

MAGNAFLUX

A Division of Illinois Tool Works Inc.

QUASAR

Establishing the Training Part Set

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Magnaflux
Quasar Systems
5550 Midway Park Place NE
Albuquerque, NM 87109
(505) 247-9660
www.magnaflux.com

Establishing the Training Part Set

In production operation, the Quasar system compares each part being tested to the statistical parameters of a reference database. This reference database is created by training the system using a **Training Set** of carefully selected parts. These Training Set parts must represent or “model” all the important characteristics of **structurally acceptable** and **structurally unacceptable** parts. For that reason, **selecting the parts for the Training Set is the single most important step in setting up a Quasar system for production inspection.** The Training Set completely defines structurally acceptable and structurally unacceptable part characteristics for the system. If the Training Set is deficient, one or more of the following undesirable results will occur:

1. The Sorting Module (the software program customized for sorting this part) will not be robust. That is, as new production lots are introduced, the false reject rate will become excessive, so the system training will have to be repeated. This occurs when the Training Set does not adequately represent the total process variation for acceptable parts.
2. The Sorting Module will not correctly reject structurally unacceptable parts. This occurs when the Training Set does not include examples of all structurally unacceptable types and/or the structurally unacceptable parts are taken from a different process population than the structurally acceptable parts. For example, the structurally unacceptable parts might all be taken from a production lot that was not represented in the structurally acceptable parts.
3. It will be impossible to develop a Sorting Module that accurately sorts the training parts. This occurs when a significant percentage of the parts in the Training Set are misclassified. Often this happens when parts with superficial indications are classified as structurally unacceptable, but it can also occur if parts with significant undetected and unrecognized structural deficiencies are classified as structurally acceptable.

Following the procedure described here will help ensure that an accurate, robust Sorting Module is developed most efficiently.

Structurally Acceptable Parts

The structurally acceptable part set must represent the total process variation at the specific point in the manufacturing process where parts will be tested. The approach to obtaining a representative set will depend on the total manufacturing process and should be planned carefully.

Experience has shown that a sample of about 100 to 200 structurally acceptable parts is required to characterize most manufacturing processes. Remember that the number of different process variations represented is much more important than the total number of parts. It is much more useful to have 1 part each from 100 different lots (or dies, or pours, or machining cells, etc.), than 100 parts from 1 lot. While exact quantities are not critical, the Training Set should consist of balanced representation from each different lot produced.

There are several principles to consider in gathering structurally acceptable parts.

1. The parts must be collected from the exact point in the manufacturing process where the Quasar test will be conducted.
2. The set should include parts that are processed by each different piece of manufacturing equipment. For example, if the part is produced in four die cavities, parts should be obtained from each cavity.
3. The set should represent the range of dimensional variations. For example, it should include parts made with both new dies and dies that are near the end of their useful life, if possible.
4. The set should represent the range of raw materials. For example, if there is a tolerable range of trace metal, parts should be obtained to represent that range. Parts should be obtained from several pours, several heats of steel and/or all representative suppliers of powder or steel (as appropriate).
5. The set should represent the acceptable range of heat treat conditions (thermal history) including variations in furnace temperatures or profiles and/or quenching.
6. Sets should be gathered to represent acceptable batch variations in the approved manufacturing process such as time of day or shift.
7. Each part should be marked with a unique identifier, such as a simple sequential numbering of the parts. All relevant information for the parts should be recorded, such as date code, material lot, equipment number, and serial number, if applicable. Please see discussion below on Part Set Documentation.
8. Not all process variations may be collected for the initial Training Set, and further additions to the database may be necessary as further variations are encountered during production running.
9. All parts in the Training Set must be of the same engineering revision level and approved production (or production intent) manufacturing processes.

Some variables are easily identified and quantified, such as the number of presses or molds. Other variables are more subtle and must be handled statistically. To address this, Magnaflux Quasar recommends that at least 10-20 samples from each process group be collected for use in building the database.

Generally, the parts stream from a process can be mixed, with parts from all of the approved production (or production intent) manufacturing equipment being represented in the output. In this case, it can be assumed that a sufficiently large, random sample will represent the distribution. In this situation, time-based sampling can be used to select parts. For example, a reasonable sample might be 10 parts each from 10 consecutive shifts. Alternately, sample gathering may be determined based on when material or processes change. For example, if dies are changed or if new heat codes of steel are received every 10 shifts, then it would be better to change from consecutive shifts to perhaps one alternating shift every few days for 30 days.

