selection of tightening sample size of quick switching variables sampling systems involving minimum sum of the risks

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Abstract
This article extends the concepts of Quick Switching Variables Sampling Systems [QSVSS ($n_{T\sigma}$, $n_{N\sigma}$; k)] involving a minimum sum of risks when the sample size is tightening. The operating procedure and a table is given for finding the QSVSS($n_{T\sigma}$, $n_{N\sigma}$; k) involving minimum sum of risks for specified Acceptable Quality Level and Limiting Quality Level.

Keywords: Quick Switching System, Variables Sampling, Acceptable Quality Level (AQL), Limiting Quality Level (LQL) and Minimum Sum of Risks

Introduction
Acceptance sampling is lead to quality standard and inspection rules. The inspection rules may give several kinds of plans. In acceptance sampling, many sampling will be handled, but two are used major areas, viz, attributes and variables sampling. Quick Switching Sampling System is regarded as high efficient protocol for acceptance sampling. Previously, it was proposed by Dodge (1967) [2] and it was further investigated by various authors, Romboski (1969) [10] and Govindaraju (1991) [4]. It was also examined by Taylor (1996) [13] to identify a method to evaluate and select Quick Switching Sampling System. As the base to the above arguments, in 1957 Golub Abraham described the designing of single sampling inspection plan for fixed sample size, which was noticed as the sampling plan involving minimum sum of risks. Govindaraju and Subramani (1990a) [5] have constructed tables for selection of single sampling quick switching systems (QSS-1) for given Acceptable Quality Level and Limiting Quality Level. The author (1990b) [6] also provided the table which is used to select an MDS-1 plan for given AQL (p_1) and LQL (p_2) with minimum sum of risks. Palanivel (1999) [9] has constructed the table on Quick Switching Variables Single Sampling (QSVSS) Systems. Senthilkumar and Sivakumaran (2004) [11] have constructed the table for selection of minimum risk single sampling quick switching system QSS-1(n; c_1, c_2) by attributes. In later Senthilkumar at el (2013) [12] have constructed the procedure for QSVSS (n; k_T, k_N) for involving minimum sum of risk.
This paper provides the concepts of Quick Switching Variables Sampling Systems [QSVSS ($n_{T\sigma}$, $n_{N\sigma}$; k)] involving a minimum sum of risks for specified Acceptable Quality Level and Limiting Quality Level.

Quick Switching Variables Sampling System of Type QSVSS ($n_{T\sigma}$, $n_{N\sigma}$; k)
The conditions and the assumptions under which the QSVSS scheme can be applied are as follows:

Conditions for Application
- Production is steady, so that results on current, preceding and succeeding lots are broadly indicative of a continuing process.
- Lots are submitted substantially in the order of production.
- Inspection is by variables, with the quality being defined as the fraction of non-conforming.
- The sample units are selected from a large lot and production is continuous.
- The production process should be depends on automation and manhandling the process is very limited.

Basic Assumptions

- The quality characteristic is represented by a random variable X measured on a continuous scale.
- Distribution of X is normal with mean and Standard Deviation.
- An upper limit U, has been specified and a product is qualified as defective when X>U. [When the lower limit L is Specified, the product is a defective one if X<L].
- The Purpose of inspection is to control the fraction defective, p in the lot inspected.

When the conditions listed above are satisfied the fraction defective in a lot will be defined by

$$p = 1-F(v) = F(-v)$$

with $v = (U-\mu)/\sigma$

and
$$F(y) = \int_{-\infty}^{y} \frac{1}{\sqrt{2\pi}} e^{-Z^2/2} dz \qquad (1)$$

Where Z ~ N (0, 1). It is to be recalled here that the criterion for the σ -method variable plan is to accept the lot if $\bar{x} + k_\sigma \sigma \leq U$, where U is the upper specification limit or $\bar{x} - k_\sigma \sigma \geq L$, where L is the lower specification limit. The operating procedure of QSVSS ($n_{T\sigma}, n_{N\sigma}; k$) is described below.

Operating Procedure

The steps involved in this procedure are as follows

Step 1. Under normal inspection, draw a sample of size $n_{N\sigma}$ from the lot, inspect and record the measurement of the quality characteristic for each unit of the sample. Compute the sample mean $\bar{x}$. Where $\bar{x}_N = \Sigma x_i / n_N$

Step 2. i) if $\bar{x}_N + k_\sigma \sigma \leq U$ or $\bar{x}_N - k_\sigma \sigma \geq L$ accept the lot and repeat step 1 for the next lot.
ii) if $\bar{x}_N + k_\sigma \sigma > U$ or $\bar{x}_N - k_\sigma \sigma < L$ reject the lot go to step 3.

