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Design and Construction of Six Sigma Tightened–Normal–Tightened Variables Sampling Scheme Indexed by Six Sigma Quality Levels

Dr.D.Senthilkumar[1], B.Esha Raffie[2]
Department of Statistics, PSG College of Arts & Science, Coimbatore – 641 014.

Abstract: Motorola developed the Six Sigma methodology in the mid-1980s as a result of recognizing that products with high first-pass yield rarely failed in use. Six Sigma aims to deliver quality products to the customers. It also intends to reduce output variation by predicting process results. Processes here would be measure, analyze, improve and control, Variation here means how much has the output deviated from the actual. This article proposes Six Sigma Tightened – Normal – Tightened Variables Sampling Schemes (SSTNTVSS (n_T, n_N; k)) where the quality characteristic follows a normal distribution. Tables are constructed for the selection of parameters of known standard deviation Six Sigma Tightened – Normal – Tightened Variables Sampling Schemes for a given Six Sigma acceptable quality level (SSAQL) and Six Sigma limiting quality level (SSLQL).
Keyword: Variables Sampling Scheme, Six Sigma Tightened – Normal – Tightened Switching Rules, Six Sigma Acceptable Quality Level, Six Sigma Limiting Quality Level, Operating characteristics curve (OC) and Normal distribution.

I. INTRODUCTION

The tightened- normal-tightened (TNT) sampling scheme was devised by Calvin (1977). This scheme utilizes two c = 0 single-sampling plans of different sample size, together with switching rules, to build up the shoulder of the operating characteristic (OC) curve. Assuming c to take values other than zero, the TNT scheme can be designated as TNT-(n_T, n_N; c), which refers to a TNT scheme where the normal and tightened single-sampling plans have the same acceptance number c but, on tightened inspection, the sample size is n_T and, on normal inspection, the sample size is n_N ($< n_T$). Another way of defining the TNT scheme is to say that the normal and tightened plans utilize the sample size n but with different acceptance numbers. This type of TNT scheme can be designated as TNT-(n ; c_T, c_N), which refers to a TNT scheme where the normal single-sampling plan has a sample of size n but different acceptance numbers, say c_N , and c_T ($< c_N$) respectively. Suresh and Balamurali (1994) have designed another type of TNT (n;0,1), which involves switching between two sampling plans with a fixed sample size n and two smallest acceptance numbers namely 0 and 1. Vijayaraghavan and Soundararajan (1996) have investigated the performance of two plan system designated as TNT-(n; c_1, c_2) scheme. Muthuraj and Senthilkumar (2006) have introduced the method of designing and construction of the Tightened – Normal – Tightened Variables Sampling Scheme of type TNTVSS (n; k_T, k_N) and indicated the method of designing the sampling scheme based on the given (AQL, LQL). An additional TNT scheme designated as Tightened – Normal – Tightened variables sampling scheme (n_1,n_2;k) is introduced by Senthilkumar and Muthuraj (2010), which involves switching between two variables sampling plans with different sample sizes together with acceptance criteria. Radhakrishnan and Sivakumaran(2010) have introduced the Procedure for the Construction of TNT Schemes of type(n_1, n_2:c) indexed by Six Sigma Quality Levels with attributes sampling plan as a reference plan. This article proposes Six Sigma Tightened – Normal – Tightened with Variables Sampling Plan as a reference plan, designated as SSTNTVS (n, k_T, k_N) where the quality characteristic follows a normal distribution and has an upper or a lower specification limit. The SSTNTVS inspection scheme will be useful when testing is costly and destructive. Tables are also constructed for the selection of parameter of known and unknown standard deviation. Six Sigma Tightened – Normal – Tightened Variables Sampling Schemes for a given Six Sigma acceptable quality level (SSAQL) with the producer's risk $\alpha^*=3.4\times10^{-6}$ and Six Sigma limiting quality level (SSLQL) with the consumer's risk $\beta^{*\,*} \geq c\alpha^*$, where c=2.

A. Six Sigma TNT Variables Sampling Scheme of type SSTNTVSS (n_T, n_N; k)

The Conditions and the assumptions under which the TNT schemes can be applied are as follows:

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B. Conditions for application

i) Production is steady so that results on current, preceding and succeeding lots are broadly indicative of a continuing process.
ii) Lots are submitted substantially in the order of production.
iii) Inspection is by variables, with quality of an individual item defined in terms of fraction defective.
iv) Six Sigma is to eliminate waste and inefficiency, thereby increasing customer satisfaction by delivering what the customer is expecting.
v) Six Sigma is a highly disciplined process that helps us focus on developing and delivering near-perfect products and services

C. Basic assumptions

a) The quality characteristics is represented by a random variable X measurable on a continuous scale
b) Distribution of X is normal with mean μ and standard deviation σ.
c) 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].
d) 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

$$p = 1 - F(v) = F(-v) \quad \text{with } v = (U-\mu)/\sigma \quad \text{and} \quad F(y) = \int_{-\infty}^{y} \frac{1}{\sqrt{2\pi}} e^{-z^2/2}\, dz \qquad (1)$$

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 $\bar{x}+k\sigma \le U$, where U is the upper specification limit or $\bar{x}+k\sigma \ge L$, where L is the lower specification limit. The operating procedure of SSTNTVSS (n_T, n_N; k) is described below.

