Inspection Error Adjustment in the Design of Single Sampling Attributes Plan.

指導老師：童超塵　老師
作者：K. Govindaraju
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報告人：張志偉

Abstract

- This article presents an approach for the design of single sampling attributes plans of given strength when inspection errors are present.
- The design approach also recommends repeated testing of sampled nonconforming units for conformance in order to reduce the adverse effect of the inspection errors.

Introduction

- In this article, we employ the strategy of repeat testing of nonconforming units in order to reduce the adverse impact of inspection errors that mainly affect the producer.
- While testing a unit of inspection for its conformance, inspection errors are caused.
- The sources of inspection errors include the inspector or human error, instrument or other measurement related errors, and so on.

Impact of inspection error

- Consider an example : Let

Acceptable Quality Level = $p_{1-\alpha}$ = 0.005 (0.5%)
Limiting Quality Level = p_β = 0.025 (2.5%)
Producer's risk of rejecting *AQL* quality lot = α = 0.05 (5%)
Consumer's risk of accepting *LQL* quality lot = β = 0.10 (10%)

- Assuming Type B OC curve for OC curve by Guenther's procedure.(1969)

Sample size, $n = 266$
Acceptance Number, $Ac = 3$

- The actual achieved risks for the above attributes plan are 4.57% and 9.9%.
- Relating the true fraction nonconforming units *p* to the apparent fraction nonconforming units *p'* is given by

$$p' = e_1(1-p) + (1-e_2)p$$

- The true and apparent fraction nonconforming levels become equal at $e_1/(e_1 + e_2)$ by Lavin and Collins.

- For $p < e_1/(e_1 + e_2)$, the apparent probability of acceptance $P_a(p')$ is less than the true probability $P_a(p)$.

Repeat tests and inspection error

- Repeated testing of nonconforming items is an approach suggested for product screening or 100% inspection.

- Some of the product specific testing procedures may allow only false negatives but not false positives.

- For most situations p, e_1, e_2 are small by Lavin(1946)：

$$p' = p + e_1$$

- In other words, the control of Type I inspection error e1 is more critical as one would normally expect the submitted lot quality to be good or acceptable than poor all the time.

- Let AQL=0.5%, α=5%, LQL=2.5%, β=10%

TABLE 1 Determination of Number of Repeat Tests

m	Apparent *AQL*	Apparent *LQL*	Apparent *LQL*/*AQL*	*n*	*Ac*	n × m
1	0.104000	0.120000	1.154	3329	375	3329
2	0.014000	0.030000	2.143	707	15	1414
3	**0.004640**	**0.019200**	**4.138**	**415**	**4**	**1245**
4	0.003380	0.016500	4.882	404	3	1616
5	0.002962	0.014772	4.986	451	3	2255
6	0.002658	0.013287	4.998	501	3	3006
7	0.002392	0.011958	5.000	557	3	3899

- It is also possible to fix m taking a cost based approach. A simple approach is to compare the total cost of testing and sampling inspection with the realized value of the accepted lot and the rejected lot.

$$EV(p) = V_A P_a(p) + V_R(1 - P_a(p)) - \frac{nmc_T}{N}$$

- Let N=10,000, C_T=4, V_A=3 and V_R=0.5

TABLE 2 Cost Based Determination of *m*

m	*p* = 0.0025	*p* = 0.005	*p* = 0.01
1	1.616	1.616	1.616
2	2.402	2.324	1.907
3	2.485	2.388	1.847
4	2.339	2.230	1.645
5	2.086	1.982	1.402
6	1.786	1.682	1.104
7	1.428	1.325	0.746

Zero acceptance numbers and inspection errors

- The number of units to be tested for the *Ac*=0 plan is easily found for given LQL and β as

$$n = \frac{\log_e(\beta)}{\log_e(1 - LQL)}$$

- The impact of inspection error is much greater for the zero acceptance number plans when compared to the regular single sampling attributes plans.