Step 3. Under tightened inspection, draw a sample of size $n_{T\sigma}$ from the next lot, inspect and record the measurement of the quality characteristic for each unit of the sample. Compute the sample mean $\bar{x}$. Where $\bar{x}_T = \Sigma x_i / n_T$.

Step4. i) if $\bar{x}_T + k_\sigma \sigma \leq U$ or $\bar{x}_T - k_\sigma \sigma \geq L$ accept the lot and repeat step 1 for the next lot.
ii) if $\bar{x}_T + k_\sigma \sigma > U$ or $\bar{x}_T - k_\sigma \sigma < L$ reject the lot go to step 3.

Where $n_{N\sigma}$ and $n_{T\sigma}$ are the sample sizes of normal and tightened sampling, variable plans respectively, and k is the acceptance constant under σ-method. Where $\bar{x}$ and σ are the average quality characteristic and standard deviation respectively. The quick switching variables sampling system as defined QSVSS ($n_{T\sigma}, n_{N\sigma}; k$). As thetightened plan sample size $n_{T\sigma}$ is greater than the normal plan sample size $n_{N\sigma}$, for designing the QSVS system $n_{T\sigma}$ is fixed as a multiple of $n_{N\sigma}$. i.e. $n_{T\sigma} = m\, n_{N\sigma}$, where m >1.

Operating Characteristic Function

According to Romboski (1969) [10], the OC function of QSS is given by

$$P_a(p) = \frac{P_T}{1 - P_N + P_T} \qquad (2)$$

Based on the OC function of the QSS Romboski (1969) [10] the OC function of QSVSS ($n_{T\sigma}, n_{N\sigma}; k$) can be written as

$$P_a(p) = \frac{\phi(w_T)}{1 - \phi(w_N) + \phi(w_T)} \qquad (3)$$

With

$$w_T = \sqrt{n_{T\sigma}}(U - k_\sigma - \mu)/\sigma = (v - k_\sigma)\sqrt{n_{T\sigma}}$$
$$w_N = \sqrt{n_{N\sigma}}(U - k_\sigma - \mu)/\sigma = (v - k_\sigma)\sqrt{n_{N\sigma}}$$
$$v = (U - \mu)/\sigma$$

Under the assumption of normal approximation of the non-central t distribution (Abramowitz and Stegun, 1964) [1], the values of P_N and P_T are respectively given by

$$P_N = F(w_N) = pr[(U - \bar{x})/\sigma > k_\sigma] \qquad (4)$$
$$P_T = F(w_T) = pr[(U - \bar{x})/\sigma > k_\sigma] \qquad (5)$$

Where, P_N and P_T are the proportions of lots expected to be accepted using normal ($n_{N\sigma}$, k) and tightened ($n_{T\sigma}$, k) variables sampling plans respectively. These two equations are applied to the OC function of QSVSS ($n_{T\sigma}, n_{N\sigma}; k$). We get the following

$$P_a(p) = \frac{\Pr[(U-\bar{x})/\sigma > k_\sigma]}{1 - \Pr[(U-\bar{x})/\sigma > k_\sigma] + \Pr[(U-\bar{x})/\sigma > k_\sigma]} \qquad (6)$$

If $P_a(p_1)$ and $P_a(p_2)$ are

$$P_a(p_1) = \frac{\Pr[(U-\bar{x})/\sigma > k_\sigma]}{1 - \Pr[(U-\bar{x})/\sigma > k_\sigma] + \Pr[(U-\bar{x})/\sigma > k_\sigma]} = 1 - \alpha \qquad (7)$$

$$P_a(p_2) = \frac{\Pr[(U-\bar{x})/\sigma > k_\sigma]}{1 - \Pr[(U-\bar{x})/\sigma > k_\sigma] + \Pr[(U-\bar{x})/\sigma > k_\sigma]} = \beta \qquad (8)$$

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

$$\alpha + \beta = 1 - P_a(p_1) + P_a(p_2) \qquad (9)$$

For given AQL and LQL, the parametric values of QSVSS namely k, the sample sizes $n_{N\sigma}$, $n_{T\sigma}$, α and β are determined by using a computer search.