If the parts are not mixed, for example if there are 2 or more independent lines, then the set should consist of approximately equal numbers of parts from each line. This will assure that there is no bias built into the Sorting Module.

The classification of acceptable parts should be validated using the best available conventional NDT and even destructive methods if necessary. Parts that do not meet the minimum performance or material requirements should be removed from the structurally acceptable part sample and reclassified as structurally unacceptable.

Structurally Unacceptable Parts

The structurally unacceptable part sample set should also be representative of the acceptable range of process variation. It is not necessary to sample every variation, but the structurally unacceptable parts should be gathered for several different manufacturing process conditions.

Experience has shown that a sample of 50 to 100 structurally unacceptable parts is required to characterize most manufacturing processes. This sample size may not be achieved immediately, but should be built over time as the understanding of severity and location becomes understood.

The general considerations for selecting structurally unacceptable parts are:

1. The structurally unacceptable parts must be collected at the same point in the production (or production intent) manufacturing process as the structurally acceptable parts (unless the reason for rejection is a missed operation).
2. The sample set must include parts that represent all of the structurally unacceptable types, including local anomalies such as cracks, shrinks, missing features, etc., and material characteristics such as nodularity, carbides, thermal history, chemistry, etc. It must include several parts for each structurally unacceptable type. If a structural anomaly can occur in more than one location on a part, the sample should include examples of each, where practical.
3. The sample should include structurally unacceptable parts from several different production lots. It is imperative that the structurally unacceptable parts are from lots from which you also have structurally acceptable parts.
4. The classification of all structurally unacceptable parts should be verified, using the best available conventional NDT and destructive methods. All test results (destructive and non-destructive) should be documented and retained for future reference. Please see discussion below on Part Set Documentation.
5. The structurally unacceptable parts should be ranked by severity (based on the NDT and destructive testing results and engineering judgment) using a scale of 1 to 5, where 1 is least structurally unacceptable and 5 is most structurally unacceptable. If there is substantial doubt about the severity of a structurally unacceptable, the part should be assigned the lower severity. If there is doubt whether a part is truly structurally unacceptable, the part should be classified as "Unknown." Consult *Quasar Severity Rating Guidelines*.
6. Structurally unacceptable samples should be 'naturally occurring' whenever possible. If it is necessary to create artificial examples for rejection, consult Magnaflux Quasar personnel for guidelines, as this must be done to most accurately reproduce the anomalies normally produced by the process.

Part Set Documentation & Retention

The part sample set should be documented in a database or spreadsheet format. This database should include, as possible:

1. Processing information such as die or cavity information, batch information, production date, process 'rev' level, and any other identifying process conditions.
2. Date/Time the part was entered into the Quasar Parts Library.
3. Any visual indications on the part, structurally unacceptable type and location. Photos of structurally unacceptable parts should be retained whenever possible.
4. Destructive test results for 'structurally acceptable' or 'structurally unacceptable' parts.

This documentation will aid in creating the initial Sorting Module, and in maintaining it as additional parts are collected. See Magnaflux Quasar personnel for a sample spreadsheet.

The retention of the parts in this Training Set will vary with part type and company policy, but every practical effort should be made to retain a sufficient variety and quantity of parts to provide a Master Sample Set for future reference and validation. Some companies have strict policies regarding the retention and securing of unacceptable parts, which must be followed.

Prototype Parts

Under certain circumstances, sorting may be required during the prototype phases of a product's development. This is possible to achieve, however, care needs to be taken in collecting the Training Set of parts. It will be necessary to collect a greater number of samples per lot in the beginning, but as more lots are produced and added to the database, the number of parts from the initial lots should be reduced. **As the product moves to production and the process gains PPAP approval, it may be necessary to abandon the prototype database built with prototype parts completely and replace it with production parts as described above.** Consult Magnaflux Quasar personnel for guidelines.

Acknowledged:

Signature: _____ **Date:** _____

Print Name: _____

Title: _____

Company: _____