

Chapter 13.

Selection of Samples for Welding Tests

In some cases, 100 percent inspection of a product may be required. Otherwise, sampling procedures are often specified. Sampling is the selection of a portion of the production for inspection or test purposes. A sample is a representative portion chosen from a larger group. Conclusions can be drawn about the overall quality of an entire production run based on the outcome of the tests or inspections and the statistical basis for the sampling procedure. The test specifications or the procedures, or both, usually detail the sampling methods for the inspector. The following sections present sampling-related terms that may appear on procedures and the basic ideas of statistical sampling.

Procedural Sampling Methods

Some of the terms and methods found in test procedures for sampling are *complete*, *partial*, *specified*, and *random*.

Complete Sampling: Complete sampling is the inspection of an entire production lot of weldments in a prescribed manner. It may be the inspection of just the critical joints of each weldment. Complete sampling with 100 percent inspection requires the inspection of all welded joints by the prescribed methods. Complete sampling may be used where the highest quality is required for safety or for other reasons. Complete sampling is costly and time consuming when compared to partial sampling.

Partial Sampling: Partial sampling involves the inspection of a certain number of weldments

less than the total number in the lot or production run. The method of selection of the weldments to be inspected and the type of inspection should be prescribed. The rejection criteria and disposition routine for any substandard weldment found by the sampling inspection should also be specified on the procedure.

Specified Partial Sampling: Specified partial sampling occurs when a particular frequency or sequence of sample selection from the lot or production run is prescribed on the drawing or specification. An example of specified partial sampling is the selection of every fifth unit for inspection, starting with the fifth unit. Since the producer knows in advance which units will be subjected to inspection, he may devote more care to the production of the units to be inspected at the expense of the units he knows will not be inspected. Thus, the overall quality level of the production run may be lower than that indicated by the inspected units.

Random Partial Sampling: Random partial sampling occurs when the unit to be inspected is selected in a random manner. For example, consider that one out of every five units from a production run is to be inspected, and the selection of each of the candidate units from the subgroups of five is made by the inspector in a random manner. Then each of the five units has an equal chance of being chosen, and random partial sampling occurs.

Since the producer does not know in advance which units will be selected for inspection, he must take equal care in the production of all

units and a more uniform product quality should result.

Sampling Plans For Inspection by Attributes: Inspection by attributes (or characteristics) involves classifying the unit simply as defective or nondefective; or, it may be classified by the number of defects in the unit of the product, counted with respect to a given requirement (such as defects per hundred units) or set of requirements.

The result of weldment inspections is the identification of weldment defects (discontinuities) of various types as described in Chapter 9. Some of these defects may be more severe than others. Some may be acceptable within the code or specification requirements, and some may not. Thus, the result of weldment inspections can be classified as inspection by attributes.

MIL-STD-105D (Ref. 13.2) contains procedures and tables with sampling plans for inspection by attributes. The sampling plans are relatively easy to use and interpret, once a few basic ideas are understood.

Operating Characteristic Curve (OC):

A sampling plan is specified by a lot or batch size (N), a sample size (n), and an acceptance number (c). For each sampling plan, there is an operating characteristic curve indicating the percentage of lots or batches that may be expected to be accepted for a given process quality level. Put another way, the OC curve presents the probability of acceptance as opposed to the true quality level of the process.

In most sampling plans, the producer's risk and the consumer's risk are both set at 0.10. The producer runs a 10 percent risk of having a lot rejected in which the quality level is actually as good as the "acceptable quality level" (AQL). The AQL is defined as the maximum percent defective (or the maximum number of defects per hundred units) that, for the purposes of sampling inspection, can be considered satisfactory as a process average.

The consumer runs a 10 percent risk of accepting lots in which the quality level is actually as low as or lower than the "lot tolerance percent

defective" (LTPD). The LTPD is usually defined as the percent defective at which there is a 10 percent probability of acceptance.

From Fig. 13.1, a typical OC curve, the AQL and the LTPD can be determined. A 0.10 probability of rejection, the producer's risk, is a 0.90 probability of acceptance ($1.00 - 0.10$). Therefore, the AQL in this example is 0.4 percent. In other words, the producer runs a 10 percent risk of having lots rejected that have as few as 0.4 percent defective units. The consumer's risk of 0.10 leads to a LTPD of 2.2 percent, which means that the consumer runs a 10 percent risk of accepting lots that have as many as 2.2 percent defective units.

In plans where defective units found in sampling are repaired or replaced, the "average outgoing quality" (AOQ) is greater than the process quality. This is true because defective units are replaced with good units, thereby increasing the average outgoing quality over that which would have occurred had the defective units not been replaced. In such plans, the average outgoing quality at the LTPD point is greater than that indicated by the OC curve. The "average outgoing quality limit" (AOQL) can be determined for any given quality level (percent defective).

MIL-STD-105D: The sampling plans in MIL-STD-105D are indexed by AQL and sample size code letter. The sample size code letter is determined by lot or batch size from a table. The sample plans cover a wide range of AQLs and lot sizes from 2 to infinite. Operating characteristic curves and AOQL curves are given for each sampling plan. For any given lot size and AQL, the user can find a plan that will satisfy a given consumer's risk.