A procedure for QSVSS ($n_{T\sigma}$, $n_{N\sigma}$; k) System involving Minimum sum of the risks

From table 1, a procedure for designing of Quick Switching Variables Sampling Systems involving Minimum sum of risks for the given values of AQL and LQL is indicated below.

Table 1 is used to select the QSVSS for given values of (AQL, 1-α), (LQL, β*)*. The plan given here have the minimum sum of the risks. Fixes the values of p_1 and p_2 from which a Quick Switching Variables Sampling System can be selected under known σ-method. Entering the row, giving p_1 and p_2, one gets the acceptance criteria k, α+β and the sample sizes $n_{N\sigma}$ and $n_{T\sigma}$ of QSVSS ($n_{T\sigma}, n_{N\sigma}; k_\sigma$). For example, for given p_1=0.002, p_2=0.007, $n_{T\sigma}$=320, $n_{N\sigma}$=160, k_σ=2.852, α=5% and β=0%.

QSVSS with Unknown σ variables plan as the reference plan

If the population standard deviation σ is unknown, then it is estimated from the sample standard deviation s (n-1 as the divisor). If the sample sizes of the unknown sigma variables system (s method) are n_s and m_{ns} the acceptance parameter is k_0, then the operating procedure is as follows:

Step1. Under normal inspection, draw a sample of size $n_{N\sigma}$ from the lot, inspect and record the measurement of the quality characteristic for each unit of the sample. Compute the sample mean $\bar{x}$. Where $\bar{x}_N = \sum x_i / n_N$

$$S = \sqrt{\sum (x_i - \bar{x})^2 / n_N - 1}$$

Step2. i) if $\bar{x}_N + k_S S \leq U$ or $\bar{x}_N - k_S S \geq L$ accept the lot and repeat step 1 for the next lot.

ii) if $\bar{x}_N + k_s s > U$ or $\bar{x}_N - k_S S < L$ reject the lot go to step 3.

Step3. Under tightened inspection, draw a sample of size $n_{T\sigma}$ from the next lot, inspect and record the measurement of the quality characteristic for each unit of the sample. Compute the sample mean $\bar{x}$. Where $\bar{x}_T = \sum x_i / n_T$ $S = \sqrt{\sum (x_i - \bar{x})^2 / n_T - 1}$

Step4. i) if $\bar{x}_T + k_s s \leq U$ or $\bar{x}_T - k_S S \geq L$ accept the lot and repeat step 1 for the next lot.

ii) if $\bar{x}_T + k_s s > U$ or $\bar{x}_T - k_S S < L$ reject the lot go to step 3.

Here $\bar{X}$ and s are the average and the standard deviation of quality characteristic respectively of the sample. Under the assumptions for Quick Switching System stated, the probability of acceptance P_a (p), of a lot is given in the equation (5.3) and P_T and P_N respectively are

$$P_T = \int_{-\infty}^{w_T} \frac{1}{\sqrt{2\pi}} e^{-z^2/2} dz$$

and $$P_N = \int_{-\infty}^{w_N} \frac{1}{\sqrt{2\pi}} e^{-z^2/2} dz$$

with $$w_N = \frac{U - k_s - \mu}{S} \cdot \frac{1}{\sqrt{\left(\frac{1}{n_s} + \frac{k^2}{2n_s}\right)}}$$

$$w_T = \frac{U - k_s - \mu}{S} \cdot \frac{1}{\sqrt{\left(\frac{1}{n_s} + \frac{k^2}{2n_s}\right)}}$$

Designing QSVSS ($n_{N\sigma}$, $n_{T\sigma}$; k_σ) with known σ for given AQL and LQL

Example

Table 1 can be used to determine QSVSS($n_{T\sigma}$, $n_{N\sigma}$; k_σ) for specified values of AQL and LQL. For example, if it is desired to have a QSVSS($n_{T\sigma}$, $n_{N\sigma}$; k_σ) for given AQL = 0.003 and LQL = 0.007, and m=2. Table 1 gives n_N = 164, and k = 2.723. The sample size $n_{T\sigma}$ = m $n_{N\sigma}$ = (2) (164) = 328. Thus, for given requirement, the QSVSS ($n_{T\sigma}$, $n_{N\sigma}$; k_σ) is specified by the parameters $n_{T\sigma}$ =328, $n_{N\sigma}$ = 164, and k = 2.723, α=6% and β=0% as desired plan parameters.