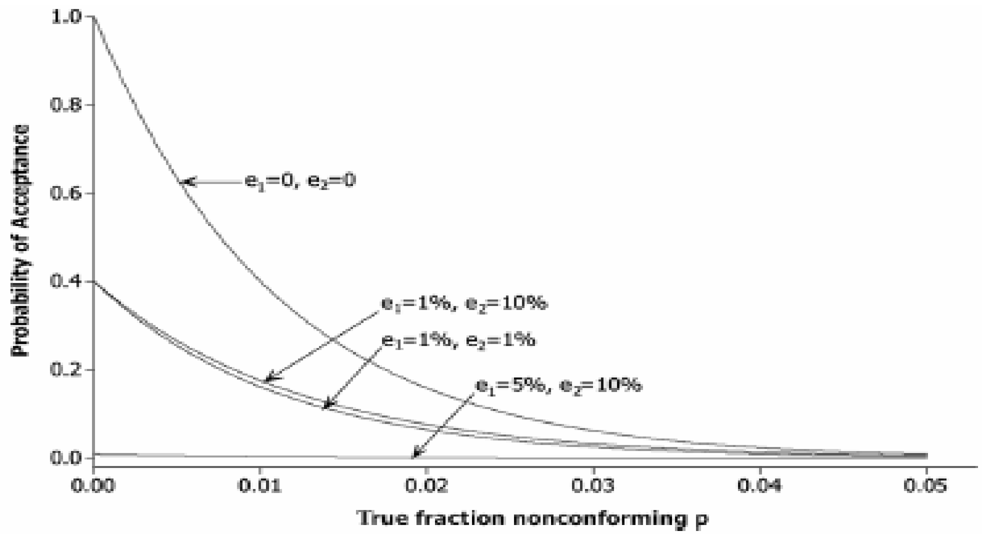

FIGURE 1 The effect of inspection error on the zero acceptance number OC curve.

TABLE 3 Sample Sizes for the Zero Acceptance Number Plan for given *LQL*, e_1 and e_2

Consumer's risk $\beta = 10\%$

Sample size n for

LQL (%)	$e_1 = 0$, $e_2 = 0$	$e_1 = 1\%$, $e_2 = 1\%$	$e_1 = 1\%$, $e_2 = 10\%$	$e_1 = 5\%$, $e_2 = 1\%$	$e_1 = 5\%$, $e_2 = 10\%$	$e_1 = 10\%$, $e_2 = 5\%$	$e_1 = 10\%$, $e_2 = 10\%$
0.1	2302	209	211	45	45	22	22
0.2	1151	192	195	44	44	22	22
0.5	460	154	159	41	42	21	21
1.0	230	116	121	38	39	21	21
1.5	153	93	98	35	36	20	20
2.0	114	77	82	33	34	19	19
2.5	91	66	71	31	32	18	19
3.0	76	58	62	29	30	18	18
3.5	65	51	55	27	28	17	17
4.0	57	46	50	26	27	17	17
5	51	42	45	24	25	16	16
5	45	38	42	23	24	15	16
6	38	33	36	21	22	15	15
7	32	29	31	19	20	14	14
8	28	25	28	18	19	13	13
9	25	23	25	16	18	12	13
10	22	21	23	15	16	12	12
15	15	14	15	11	12	9	10
20	11	10	12	9	10	8	8

Consumer's risk $\beta = 5\%$

Sample size n for

LQL (%)	$e_1 = 0$ $e_2 = 0$	$e_1 = 1\%$ $e_2 = 1\%$	$e_1 = 1\%$ $e_2 = 10\%$	$e_1 = 5\%$ $e_2 = 1\%$	$e_1 = 5\%$ $e_2 = 10\%$	$e_1 = 10\%$ $e_2 = 5\%$	$e_1 = 10\%$ $e_2 = 10\%$
0.1	2995	272	274	58	58	29	29
0.2	1497	249	253	57	57	28	28
0.5	598	200	206	54	54	28	28
1.0	299	150	158	49	50	27	27
1.5	199	120	127	46	47	26	26
2.0	149	100	107	43	44	25	25
2.5	119	86	92	40	41	24	24
3.0	99	75	81	37	39	23	23
3.5	85	67	72	35	37	22	22
4.0	74	60	65	33	35	21	22
5	66	54	59	31	33	21	21
5	59	50	54	30	31	20	20
6	49	43	46	27	29	19	19
7	42	37	40	25	26	18	18
8	36	33	36	23	24	17	17
9	32	29	32	21	23	16	16
10	29	27	29	20	21	15	16
15	19	18	20	15	16	12	13
20	14	13	15	12	13	10	10

Conclusion

- The problem of inspection error is more serious for zero acceptance numbers.
- Repeat testing of nonconforming items is necessary to reduce the adverse impact of inspection errors on the producer's risk.
- The use of repeat tests is essential to avoid rejection of lots whose true quality is in the parts per million ranges.