Control Charts for Attributes

Control charts for attributes can be used effectively for production line products to indicate the product average quality level and the acceptable variation about the average. As the name implies, the chart shows whether or not the quality level is in "control," that is, within prescribed limits. Control charts are constructed by taking samples of a given size from each subgroup of product as it comes off the line. The

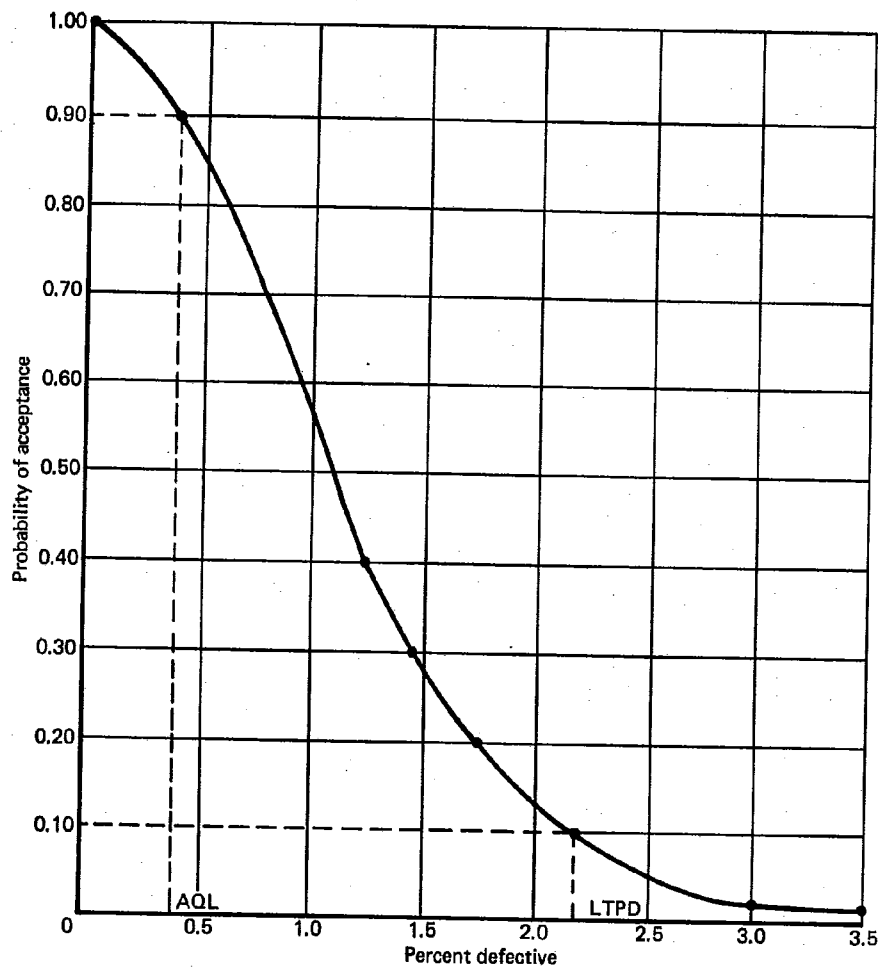


Fig. 13.1—Operating characteristic curve

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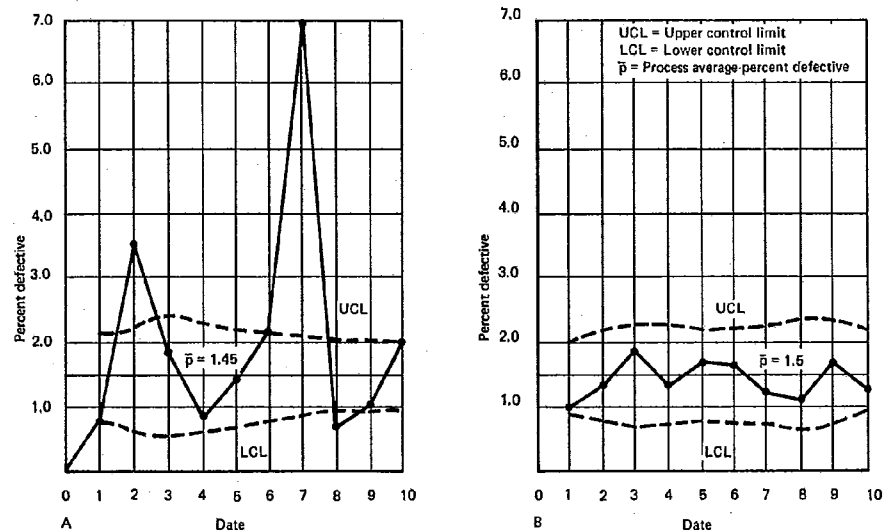


Fig. 13.2—Examples of control charts for percent defective

average percent defective (or average defect per unit or hundred units as the case may be) is calculated from each sample, as well as the sample standard deviation (a measure of variance about the average). Once the process average has been established, the sample percent defectives are plotted on the chart against the sequence (time, lot, etc.) in which the samples are taken. The sample standard deviations are used to calculate control limits.

A process that is out of control is shown in Fig. 13.2A, and a process that is in control is shown in Fig. 13.2B. When a process goes out of control, the manufacturing processes are investigated to determine the cause, and then to make the necessary corrections. Control charts can also be used to detect when the process average is shifting. The interested vendor is referred to Ref. 13.1 for a detailed treatise on the construction and interpretation of control charts.

Summary

Sampling is used whenever 100 percent inspection is uneconomical or impractical. When sampling procedures are employed, there

are always risks to both the producer and the consumer.

When the sampling plan is given on the procedure or specification, the inspector need only follow the procedure. Sampling plans may be chosen for specific risks from MIL-STD-105D.

Complete sampling is used when weldments of the highest quality are required for critical services. One or more methods of nondestructive testing, along with visual inspection, may be specified for the critical points.

For the average welding job, the inspection generally involves a combination of complete sampling and random partial sampling. All of the welds (complete sampling) are inspected visually; random partial sampling is then applied using one or more of the various methods of nondestructive testing.

References

- 13.1 Grant, E.L., *Statistical Quality Control*. New York: McGraw-Hill Book Co., Inc., 1952.
- 13.2 MIL-STD-105D, "Sampling Procedures and Tables for Inspection by Attributes," July 18, 1961.