Designing QSVSS (N_{NS}, N_{TS}; K_S) with known S for given AQL AND LQL

Example

Table 1 can be used to determine QSVSS(n_{Ts}, n_{Ns}; k_s) for specified values of AQL and LQL. For example, if it is desired to have a QSVSS(n_{Ts}, n_{Ns}; k_s) for given AQL = 0.003 and LQL = 0.007, and m=2. Table 5.1 gives n_N = 772, and k = 2.724. The sample size n_{Ts} = m n_{Ns} = (2) (772) = 1544. Thus, for given requirement, the QSVSS (n_{Ts}, n_{Ns}; k_s) is specified by the parameters, n_{Ts} =1544, n_{Ns} = 772, and k = 2.724α=6% and β=0% as desired plan parameters.

Plotting the OC Curve

The OC curve for the Quick Switching Sampling System by Variables with $n_{T\sigma}$=352, $n_{N\sigma}$=176, k_σ=2.733, α=9% and β=0% and Fig 1 shows the OC curve of Quick Switching Sampling system by variables involving minimum sum of risks.

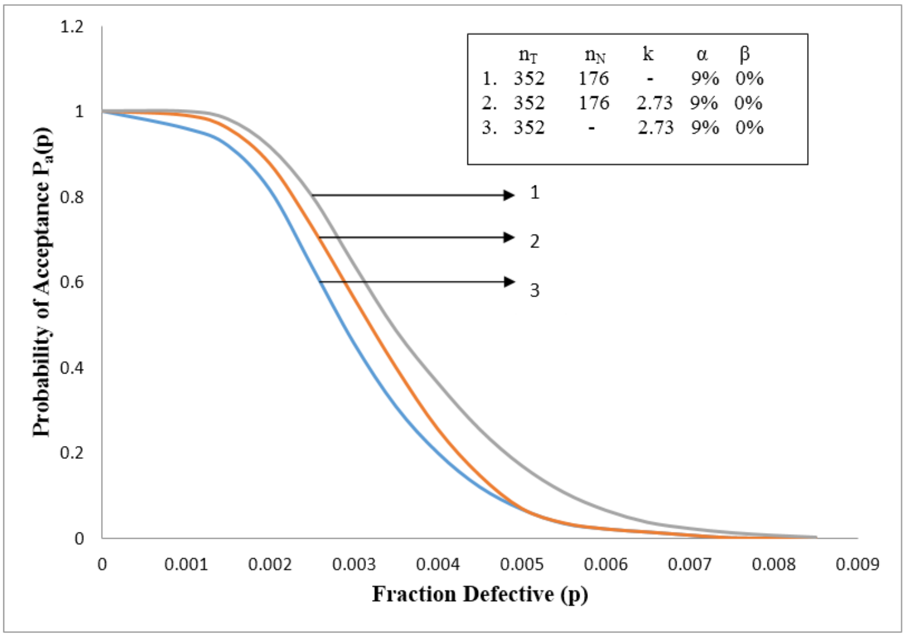

Fig 1: Normal, Composite and Tightened OC Curves with minimum sum of risks for QSVSS, ($n_{T\sigma}$=352, $n_{N\sigma}$=176, k_σ=2.733, α=9% and β=0%)

Construction of Table

The OC function of QSVSS ($n_{T\sigma}$, $n_{N\sigma}$; k_σ) is given by equation (2). For specified p_1 and p_2 the equation (6) would result in

$$P_a(p) = \frac{P_T}{1 - P_N + P_T} \quad (10)$$

where

$$P_T = \int_{-\infty}^{w_T} \frac{1}{\sqrt{2\pi}} e^{-z^2/2} dz \quad (11)$$

and

$$P_N = \int_{-\infty}^{w_N} \frac{1}{\sqrt{2\pi}} e^{-z^2/2} dz \quad (12)$$

Using iterative procedure equations, (11) and (12) is solved for given values of p_1, p_2, m, α and β to get the values of $n_{N\sigma}$ and k_σ for the specified pair of points, say (p_1, α) and (p_2, β) on the OC curve. Here, the values of m canbe taken m >1and find the desired parameters. In Table 1, provided, if m=2, the values of $n_{T\sigma}$, $n_{N\sigma}$, k_σ, α andβ areconstructed. A procedure for finding the parameters of unknown σ - method plan from known σ-method plan with parameters (n_S, k_{TS}, k_{Ns}), are obtained by using computer search routine through C++ programme. The values of n_T, n_N, k for the QSVSS that satisfying equation (2) are obtained using (10). By definition, minimizing the sum of risks are determined as