III. OPERATING PROCEDURE

The steps involved in this procedure is as follows

Step 1: Inspect under tightened inspection using the single sampling plan with sample size $n_{T\sigma}$ and the acceptance constant k. Accept the individual lot if $\bar{x}_T + k\sigma \le U$ or $\bar{x}_T - k\sigma \ge L$ where $\bar{X}$ is the sample mean. If t lots in a row are accepted, switch to normal inspection (Step 2).

Step 2: Inspect under normal inspection using the single sampling plan with sample size $n_{N\sigma}$ and the acceptance constant k. Reject the individual lot if $\bar{x}_N + k\sigma \le U$ or $\bar{x}_N - k\sigma \ge L$ where $\bar{X}$ is the sample mean. When an additional lot is rejected in the next s lots after a rejection, switch to tightened inspection.

Thus, a TNTVSS is specified by the parameters n_T, n_N, k, s and t, where n_T and n_N are the sample sizes of the variables sampling plans under tightened and normal inspection respectively, t and s are the switching factors. As the tightened plan sample size n_T is greater than the normal plan sample size n_N, for designing the TNT scheme, n_T is fixed as a multiple of n_N, i.e. $n_T = mn_N$, where m ranging from 1.25 to 2. Thus, the TNT scheme can also be designated as TNTVSS (mn_N, n_N; k_σ).

When s=4 and t=5, the OC function of the TNTVSS becomes the OC function of MIL – STD – 105D, involving only tightened and normal inspection and are derived by Dodge (1965), Hald and Thyregod (1965) and Stephen and Larson (1967).

A. Operating Characteristic Function

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According to Calvin (1977), the OC function of the TNT scheme is given by

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

where P_T and P_N are the proportion of lots expected to be accepted using tightened (n_σ, k_T) and normal (n_σ, k_N) variables single sampling plans respectively. Under the assumption of normal distribution, the expression for P_T and P_N are given by

$$P_T = \Pr\left[(U - \overline{X})/\sigma \geq k_T\right] \qquad (3)$$

and $P_N = P\left[(U - \overline{X})/\sigma \geq k_N\right]$ (4) respectively. Equations (3) and (4) are substituted in (2) to find $P_a(p)$ values for given p, s, t, n_T, n_N, and k. As the individual values of X follows normal distribution with mean μ and variance σ^2, the expressions given in (3) and (4) can be restated as $P_T = \int_{-\infty}^{w_T} \frac{1}{\sqrt{2\pi}} e^{(-z^2/2)}\, dz$ and $P_N = \int_{-\infty}^{w_N} \frac{1}{\sqrt{2\pi}} e^{(-z^2/2)}\, dz$

respectively, with

$$w_T = \sqrt{n_\sigma}\,(U - k_T\sigma - \mu)/\sigma = (v - k_T)\sqrt{n_\sigma} \quad w_N = \sqrt{n_\sigma}\,(U - k_N\sigma - \mu)/\sigma = (v - k_N)\sqrt{n_\sigma}$$

and $\nu = (U - \mu)/\sigma$

To determine the values of n_T, n_N, and k the given values of p_1, p_2, α* and β*should satisfy the following two equations. If $P_a(p_1)$ and $P_a(p_2)$ are fixed at 99.99966% and more than 0.00068% respectively. That is,

$$P_a(p_1) = \frac{P_{T1}(1-P_{N1}^s)(1-P_{T1}^t)(1-P_{N1}) + P_{N1}P_{T1}^t(1-P_{T1})(2-P_{N1}^s)}{(1-P_{N1}^s)(1-P_{T1}^t)(1-P_{N1}) + P_{T1}^t(1-P_{T1})(2-P_{N1}^s)} = 1-\alpha^* \quad (5)$$

$$P_a(p_2) = \frac{P_{T2}(1-P_{N2}^s)(1-P_{T2}^t)(1-P_{N2}) + P_{N2}P_{T2}^t(1-P_{T2})(2-P_{N2}^s)}{(1-P_{N2}^s)(1-P_{T2}^t)(1-P_{N2}) + P_{T2}^t(1-P_{T2})(2-P_{N2}^s)} = \beta^* \quad (6)$$

For given SSAQL and SSLQL, the parametric values of SSTNTVSS namely k and the sample sizes n_T and n_N are determined by using a computer search

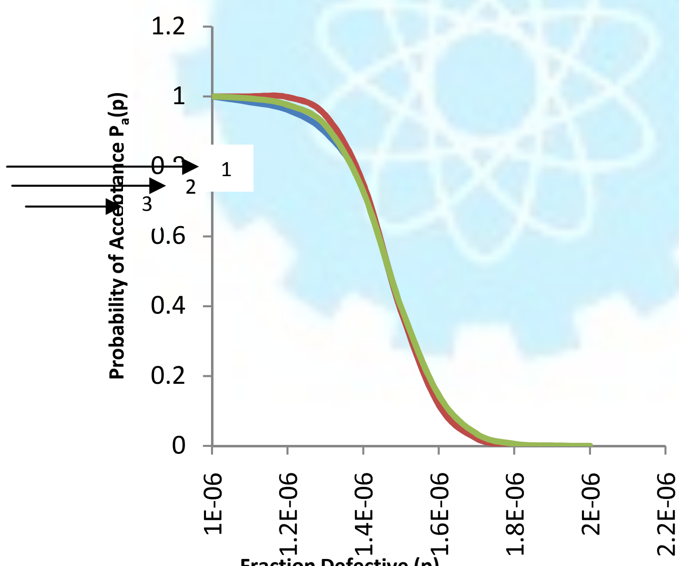

Figure 1. OC curves of single sampling variables (tightened), TNTVSS and single sampling variables (normal). (1), SSP (tightened) n_T =4621, k =4.675; (2), TNTVSS n_T =4621, n_N =3697, k =4.675; (3), SSP (normal) n_N =3697, k =4.675, these are associated with sigma level is 4.5.

