Statistical Quality Control
Course 02413
HS, IMM, DTU
November 2005

Assignment III

Foreword

Your *Assignment III* report is to be **worked out on an individual basis** and handed in on Monday the 4th of December 2005 at the latest.

Two technical standards are mentioned in the assignment, namely ISO 2859 and ISO 3951. These standards are the ones generally used nowadays.

However, both these standards are copyright protected, and they are rather expensive to buy.

Instead we use two previous versions called 'Military Standard 105D' and 'Military Standard 414', respectively (in fact the book discusses 105E, but it is similar to 105D). Both these standards are discussed in the course textbook, and I have put download versions on the home page of the course.

You may download them on your computer, but do not print them out - it is only parts of them you really need!

In the assignment you are asked to comment on various points or do comparisons of alternative procedures. The meaning is that generally you are asked to give a short, precise, statement.

However, since most of the technical work is accomplished by the download matlab programs it is important that you are careful in working out these comments.

Download programs

It is expected that you make extensive use of the programs in the matlab library when doing this assignment. You can download them and perhaps modify them to your own needs if you wish (adding labels for one example).

The download programs are found at the course home-page

www.imm.dtu.dk/courses/02413/

where there is a link to Matlab library m-files.

If you click on "List and use of library m-files" you get a list.

1 Acceptance Sampling

We again consider the ammunition factory JAM, which among other products manufactures cartridges for a specific type of sporting guns. It is most important that each cartridge holds a charge with a weight close to 6.3 g. When the cartridges have been manufactured JAM packs them into lots with 10 000 cartridges in each lot before sale and transportation to customers.

JAM has (in September 2005) introduced SPC to survey that the cartridges are manufactured to hold charges within the **specification limits 6.3 g ± 0.5 g** and now JAM has decided to introduce acceptance sampling for lots to convince sceptical customers that the quality is in accordance with the advertised standards. For this purpose JAM considers a number of alternative acceptance plans.

At first JAM considers applying an inexpensive binary method of measurement to determine if the charge of a specific cartridge is within the specification limits or outside. The fraction of non-conforming cartridges corresponds to the probability, p, that a cartridge holds a charge outside the specification limits.

1.1 Relation between process parameters and p

Consider three cases for the standard deviation of the charge, namely $\sigma = 0.16g$, $\sigma = 0.18g$ and $\sigma = 0.20g$. For these cases determine the relation between p and the mean charge μ. You may for example fill out the following table or do a little drawing:

	Alternative values for μ							
$\sigma = 0.16$	6.20	6.25	6.30	6.35	6.40	6.45	6.50	6.55
$p =$								
$\sigma = 0.18$	6.20	6.25	6.30	6.35	6.40	6.45	6.50	6.55
$p =$								
$\sigma = 0.20$	6.20	6.25	6.30	6.35	6.40	6.45	6.50	6.55
$p =$								

Comment on the relation between p and possible values of μ and σ.

In the following we will consider the lot size 10 000 to be 'very large' compared to the sample sizes, that are relevant in this assignment.

2 Sampling inspection by attributes

Based on the binary (attribute) method of measurement JAM wants to determine, discuss and compare the following types of acceptance plans for the lots produced:

2.1 Conventional single sampling plan construction

JAM wants to consider the possibility of setting certain precise requirements for the sampling inspection as an alternative to using ISO 2859(Mil.std. 105D) (to be used below).

1): Determine an optimal (minimum sample size) single sampling plan for inspection by attributes. The producer's risk is required to be at most 5% for AQL = 1% and the consumer's risk is required to be at most 10% for LQ = 3%.

Determine the sampling plan and sketch the OC function.

2): As a possible alternative determine a single sampling plan for inspection by attributes where it is now required that IQL = 2% and the slope of the OC function is required to be close to -50 when the fraction of non-conforming cartridges (p) is equal to IQL.

Determine the sampling plan and sketch the OC function.

2.2 Rectifying sampling inspection

JAM has experienced periods of production where an unacceptable amount of the cartridges hold charges outside the specification limits. Since it is costly to withdraw a lot (destruction of 10 000 explosive cartridges) it is suggested to apply rectifying inspection.

This is achieved by weighing the filled cartridges in the lot and replacing seemingly not conforming cartridges with conforming cartridges. It is assumed that it by this method is possible to identify all non-conforming cartridges in the lot and replace them with conforming cartridges.

A number of alternatives are considered:

1): Determine an optimal single sampling plan for rectifying inspection by attributes. The producer's risk is required to be at most 5% for AQL = 1%, and it is furthermore required that AOQL is at most 2%.

Sketch the OC-, the AOQ- and the ATI functions.

2): Determine an optimal single sampling plan for rectifying inspection by attributes. ATI is required to be minimized for AQL = 1%, and the consumer's risk is required to be at most 10% for LQ = 3%.

Sketch the OC-, the AOQ- and the ATI functions.

3): Determine an optimal single sampling plan for rectifying inspection by attributes. ATI is required to be minimized for AQL = 1%, and it is furthermore required that AOQL is at most 2%.