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

where,

$$P_a(p_1) = \frac{\Pr[(U-\bar{x})/\sigma > k_\sigma]}{1 - \Pr[(U-\bar{x})/\sigma > k_\sigma] + \Pr[(U-\bar{x})/\sigma > k_\sigma]} = 1 - \alpha$$

$$P_a(p_2) = \frac{\Pr[(U-\bar{x})/\sigma > k_\sigma]}{1 - \Pr[(U-\bar{x})/\sigma > k_\sigma] + \Pr[(U-\bar{x})/\sigma > k_\sigma]} = \beta$$

The sample size $n_{T\sigma}$ equals $mn_{N\sigma}$ and n_{Ts} equals mn_{Ns}, and hence only $n_{T\sigma}$, $n_{N\sigma}$, k, α and β are tabulated.

Table 1: The values of $n_{T\sigma}$, $n_{N\sigma}$, k_σ, n_{Ts}, n_{Ns}, k_s, α, β for given AQL and LQL Involving Minimum Sum of Risks.

p_1	p_2	$n_{T\sigma}$	$n_{N\sigma}$	k_σ	α	β	n_{TS}	n_{NS}	k_S
0.001	0.002	504	252	3.080	9	1	2895	1447	3.081
	0.003	350	175	3.072	8	0	2001	1001	3.072
	0.004	338	169	3.062	7	0	1922	961	3.062
	0.005	326	163	3.072	6	0	1864	932	3.072
	0.006	324	162	3.062	5	0	1843	921	3.062
	0.007	314	157	3.062	4	0	1786	893	3.063
	0.008	312	156	3.062	3	0	1774	887	3.063
	0.009	310	155	3.062	2	0	1763	882	3.063
	0.010	300	150	3.052	1	0	1697	848	3.053
	0.020	198	99	3.012	1	0	1096	548	3.013
	0.030	158	79	2.992	1	0	865	433	2.994
	0.040	134	67	2.982	1	0	730	365	2.984
	0.050	132	66	2.972	1	0	715	357	2.974
	0.060	130	65	2.972	1	0	704	352	2.974
	0.070	128	64	2.972	1	0	693	347	2.974
	0.080	124	62	2.972	1	0	672	336	2.974
	0.090	118	59	2.962	1	0	636	318	2.964
	0.100	112	56	2.962	1	0	603	302	2.964
	0.110	106	53	2.952	1	0	568	284	2.955
	0.120	102	51	2.942	1	0	543	272	2.945
	0.130	98	49	2.942	1	0	522	261	2.945
	0.140	94	47	2.932	1	0	498	249	2.935
	0.150	90	45	2.932	1	0	477	238	2.935
0.002	0.003	356	178	2.862	9	0	1814	907	2.863
	0.004	344	172	2.862	8	0	1753	876	2.863
	0.005	332	166	2.852	7	0	1682	841	2.853
	0.006	330	165	2.852	6	0	1672	836	2.853
	0.007	320	160	2.852	5	0	1622	811	2.853
	0.008	318	159	2.842	4	0	1602	801	2.843
	0.009	316	158	2.842	3	0	1592	796	2.843
	0.010	306	153	2.832	2	0	1533	767	2.833
	0.020	204	102	2.792	1	0	999	500	2.794
	0.04	140	70	2.762	1	0	674	337	2.764
	0.05	138	69	2.772	1	0	668	334	2.774
	0.06	136	68	2.752	1	0	651	326	2.754
	0.07	134	67	2.762	1	0	645	323	2.765
	0.08	130	65	2.762	1	0	626	313	2.765
	0.09	124	62	2.742	1	0	590	295	2.745
	0.1	118	59	2.752	1	0	565	282	2.755
	0.11	112	56	2.732	1	0	530	265	2.735
	0.04	140	70	2.762	1	0	674	337	2.764
	0.05	138	69	2.772	1	0	668	334	2.774