B. Behavior of OC curves of SSTNTVS-(n_T, n_N; k) schemes

Figure 1 show the OC curves of six sigma tightened and normal inspection plans, and the composite OC curve of the SSTNTVS (n_T, n_N; k) scheme. Figure 1 assumes n_T =4621, n_N=3697, k =4.675 from this figure, it can be observed that, for good quality, i.e. for

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smaller value of the fraction defective, the OC curve of the SSTNTVS(n_T, n_N; k) scheme coincides with the OC curve of the normal plan. As quality deteriorates, the scheme OC curve moves towards that for tightened inspection.

Figures 2 show the OC curves of tightened and normal inspection plans, and Sigma level of the SSTNTVS(n ; k_T, k_N) scheme. Figure 2 n_T = 1146, n_N=764, k=4.589, 4.0 sigma level and n_T = 4589, n_N=3059, k=4.669, 4.5 sigma level From these OC curves, it can be observed that, the plan OC curves at a good quality, i.e., for very smaller values of fraction defective with more sigma level

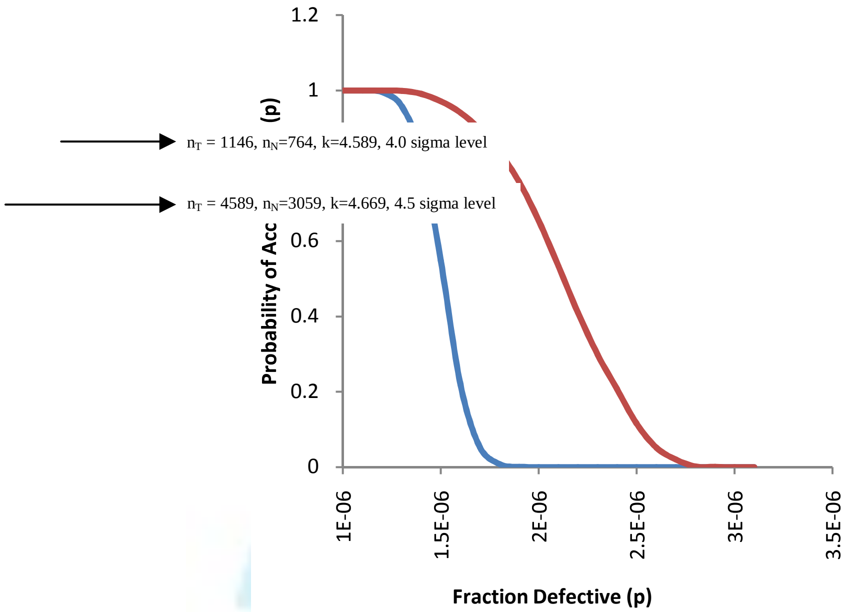

Figure 2: SSTNTVSS OC Curve for the scheme TNTVSS n_T =4589, n_N =3059, k =4.669, 4.5Sigma level and TNTVSS n_T =1146, n_N =764, k =4.589, 4.0 Sigma level

C. SSTNTVSS with unknown σ variables plan as the reference plan

If the population standard deviation σ is unknown, it is estimated from the sample standard deviation S (n-1 in the division). If the sample size of the unknown sigma variables scheme (S – method) is n_{Ts} under tightened inspection and n_{Ns} under normal inspection and the acceptance constant is k, then the operating procedure is as follows:

Step 1: Inspect under tightened inspection using the single sampling plan with sample size n_{Ts} and the acceptance constant k. Accept the individual lots if $\overline{X}_T + k\,S \le U$ or $\overline{X}_T - k\,S \ge L$ where $\overline{X}$ is a sample mean. If t lots in a row are accepted, switch to normal inspection (Step 2).

Step 2: Inspect under normal inspection using the single sampling plan with sample size n_{Ns} and the acceptance constant k_N. Reject the individual lot if $\overline{X}_N + k\,S > U$ or $\overline{X}_N - k\,S < L$ where $\overline{X}$ is a sample mean. When an additional lot is rejected in the next s lots after a rejection, switch to tightened inspection.

Here $\overline{X}$ and S are the average and the standard deviation of quality characteristic respectively from the sample. Under the assumptions for SSTNTVSS stated, the probability of acceptance $P_a(p)$ of a lot is given in the equation (2) and P_T and P_N respectively ar $P_T = \int_{-\infty}^{w_T} \frac{1}{\sqrt{2\pi}} e^{-z^2/2}\,dz$ and $P_N = \int_{-\infty}^{w_N} \frac{1}{\sqrt{2\pi}} e^{-z^2/2}\,dz$

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

and $$w_T = \frac{U - k_T S - \mu}{s} \frac{1}{\sqrt{\left(\frac{1}{n_s} + \frac{k_T^2}{2n_s}\right)}}$$

