

# Continuous Sampling Planning

Quality Management  
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## **Introduction**

Lot acceptance sampling plans (LASP) are used during production to test units submitted for evaluation against certain hypotheses. From a manufacturing perspective, LASP's provide a check on a company's quality control processes. Most LASP samples of a product are carried out in lots. In standard sampling a hypotheses of the sample makes up the criteria by which the process is judged. These units are then accepted or rejected on the basis of the set forth hypothesis. If a process has tested adequately, the lot or unit is accepted and passed on to the retailer or customer. If, however; quality control is not sufficient, sampling will prevent unacceptable product from leaving the manufacturer. Accepting or rejecting a lot or unit is synonymous with not rejecting or rejecting the null hypothesis in the hypothesis test. Because grouping into lots is not always advantages, continuous sampling as outlined below, takes a slightly different approach to quality control in manufacturing.

## **Continuous Sampling Defined**

The concept of continuous sampling planning originated in 1943 by Dodge. Known as CSP-1, continuous sampling is used where product flow is continuous and not easily grouped in lots. Two parameters exist for continuous sampling. One is the frequency ( $f$ ) and the second is the clearing number ( $i$ ). The frequency ( $f$ ) is defined by a number such as  $1/20$ ,  $1/30$ , or  $1/X$ . The clearing number ( $i$ ) is a number such as 30 or 60. A company checks all of its product until 100% of  $i$  number of units are inspected and found to be defect free. After 100% of  $i$  number of units are found to be defect free 100% inspection is ceased, and one out of every  $X$  number of units is checked. The sampling continues until a defect is found. After finding a defect the cycle repeats itself until 100% of  $i$

number of units has been found to be defect free. At this point the sample 1/X will begin again.

### Using Continuous Sampling

Carrying out a continuous sampling plan is simple and can be carried out in 3 steps. 1.

Inspect all  $i$  data. 2. If no defects are found, randomly sample fraction  $f$  of data and

check again for defects. 3. Whenever a defect is found, correct the flaw and repeat step

1. There are two main parameters to consider when executing a continuous sample. All

other relevant measurements for continuous sample planning can be derived from these

two parameters. The parameters with their variables defined can be seen in Figures 1 and

2.

Figure 1 CSP-1 Parameters

AOQ Average outgoing quality for long-run CSP – 1 plan.

$$AOQ = (p)(P_a) \frac{(N-n)}{N}$$

AFI Average fraction inspected for long-run CSP – 1 plan.

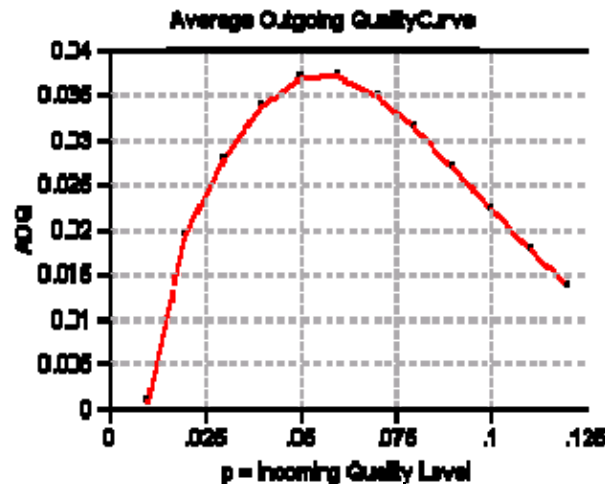
$$AFI = \frac{f}{f + q^i(1-f)}$$

Figure 2 AOQ and AFI Variables

$f$	Sampling frequency for short-run CSP – 1 plan
$i$	Clearance number for short-run CSP – 1 plan
$p$	Incoming quality level
$p_a$	probability of accepting incoming unit
$q^i$	$= 1-p$
$N$	Lot size

When a series defects are gathered, a good continuous sampling plan will inspect 100% the rejected units and replace and defective parts or products. In this case all defects are made whole and accepted. AOQ refers to the long term defect level of this sampling plan and 100% inspection of rejected units. The average fraction inspected is simply the average of the fractions  $1/X$  sampled. Results can then be further analyzed by creating an Average Outgoing Quality Curve (Figure 3). An Average Outgoing Quality Curve plots the AOQ (Y-axis) against  $p$ , the incoming quality level (X-axis). Figure 3 tells us that with high levels of incoming quality (low  $p$  values); the average outgoing quality was also very good.

Figure 3 Average Outgoing Quality Curve



NIST/SEMATECH e-Handbook of Statistical Methods, <http://www.itl.nist.gov/div898/handbook/>, date.

When incoming quality begins to drop defective items are inspected and replaced, thus increasing the average outgoing quality. The curve in Figure 3 shows that after reaching a certain level  $p$ , AOQ begins to drop. In other words diminishing AOQ takes place as

the value of  $p$  increases. The maximum AOQ point on the curve represents the worst possible quality that results from the correction of defects.

### **Example**

Cart Racing is a technical sport and requires precision in driving abilities as well as in mechanics and cart workmanship. Professional cart racers will have multiple race carts and expect their carts to meet specific specifications. One way to ensure a race cart meets specifications is to run the cart on a DYNOMite Dynamometer. A Dynamometer is always connected to a Data Acquisition Computer that reads such information as true Hp, torque, RPM, elapsed time, etc. By designating a clearance number of say, 15, and a frequency of  $1/5$ , a custom cart builder could apply continuous sampling to Dynamometer testing to ensure his carts meet certain criteria. After running multiple samples the cart builder could figure out his AOQ level. Putting the data in graph like that of figure three could show the cart builder his AOQ as compared to  $p$ , his or her incoming quality. Using this data can provide further insight into where quality originated and where quality improvement is still lacking.

### **How to get more information**

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Chen and Chau. Joint Design of Economic Manufacturing Quantity, Sampling Plan and Specification Limits. Economic Quality Control, Vol 17, No. 2, 145-153.

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<http://www.itl.nist.gov/div898/handbook/>, date.