	0.12	108	54	2.742	1	0	514	257	2.745
	0.13	104	52	2.733	1	0	492	246	2.735
	0.14	100	50	2.723	1	0	471	235	2.725
	0.15	96	48	2.713	1	0	449	225	2.716
	0.004	352	176	2.733	9	0	1666	833	2.733
	0.005	340	170	2.733	8	0	1609	805	2.733
	0.006	338	169	2.723	7	0	1591	795	2.723
	0.007	328	164	2.723	6	0	1544	772	2.724
	0.008	326	163	2.713	5	0	1525	763	2.714
	0.009	324	162	2.683	4	0	1490	745	2.684
	0.01	314	157	2.693	3	0	1452	726	2.694
	0.02	212	106	2.673	2	0	969	485	2.674
	0.03	172	86	2.643	1	0	773	386	2.644
	0.04	148	74	2.643	1	0	665	332	2.645
0.003	0.05	146	73	2.653	1	0	660	330	2.655
	0.06	144	72	2.653	1	0	651	325	2.655
	0.070	142	71	2.633	1	0	634	317	2.635
	0.080	138	69	2.643	1	0	620	310	2.645
	0.090	132	66	2.623	1	0	586	293	2.625
	0.100	126	63	2.633	1	0	563	281	2.635
	0.110	120	60	2.613	1	0	530	265	2.615
	0.120	116	58	2.623	1	0	515	258	2.625
	0.130	112	56	2.603	1	0	491	246	2.606
	0.140	108	54	2.593	1	0	471	236	2.596
	0.150	104	52	2.603	1	0	456	228	2.606
	0.005	348	174	2.633	9	0	1554	777	2.634
	0.006	346	173	2.633	8	0	1545	773	2.634
	0.007	336	168	2.623	7	0	1492	746	2.624
	0.008	334	167	2.623	6	0	1483	742	2.624
	0.009	332	166	2.613	5	0	1466	733	2.614
	0.010	322	161	2.613	4	0	1421	711	2.614
	0.020	220	110	2.583	3	0	954	477	2.585
	0.030	180	90	2.563	2	0	771	386	2.565
	0.040	156	78	2.553	1	0	664	332	2.555
0.04	0.050	154	77	2.533	1	0	648	324	2.535
	0.060	152	76	2.533	1	0	640	320	2.535
	0.070	150	75	2.543	1	0	635	318	2.545
	0.080	146	73	2.523	1	0	611	305	2.525
	0.090	140	70	2.533	1	0	589	295	2.535
	0.100	134	67	2.533	1	0	564	282	2.536
	0.110	128	64	2.513	1	0	532	266	2.516
	0.120	124	62	2.523	1	0	519	259	2.526
	0.130	120	60	2.503	1	0	496	248	2.506
	0.140	116	58	2.513	1	0	482	241	2.516
	0.150	112	56	2.483	1	0	457	229	2.486
	0.006	358	179	2.553	9	0	1525	763	2.554
	0.007	348	174	2.553	8	0	1483	741	2.554
	0.008	346	173	2.554	7	0	1474	737	2.554
	0.009	344	172	2.544	6	0	1457	728	2.544
	0.010	334	167	2.544	5	0	1414	707	2.544
	0.020	232	116	2.514	4	0	965	482	2.515
	0.030	192	96	2.494	3	0	789	394	2.495
	0.040	168	84	2.474	2	0	682	341	2.475
	0.050	166	83	2.454	1	0	666	333	2.455
0.005	0.060	164	82	2.464	1	0	662	331	2.465
	0.070	162	81	2.464	1	0	654	327	2.465
	0.080	158	79	2.444	1	0	630	315	2.446
	0.090	152	76	2.454	1	0	610	305	2.456
	0.100	146	73	2.434	1	0	578	289	2.436
	0.110	140	70	2.434	1	0	555	277	2.436
	0.120	136	68	2.444	1	0	542	271	2.446
	0.130	132	66	2.414	1	0	517	258	2.416
	0.140	128	64	2.424	1	0	504	252	2.426
	0.150	124	62	2.394	1	0	479	240	2.396
	0.007	360	180	2.494	8	0	1479	740	2.495
	0.008	358	179	2.494	8	0	1471	736	2.495
0.006	0.009	356	178	2.494	7	0	1463	732	2.495
	0.010	346	173	2.494	6	0	1422	711	2.495
	0.020	244	122	2.474	5	0	991	495	2.475