The values of n_S, k_{NS}, and k_{Ts} for given p_1, p_2, α^* and β^* can be determined and should satisfy the following equations

$$P_a(p_1) = \frac{P_{T1}(1-P_{N1}^S)(1-P_{T1}^t)(1-P_{N1}) + P_{N1}P_{T1}^t(1-P_{T1})(2-P_{N1}^S)}{(1-P_{N1}^S)(1-P_{T1}^t)(1-P_{N1}) + P_{T1}^t(1-P_{T1})(2-P_{N1}^S)} = 1-\alpha^* \quad (7)$$

$$P_a(p_2) = \frac{P_{T2}(1-P_{N2}^S)(1-P_{T2}^t)(1-P_{N2}) + P_{N2}P_{T2}^t(1-P_{T2})(2-P_{N2}^S)}{(1-P_{N2}^S)(1-P_{T2}^t)(1-P_{N2}) + P_{T2}^t(1-P_{T2})(2-P_{N2}^S)} = \beta^* \quad (8)$$

D. Designing SSTNTVSS ($n_{N\sigma}$, $n_{T\sigma}$; k_σ) with known σ for given SSAQL and SSLQL

Table 1 can be used to determine SSTNTVSS ($n_{N\sigma}$, $n_{T\sigma}$; k_σ) for specified values of SSAQL and SSLQL. For example, if it is desired to have a SSTNTVSS ($n_{N\sigma}$, $n_{T\sigma}$; k_σ) for given SSAQL = 0.000005 and SSLQL = 0.000006, and m=1.25, $\alpha^*= 3.4\mathrm{x}10^{-6}$, $\beta^* \geq 2\alpha^*$. Table 1 gives $n_{N\sigma}$ = 15528, and k_σ = 4.416 as desired scheme parameters, which is associated with 4.9 sigma level. The sample size is $n_{T\sigma}$ = m $n_{N\sigma}$ =(1.25) (15528) = 19410. Thus, for given requirement of SSTNTVSS ($n_{T\sigma,}$ $n_{N\sigma}$; k_σ) is specified by the parameters $n_{T\sigma}$ = 19410, $n_{N\sigma}$ = 15528 and k_σ = 4.416.

E. Explanation

The ball point pen manufacturing company, if the manufacturer of ball point pen fixes the quality (height and width of ball point pen) of ball point pen as SSAQL = 0.000005 (5 ball point pen non conforming out of 1 million items), then inspect under tightened inspection with sample of size 19410 ball point pens and acceptance constant k_σ = 4.416 from the manufactured lot of a particular month. If 5 (t) lots in a row are accepted under tightened inspection, then switch to normal inspection. Again inspect under normal inspection with a sample of 15528 ball point pens and acceptance number k_σ = 4.416 from the manufactured lot of a particular month. Switch to tightened inspection, if an additional lot is rejected in the next 4 lots and inform the management for corrective action.

F. Designing SSTNTVSS($n_{Ts,}$ n_{Ns}; k_s) with unknown σ for given SSAQL and SSLQL

Table 1 can be used to determine SSTNTVSS($n_{Ts,}$ n_{Ns}; k_s) for specified values of SSAQL and SSLQL. For example, if it is desired to have a SSTNTVSS ($n_{Ts,}$ n_{Ns}; k_s) for given SSAQL = 0.00001 and SSLQL = 0.00007, and m=1.25, $\alpha^*= 3.4\mathrm{x}10^{-6}$, $\beta^* \geq 2\alpha^*$. Table 1 gives n_{Ns}= 3262, and k = 4.009 as desired scheme parameters, which is associated with 4.5 sigma level. The sample size is n_{Ts} = m n_{Ns} =(1.25) (3262) = 4078. Thus, for given requirement of SSTNTVSS($n_{Ts,}$ n_{Ns}; k_s) is specified by the parameters n_{Ts} = 4078, n_{Ns} = 3262 and k = 4.009.

G. Explanation

In a shoe manufacturing company, if the manufacturer of shoe fixes the quality (height, length, size and etc) of shoe as SSAQL = 0.00001 (1 shoe non-conforming out of 10 thousand items), then inspect under tightened inspection with sample of size 4078 shoes and acceptance constant k = 4.009 from the manufactured lot of a particular month. If 5 (t) lots in a row are accepted under tightened inspection, then switch to normal inspection. Again inspect under normal inspection with a sample of 3262 shoes and acceptance number k = 4.009 from the manufactured lot of a particular month. Switch to tightened inspection, if an additional lot is rejected in the next 4 lots and inform the management for corrective action.

1) Construction of Table 1, 2 and 3

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

$$P_a(p_1)=\frac{P_{T1}(1-P_{N1}^{s})(1-P_{T1}^{t})(1-P_{N1})+P_{N1}P_{T1}^{t}(1-P_{T1})(2-P_{N1}^{s})}{(1-P_{N1}^{s})(1-P_{T1}^{t})(1-P_{N1})+P_{T1}^{t}(1-P_{T1})(2-P_{N1}^{s})}=1-\alpha^* \quad (9)$$

$$P_a(p_2)=\frac{P_{T2}(1-P_{N2}^{s})(1-P_{T2}^{t})(1-P_{N2})+P_{N2}P_{T2}^{t}(1-P_{T2})(2-P_{N2}^{s})}{(1-P_{N2}^{s})(1-P_{T2}^{t})(1-P_{N2})+P_{T2}^{t}(1-P_{T2})(2-P_{N2}^{s})}=\beta^* \quad (10)$$

where

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

Using iterative procedure equations, (9.9) and (9.10) are solved forgiven values of p_1, p_2, m, α* and β* to get the values of $n_{N\sigma}$ and k_σ for specified pair of points, say (p_1, α*) and (p_2, β*) on the OC curve. Here, the values of m ranging from 1.25 to 2 are considered to get the desired parameters. The values of $n_{T\sigma,}$ $n_{N\sigma}$ and k_σ are constructed. The sample size $n_{T\sigma}$ equals $mn_{N\sigma}$ and n_{Ts} equals mn_{Ns}, and hence only $n_{N\sigma}$ and n_{Ns} are tabulated.