Sketch the OC-, the AOQ- and the ATI function. Determine the producers risk, α, at AQL=1% and determine the LQ-value which corresponds to $\beta = 0.10$.

4): Compare and discuss the above alternative principles for selecting a sampling inspection procedure.

2.3 Sampling with inspection savings

In order to reduce inspection costs a double sampling procedure is suggested.

1): As a basis for this the above **(in 2.2, question 3)** determined ATI/AOQL single sampling plan (given by (n,c)) is chosen , and the double sampling procedure can suitably be matched at two points of the single sampling OC-function. The points can be the OC=0.95 ($\alpha = 0.05$) and OC=0.10 ($\beta = 0.10$) points as is often used.

2): Also determine a sequential sampling procedure that matches the ATI/AOQL plan. The plan can again be matched at two points of the OC-function for the single sampling plan found. The points can again be the OC=0.95 ($\alpha = 0.05$) and OC=0.10 ($\beta = 0.10$) points.

Illustrate the sequential plan by sketching the graphical procedure for the acceptance/rejection (**beware: the formulas in Montgomery are incorrect, use my handouts**).

3): Determine and sketch the ASN functions for the double sampling and the sequential plan. Comment on what is achieved by using double sampling or sequential sampling as alternatives to single sampling.

2.4 Application of ISO 2859-1 (Mil.std. 105D)

Alternatively it is considered to use the principles of ISO 2859-1(Mil.std. 105D) as follows:

1): Determine the single sampling plans (normal, tightened and reduced) for inspection by attributes by use of the international standard ISO 2859-1(Mil.std. 105D). Apply inspection level II and AQL = 1%.

For the reduced sampling inspection, normal sampling inspection and tightened sampling inspection plans sketch the OC functions.

Determine the LQ-values of these plans corresponding to acceptance probability 10%. Also determine their IQL-values.

Describe the ISO 2859-1(Mil.std. 105D) switching rules and procedures and explain in your own words what is obtained by using them.

2): Determine the double sampling inspection plans (normal, tightened and reduced) for inspection by attributes by use of ISO 2859-1(Mil.std. 105D). As above apply inspection level II and AQL = 1%.

Sketch the ASN functions of the normal and tightened double sampling inspection plans and compare them with the corresponding single sampling sample sizes. Comment on how the average sample number depends on the incoming quality.

3 Sampling inspection by variables

JAM furthermore considers applying a more sophisticated weighing method to determine a numerical value measured in gram for the charge in a cartridge.

Experience has shown that the outcome of this weighing method can be assumed to be almost identical to the true weight of the charge, and the variation of the charges within the lots investigated can safely be assumed to be normal with some μ and some σ which together reflect the quality of the production of the cartridges.

Both μ and σ can vary somewhat.

The fraction of non-conforming cartridges is defined as the probability that a cartridge holds a charge outside the specification limits 6.3 ± 0.5 g.

3.1 Conventional single sampling plan construction

Again JAM wants to consider the possibility of setting certain more strict requirements for the sampling inspection as an alternative to using (ISO 3951) Mil. std. 414 (which is used below).

1): Determine an optimal (minimum sample size) single sampling inspection plan for sampling by variables. The producer's risk is required to be at most 5% for AQL = 1% and the consumer's risk is required to be at most 10% for LQ = 3%.

Determine and sketch the OC function. Sketch the acceptance region for the plan.

3.2 Application of ISO 3951(Mil. std. 414)

Alternatively it is considered to use the principles of ISO 3951(Mil. std. 414). The plans to be considered are the plans based on the 's method' (do not use range method or known standard deviation method).

1): Determine the single sampling inspection plans (normal, tightened and reduced) for inspection by variables by use of the standard ISO 3951(Mil. std. 414). **Notification: ISO 3951 text: 'Apply inspection level II and AQL = 1%' . In Mil.std. 414 this is inspection level IV in table A-2. Therefore: use Mil.std. 414 inspection level IV and AQL =1%. See clause A7.1 .**

2): For the reduced sampling inspection, normal sampling inspection and tightened sampling inspection plans sketch the acceptance regions and the OC functions. Compare the plans with the corresponding ISO 2859-1 (Mil.std. 105D) plans and comment on advantages and disadvantages especially with respect to sample size and practical procedure.

3): Describe and justify in your own words the ISO 3951 (Mil. std. 414) switching rules and procedures briefly.

3.3 Comparisons of variable sampling plans

Compare the (ISO 3951) Mil. std. 414 plans with the plans constructed in the previous section for normal and tightened inspection with respect to sample size, producers risk and consumers risk at the AQL and LQ values mentioned. Likewise determine (read off) and compare the IQL for the plans. Comment.

4 Conclusion

Finally comment (conclude) briefly and in your own words on the following points:

1): Advantages and disadvantages of using sampling by variables in comparison with using sampling by attributes.

2): Advantages and disadvantages when using the ISO (Mil.std.) approach as opposed to the individual design of sampling inspection procedures.

3): Single sampling in comparison with double or sequential sampling in general: Implementation, practical usefulness, economic savings and costs, etc.

End of assignment