	0.030	204	102	2.454	4	0	818	409	2.455
	0.040	180	90	2.454	3	0	722	361	2.456
	0.050	178	89	2.414	2	0	697	348	2.416
	0.060	176	88	2.394	1	0	680	340	2.396
	0.070	174	87	2.394	1	0	673	336	2.396
	0.080	170	85	2.404	1	0	661	331	2.406
	0.090	164	82	2.384	1	0	630	315	2.386
	0.100	158	79	2.414	1	0	618	309	2.416
	0.110	152	76	2.394	1	0	588	294	2.396
	0.120	148	74	2.394	1	0	572	286	2.396
	0.130	144	72	2.374	1	0	550	275	2.376
	0.008	370	185	2.444	8	0	1475	738	2.445
	0.009	368	184	2.434	7	0	1458	729	2.435
	0.010	358	179	2.434	6	0	1419	709	2.435
	0.020	256	128	2.414	5	0	1002	501	2.415
	0.030	216	108	2.404	4	0	840	420	2.406
	0.040	192	96	2.364	3	0	729	364	2.366
	0.050	190	95	2.364	2	0	721	361	2.366
	0.060	188	94	2.344	1	0	705	352	2.346
0.007	0.070	186	93	2.324	1	0	688	344	2.326
	0.080	182	91	2.324	1	0	674	337	2.326
	0.090	176	88	2.334	1	0	655	328	2.336
	0.100	170	85	2.314	1	0	625	313	2.316
	0.110	164	82	2.324	1	0	607	303	2.326
	0.120	160	80	2.304	1	0	585	292	2.306
	0.130	156	78	2.294	1	0	567	283	2.296
	0.140	152	76	2.304	1	0	556	278	2.306
	0.150	148	74	2.324	1	0	548	274	2.327
	0.010	370	185	2.375	9	0	1413	707	2.375
	0.020	268	134	2.375	8	0	1024	512	2.376
	0.030	228	114	2.365	7	0	865	433	2.366
	0.040	204	102	2.334	6	0	760	380	2.336
	0.050	202	101	2.325	5	0	748	374	2.326
	0.060	200	100	2.315	4	0	736	368	2.316
	0.070	198	99	2.305	3	0	724	362	2.306
0.008	0.080	194	97	2.310	2	0	711	356	2.311
	0.090	188	94	2.264	1	0	670	335	2.266
	0.100	182	91	2.254	1	0	645	322	2.256
	0.110	176	88	2.244	1	0	619	310	2.246
	0.120	172	86	2.234	1	0	601	301	2.236
	0.130	168	84	2.245	1	0	591	296	2.246
	0.140	164	82	2.214	1	0	566	283	2.216
	0.150	160	80	2.204	1	0	549	274	2.207
	0.020	276	138	2.325	8	0	1022	511	2.326
	0.030	236	118	2.315	7	0	868	434	2.316
	0.040	212	106	2.305	6	0	775	388	2.306
	0.050	210	105	2.305	5	0	768	384	2.306
	0.060	208	104	2.285	4	0	751	375	2.286
	0.070	206	103	2.300	3	0	751	375	2.301
0.009	0.080	202	101	2.265	2	0	720	360	2.266
	0.090	196	98	2.205	1	0	672	336	2.206
	0.100	190	95	2.195	1	0	648	324	2.196
	0.110	184	92	2.185	1	0	623	312	2.186
	0.120	180	90	2.205	1	0	617	309	2.207
	0.130	176	88	2.195	1	0	600	300	2.197
	0.140	172	86	2.185	1	0	582	291	2.187
	0.150	168	84	2.175	1	0	565	283	2.177
	0.020	286	143	2.285	9	0	1033	516	2.286
	0.030	246	123	2.275	8	0	883	441	2.276
	0.040	222	111	2.275	7	0	797	398	2.276
	0.050	220	110	2.265	6	0	784	392	2.266
	0.060	218	109	2.235	5	0	762	381	2.236
0.010	0.070	216	108	2.235	4	0	755	378	2.236
	0.080	212	106	2.225	3	0	737	368	2.227
	0.090	206	103	2.205	2	0	707	353	2.207
	0.100	200	100	2.145	1	0	660	330	2.146
	0.110	194	97	2.155	1	0	644	322	2.157
	0.120	190	95	2.145	1	0	627	314	2.147
	0.130	186	93	2.105	1	0	598	299	2.107