A procedure for finding the parameters of unknown σ - method plan from known σ-method plan with parameters($n_{S,}$ $k_{TS,}$ k_{Ns}), where desired using Hamaker (1979) approximation as follows

$$n_{Ns} = n_{N\sigma}(1+k_\sigma^2/2), \quad (11)$$

and $$k_s = k_\sigma(4n_{Ns} - 4)/(4n_{Ns} - 5) \quad (12)$$

Table 1, 2 and 3 provided the values of n_σ, $k_{T\sigma}$, $k_{N\sigma}$, $n_{s,}$ k_{Ts} and k_{Ns} which satisfying the equations (9) and (10). The sigma level values are calculated using the process sigma calculator (http://www.isixsigma.com/) for given n_T, n_N and k for known Standard deviation methods.

IV. CONCLUSION

The TNT sampling scheme designated as SSTNTVSS-(n_T, n_N; k) refers to a scheme where the single-sampling tightened plan has the parameters (n_T, k), and the normal plan has the parameters (n_N, k) with $n_T > n_N$. The use of SSTNTVS scheme results in savings in the companies reduce costs related to scrap, rework, inspection, and customer dissatisfaction, when compared with single-sampling plan. These schemes are suitable when we have a without break stream of batches or lots, where quality shifts slowly and when the submitted lots are expected to be of in essence the same quality.

REFERENCES

[1] Calvin, T. W. (1977): TNT Zero Acceptance Number Sampling. American Society for Quality Control Annual Technical Conference Transactions, Philadelphia, PA, 35-39.
[2] Dodge, H. F. (1965): Evaluation of a Sampling System Having Rules for Switching Between Normal and Tightened Inspection. Technical Report No.14, Statistics Center, Rutgers University, Piscataway, NJ.
[3] Hald, A. and Thyregod, P. (1965): The Composite Operating Characteristics Under Normal and Tightened sampling Inspection by Attributes. Bulletin of the International Statistical Institute 41,517-519.
[4] Hamakar, H. C. (1979): Acceptance Sampling for Percent Defective and by Attributes, Journal of Quality Technology. Vol. 11, pp. 517-529.
[5] MIL-STD 105D (1963): Sampling Procedure and Tables for Inspection by Attributes. US Government Printing Office, Washington, DC.
[6] Muthuraj, D. and Senthilkumar , D. (2006): Designing and Construction of Tightened-Normal-Tightened Variables Sampling Scheme, Journal of Applied Statistics, vol. 33, issue 1, pp 101-111.
[7] Radhakrishnan. R. and Sivakumaran P.K.(2010): Construction and Selection of Tightened-Normal-Tightened Schemes of Type TNT-(n1, n2; c) indexed through Six Sigma Quality Levels .Proceedings of the 2010 International Conference on Industrial Engineering and Operations Management. Dhaka, Bangladesh, January 9 – 10,
[8] Senthilkumar, D. and Muthuraj, D. (2010): Construction and Selection of Tightened–Normal–Tightened Variables Sampling Scheme of type TNTVSS (n_1, n_2; k), Journal of Applied Statistics, vol. 37, issue 3, pages 375-390.
[9] Stephens, K. S and Larson, K. E. (1967): An Evaluation of the MIL-STD-105D System of Sampling Plans, Industrial Quality Control. Vol.23, pp. 310-319.
[10] Suresh, K. K and Balamurali, S. (1994): Construction and Selection of Tightened – Normal – Tightened plans indexed by maximum allowable percentage defective. Journal of Applied Statistic. Vol.21, issue 6. pp 589-595
[11] Wadsworth, M. H., Stephens, S. K., and Godfrey, A. B. (1986): Modern methods for quality control and improvement. New York, Wiley.
[12] Process Sigma Calculation: http://www.isixsigma.com/

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Table 1: SSTNTVSS(n_T, $n_{N;}$ k, σ – level) with known and unknown σ indexed by SSAQL and SSLQL (α=3.4 x 10^{-6} and $\beta \geq 2\alpha$). ($n_{T\sigma}=mn_{N\sigma}$, where m = 1.25)

SSAQL	SSLQL	$n_{T\sigma}$	$n_{N\sigma}$	k_σ	σ - Level	n_{Ts}	n_{Ns}	k_s	σ - Level
0.000001	0.000002	4621	3697	4.675	4.5	55121	44097	4.675	5.2
	0.000003	1793	1434	4.625	4.2	20964	16771	4.625	5.0
	0.000004	1120	896	4.595	4.1	12944	10355	4.595	4.8
	0.000005	830	664	4.565	4.0	9478	7583	4.565	4.7
	0.000006	670	536	4.545	3.9	7590	6072	4.545	4.7
	0.000007	565	452	4.525	3.8	6349	5079	4.525	4.6
	0.000008	493	394	4.509	3.8	5499	4399	4.509	4.6
	0.000009	441	353	4.495	3.7	4899	3919	4.495	4.5
	0.00001	330	264	4.454	3.6	3603	2883	4.454	4.5
	0.00002	228	182	4.395	3.5	2425	1940	4.396	4.3
	0.00003	164	131	4.329	3.3	1698	1358	4.330	4.2
	0.00004	145	116	4.305	3.3	1489	1191	4.306	4.2
	0.00005	128	102	4.275	3.2	1293	1034	4.276	4.1
	0.00006	115	92	4.249	3.2	1153	922	4.250	4.1
	0.00007	106	85	4.229	3.1	1056	845	4.230	4.1
	0.00008	99	79	4.209	3.1	973	779	4.210	4.0
	0.00009	93	74	4.195	3.1	906	725	4.196	4.0
	0.0001	88	70	4.174	3.1	850	680	4.176	4.0
	0.0002	64	51	4.750	2.8	783	626	4.752	3.9
	0.0003	54	43	4.015	2.8	487	390	4.018	3.8
	0.0004	48	38	3.969	2.8	422	337	3.972	3.8
	0.0005	44	35	3.935	2.7	382	306	3.938	3.7
	0.0006	41	33	3.909	2.7	356	285	3.912	3.7
	0.0007	36	29	3.859	2.6	306	245	3.863	3.7
	0.0008	31	25	3.785	2.5	255	204	3.790	3.6
	0.0009	25	20	3.739	2.4	200	160	3.745	3.5
0.000005	0.000006	19410	15528	4.416	4.9	208668	166934	4.416	5.5
	0.000007	16640	13312	4.375	4.9	175890	140712	4.375	5.5
	0.000008	8950	7160	4.359	4.7	93979	75183	4.359	5.4
	0.000009	5630	4504	4.345	4.6	58774	47020	4.345	5.2
	0.00001	3880	3104	4.329	4.5	40236	32189	4.329	5.1
	0.00002	993	794	4.245	4.1	9935	7948	4.245	4.8
0.000005	0.00003	571	457	4.195	3.9	5598	4478	4.195	4.6
	0.00004	425	340	4.155	3.8	4094	3275	4.155	4.5
	0.00005	343	274	4.125	3.7	3256	2605	4.125	4.5
	0.00006	291	233	4.099	3.6	2738	2190	4.099	4.4
	0.00007	225	204	4.079	3.6	2097	1901	4.080	4.4
	0.00008	230	184	4.059	3.5	2125	1700	4.060	4.3
	0.00009	210	184	4.059	3.5	1940	1700	4.060	4.3
	0.0001	195	156	4.029	3.4	1778	1422	4.030	4.3
	0.0002	124	99	3.929	3.3	1079	863	3.930	4.1
	0.0003	98	78	3.869	3.1	827	662	3.870	4.0
	0.0004	84	67	3.825	3.1	696	557	3.827	4.0
	0.0005	74	59	3.789	3.0	603	483	3.791	3.9

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Table 1(continued…)

SSAQL	SSLQL	$n_{T\sigma}$	$n_{N\sigma}$	k_σ	σ - Level	n_{Ts}	n_{Ns}	k_s	σ - Level
0.00001	0.00002	3595	2876	4.175	4.5	34927	27941	4.175	5.1
	0.00003	1498	1198	4.125	4.2	14238	11390	4.125	4.9
0.00005	0.00006	9869	7895	4.005	4.8	89016	71213	4.005	5.4
	0.00007	8234	6587	3.925	4.7	71657	57325	3.925	5.3
	0.00008	6946	5557	3.825	4.7	57760	46208	3.825	5.3
	0.00009	4554	3643	3.809	4.6	37588	30070	3.809	5.2
	0.0001	3253	2602	3.795	4.5	26674	21339	3.795	5.1
0.0001	0.0002	2959	2367	3.619	4.5	22334	17867	3.619	5.0
	0.0003	1155	924	3.559	4.2	8470	6776	3.559	4.8
0.0005	0.0006	11571	9257	3.365	4.9	77083	61667	3.365	5.4
	0.0007	9696	7757	3.235	4.8	60433	48346	3.235	5.3
	0.0008	4563	3650	3.209	4.6	28054	22443	3.209	5.1
	0.0009	3251	2601	3.195	4.5	19846	15877	3.195	5.0

Table 2: SSTNTVSS(n, k, σ – level) with known and unknown σ indexed by SSAQL and SSLQL (α=3.4 x 10^{-6} and $\beta \geq 2\alpha$). ($n_{T\sigma}=mn_{N\sigma}$, where m = 1.5)

SSAQL	SSLQL	$n_{T\sigma}$	$n_{N\sigma}$	k_σ	σ - Level	n_{Ts}	n_{Ns}	k_s	σ - Level
0.000001	0.000002	4589	3059	4.669	4.5	54602	36401	4.669	5.2
	0.000003	1880	1253	4.625	4.2	21981	14654	4.625	4.9
	0.000004	1146	764	4.589	4.0	13213	8809	4.589	4.8
	0.000005	858	572	4.565	3.9	9798	6532	4.565	4.7
	0.000006	666	444	4.539	3.8	7527	5018	4.539	4.6
	0.000007	564	376	4.524	3.8	6336	4224	4.524	4.6
	0.000008	489	326	4.505	3.7	5451	3634	4.505	4.5
	0.000009	434	289	4.489	3.7	4801	3201	4.489	4.5
	0.00001	402	268	4.479	3.6	4434	2956	4.479	4.5
	0.00002	227	151	4.389	3.4	2408	1605	4.390	4.3
	0.00003	167	111	4.329	3.3	1727	1151	4.330	4.2
	0.00004	123	82	4.265	3.1	1242	828	4.266	4.1
	0.00005	110	73	4.215	3.1	1082	721	4.216	4.0
0.000005	0.000008	7638	5092	4.355	4.6	80069	53379	4.355	5.3
	0.000009	5648	3765	4.345	4.5	58957	39305	4.345	5.2
	0.00001	3879	2586	4.329	4.4	40226	26817	4.329	5.1
	0.00002	992	661	4.245	4.0	9925	6617	4.245	4.7
0.00001	0.00002	3624	2416	4.175	4.4	35208	23472	4.175	5.1
	0.00003	1499	999	4.125	4.1	14247	9498	4.125	4.8
	0.00004	858	572	4.079	4.0	7996	5331	4.079	4.7
0.00005	0.00008	6947	4631	3.825	4.6	57762	38508	3.825	5.2
	0.00009	4064	2709	3.805	4.5	33479	22319	3.805	5.1
	0.0001	3252	2168	3.795	4.4	26670	17780	3.795	5.0
0.00006	0.0002	1611	1074	3.639	4.2	12278	8185	3.639	4.8
	0.0003	771	514	3.579	4.0	5709	3806	3.579	4.6