	0.140	182	91	2.095	1	0	581	291	2.097
	0.150	178	89	2.085	1	0	565	282	2.087
0.020	0.030	254	127	1.995	9	0	759	380	1.996
	0.040	230	115	1.995	8	0	688	344	1.996
	0.050	228	114	1.985	7	0	677	339	1.986
	0.060	226	113	1.975	6	0	667	333	1.976
	0.070	224	112	1.955	5	0	652	326	1.956
	0.080	220	110	1.524	4	0	475	238	1.525
	0.090	214	107	1.925	3	0	610	305	1.926
	0.100	208	104	1.925	2	0	593	297	1.926
	0.110	202	101	1.875	1	0	557	278	1.876
	0.120	198	99	1.844	1	0	535	267	1.846
	0.130	194	97	1.865	1	0	531	266	1.866
	0.140	190	95	1.834	1	0	510	255	1.836
	0.150	186	93	1.855	1	0	506	253	1.856
0.030	0.040	240	120	1.824	9	0	639	320	1.826
	0.050	238	119	1.814	8	0	630	315	1.816
	0.060	236	118	1.814	7	0	624	312	1.816
	0.070	234	117	1.794	6	0	611	305	1.796
	0.080	230	115	1.514	0	0	494	247	1.515
	0.090	224	112	1.464	4	0	464	232	1.465
	0.100	218	109	1.404	3	0	433	216	1.405
	0.110	212	106	1.383	2	0	415	207	1.385
	0.120	208	104	1.343	1	0	396	198	1.345
	0.130	204	102	1.694	1	0	497	248	1.696
	0.140	200	100	1.283	1	0	365	182	1.285
	0.150	196	98	1.855	1	0	533	267	1.857
0.040	0.050	248	124	1.714	7	0	612	306	1.716
	0.060	246	123	1.684	8	0	595	297	1.686
	0.070	244	122	1.674	7	0	586	293	1.676
	0.080	240	120	1.664	6	0	572	286	1.666
	0.090	234	117	1.654	5	0	554	277	1.656
	0.100	228	114	1.599	5	0	520	260	1.601
	0.110	222	111	1.354	3	0	425	213	1.355
	0.120	218	109	1.614	2	0	502	251	1.616
	0.130	214	È07	1.584	1	0	483	241	1.586
	0.140	210	105	1.574	1	0	470	235	1.576
	0.150	206	103	1.564	1	0	458	229	1.566
0.050	0.060	260	130	1.614	8	0	599	299	1.616
	0.070	258	129	1.564	8	0	574	287	1.566
	0.080	254	127	1.584	7	0	573	286	1.586
	0.090	248	124	1.584	6	0	559	280	1.586
	0.100	242	121	1.554	5	0	534	267	1.556
	0.110	236	118	1.544	4	0	517	259	1.546
	0.120	232	116	1.845	1	0	627	313	1.847
	0.130	228	114	1.865	1	0	625	312	1.867
	0.140	224	112	1.835	1	0	601	301	1.837
	0.150	220	110	1.855	1	0	599	299	1.857
0.060	0.070	272	136	1.524	8	0	588	294	1.526
	0.080	268	134	1.504	7	0	571	286	1.506
	0.090	262	131	1.494	7	0	554	277	1.496
	0.100	256	128	1.474	6	0	534	267	1.476
	0.110	250	125	1.324	5	0	469	235	1.325
	0.120	246	123	1.454	4	0	506	253	1.456
	0.130	242	121	1.254	3	0	432	216	1.255
	0.140	238	119	1.434	2	0	483	241	1.436
	0.150	234	117	1.404	1	0	465	232	1.406
0.070	0.080	284	142	1.444	8	0	580	290	1.445
	0.090	278	139	1.434	7	0	564	282	1.435
	0.100	272	136	1.424	7	0	548	274	1.425
	0.110	266	133	1.424	6	0	536	268	1.425
	0.120	262	131	1.254	5	0	468	234	1.255
	0.130	258	129	1.394	4	0	509	254	1.395
	0.140	254	127	1.384	3	0	497	249	1.385
	0.150	250	125	1.364	2	0	483	241	1.365
0.080	0.090	294	147	1.384	9	0	576	288	1.385
	0.100	288	144	1.384	8	0	564	282	1.385
	0.110	282	141	1.374	7	0	548	274	1.375
	0.120	278	139	1.374	6	0	540	270	1.375

	0.130	274	137	1.364	5	0	529	264	1.365
	0.140	270	135	1.364	4	0	521	261	1.365
	0.150	266	133	1.354	3	0	510	255	1.355
0.090	0.100	304	152	1.324	9	0	570	285	1.325
	0.110	298	149	1.324	8	0	559	280	1.325
	0.120	294	147	1.324	7	0	552	276	1.325
	0.130	290	145	1.314	6	0	540	270	1.315
	0.140	286	143	1.314	5	0	533	266	1.315
	0.150	282	141	1.304	4	0	522	261	1.305

Conclusion

This paper provides a procedure for tightened the sample size of Quick Switching Variable Sampling System involving minimum sum of risk for specified Acceptable Quality Level and Limiting Quality Level without fixing the producer's and consumer's risk. The concept of this paper may used for assistance to quality control engineers and plan designers in the further plan development, which were useful and tailor made for industrial shop-floor situations.

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