Table 3: SSTNTVSS(n, k, σ – level) with known and unknown σ indexed by SSAQL and SSLQL (α=3.4 x 10^{-6} and $\beta \geq 2\alpha$). ($n_{T\sigma}=mn_{N\sigma}$, where m = 2)

SSAQL	SSLQL	$n_{T\sigma}$	$n_{N\sigma}$	k_σ	σ - Level	n_{Ts}	n_{Ns}	k_s	σ - Level
0.000001	0.000002	4918	2459	4.669	4.4	58523	29262	4.669	5.1
	0.000003	2386	1193	4.625	4.2	27905	13953	4.625	4.9
	0.000004	1516	758	4.589	4.0	17479	8739	4.589	4.8
0.000002	0.000003	7635	3818	4.559	4.5	86982	43491	4.559	5.2
	0.000004	4851	2426	4.529	4.4	54605	27302	4.529	5.1
	0.000005	3622	1811	4.499	4.3	40283	20141	4.499	5.0
	0.000006	2803	1402	4.479	4.2	30921	15461	4.479	4.9
	0.000007	2368	1184	4.459	4.2	25909	12955	4.459	4.9
	0.000008	2048	1024	4.429	4.1	22135	11067	4.429	4.9
	0.000009	1811	906	4.415	4.1	19463	9732	4.415	4.8
	0.00001	1677	838	4.329	4.1	17389	8694	4.329	4.8
0.000003	0.000004	10188	5094	4.489	4.6	112832	56416	4.489	5.3
	0.000005	7607	3804	4.459	4.5	83231	41616	4.459	5.2
	0.000006	3084	1542	4.434	4.3	33395	16698	4.434	5.0
	0.000007	2605	1302	4.425	4.2	28107	14053	4.425	4.9
	0.000008	2253	1126	4.405	4.2	24109	12055	4.405	4.9
	0.000009	1992	996	4.389	4.1	21182	10591	4.389	4.8
	0.00001	1844	922	4.389	4.1	19610	9805	4.389	4.8
0.000004	0.000006	7709	3854	4.409	4.6	82636	41318	4.409	5.2
	0.000007	6512	3256	4.395	4.5	69405	34702	4.395	5.2
	0.000008	2929	1464	4.375	4.2	30957	15478	4.375	4.9
	0.000009	2590	1295	4.365	4.2	27264	13632	4.365	4.9
	0.00001	2398	1199	4.345	4.2	25032	12516	4.345	4.9
	0.00002	1327	664	4.259	4.0	13363	6681	4.259	4.7
0.000005	0.000008	7907	3954	4.355	4.6	82893	41446	4.355	5.2
	0.000009	3186	1593	4.345	4.3	33257	16629	4.345	5.0
	0.00001	2949	1475	4.329	4.3	30585	15292	4.329	4.9
	0.00002	1632	816	4.245	4.1	16339	8169	4.245	4.8
0.000006	0.00001	8258	4129	4.309	4.6	84924	42462	4.309	5.2
	0.00002	2101	1050	4.225	4.2	20850	10425	4.225	4.8
	0.00003	1492	746	4.175	4.0	14498	7249	4.175	4.8
0.000007	0.00002	3970	1985	4.209	4.4	39139	19570	4.209	5.0
	0.00003	1761	880	4.145	4.1	16887	8444	4.145	4.8
	0.00004	1299	650	4.119	4.0	12321	6160	4.119	4.7
	0.00005	1145	573	4.089	4.0	10721	5360	4.089	4.7
0.000008	0.00002	8338	4169	4.195	4.6	81702	40851	4.195	5.2
	0.00003	1856	928	4.145	4.1	17799	8900	4.145	4.8
	0.00004	1369	685	4.105	4.0	12907	6454	4.105	4.7
	0.00005	1207	604	4.075	4.0	11231	5615	4.075	4.7
	0.0004	398	199	3.769	3.6	3222	1611	3.770	4.3
	0.0005	323	161	3.695	3.5	2527	1264	3.696	4.3
0. 000009	0.00002	9505	4753	4.185	4.6	92742	46371	4.185	5.2
	0.00003	2116	1058	4.135	4.2	20204	10102	4.135	4.8
	0.00004	1561	781	4.095	4.1	14651	7325	4.095	4.8

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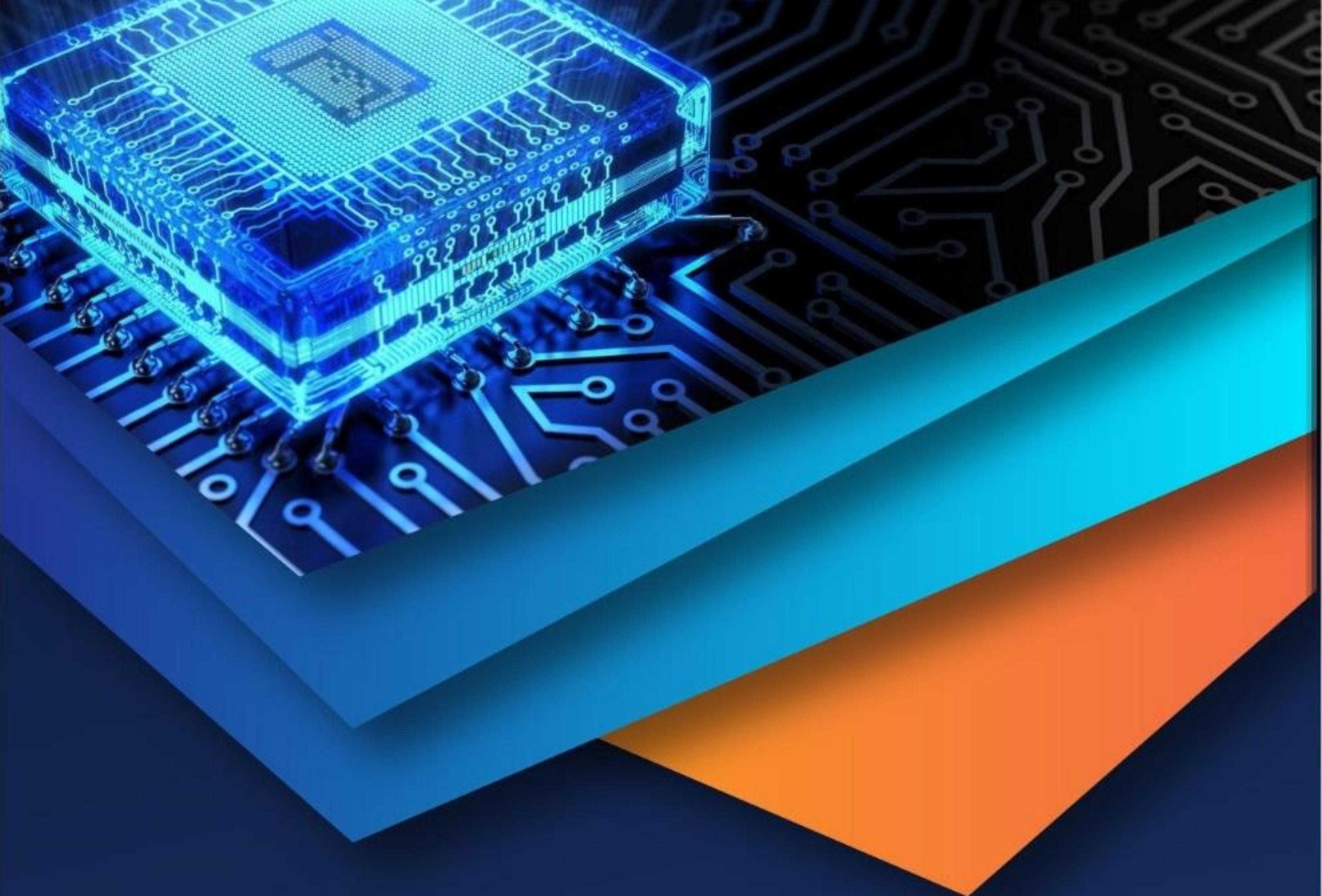
Table 3 (continued…)

SSAQL	SSLQL	$n_{T\sigma}$	$n_{N\sigma}$	k_σ	σ - Level	n_{Ts}	n_{Ns}	k_s	σ - Level
0. 000009	0.00005	1376	688	4.075	4.0	12803	6402	4.075	4.7
	0.00006	1191	596	4.029	4.0	10861	5431	4.029	4.7
0.00001	0.00002	10836	5418	4.175	4.7	105273	52636	4.175	5.3
	0.00003	2348	1174	4.125	4.2	22329	11164	4.125	4.9
	0.00004	1733	866	4.079	4.1	16149	8074	4.079	4.8
	0.00005	1528	764	4.075	4.1	14211	7106	4.075	4.8
	0.00006	1322	661	4.029	4.0	12056	6028	4.029	4.7
0.00002	0.00004	1791	895	4.005	4.1	16151	8076	4.005	4.8
	0.00005	1579	789	3.985	4.1	14113	7056	3.985	4.8
	0.00006	1367	683	3.959	4.0	12076	6038	3.959	4.7
	0.00007	1202	601	3.939	4.0	10523	5262	3.939	4.7
0.00003	0.00005	1601	800	3.985	4.1	14310	7155	3.985	4.8
	0.00006	1386	693	3.915	4.0	12005	6002	3.915	4.7
	0.00007	1218	609	3.895	4.0	10461	5230	3.895	4.7
	0.00008	1099	549	3.885	4.0	9392	4696	3.885	4.6
0.00004	0.00006	2805	1402	3.885	4.3	23970	11985	3.885	4.9
	0.00007	2466	1233	3.865	4.2	20886	10443	3.865	4.9
0.00005	0.00008	2537	1269	3.825	4.2	21099	10549	3.825	4.9
	0.00009	2317	1158	3.805	4.2	19087	9544	3.805	4.9
	0.0001	2041	1020	3.795	4.2	16737	8369	3.795	4.8



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