Designing Quality Control Programs for Coffee Products

Quality control programs ensure that the needs and expectations of consumers are consistently being met. An effective quality control program is one that can be continually observed, is efficient, and is able to isolate and measure the level of variability of quality perceptible to the consumer. Most quality control systems are put into place to reject products that do not meet set specifications, but an equally important function of a well designed quality control program is to anticipate conditions that will cause rejection.

The terms “quality control” and “quality assurance” are often used interchangeably, but they have different emphasis. The purpose of “quality control” (the main theme of this article) is to ensure the routine adherence to standards as the subject product is being produced. “Quality assurance” is a planned system of review of these results, often done by third parties. Some methods of review of data are included here, but since the major goal is the day-to-day adherence to standards, the term “quality control” is used throughout this article.

Such programs for coffee present special challenges. It involves a supply of green coffee that changes season to season in terms of quality, price, and availability. The green coffee selected for the final product is then roasted. Roast parameters and the technical ability to reproduce them profoundly affect the final product and concerns the ability of those who set the parameters (in the product development stage), the roasting technology available (type of roaster and size of batches), and the skill of the roasting technician. Packaging is the face that greets the consumer and preserves the freshness of the product, providing both marketing and shelf life functions.

Addressing the primary question: The most fundamental reason a consumer chooses a specific beverage is due to its sensory quality. Some argue that, just as many consumers of alcohol do so more for the effect than the taste, similarly one drinks coffee only for the caffeine. Given a choice, most human beings choose a better tasting coffee. In an industry as competitive as coffee, a primary focus of quality control programs must be what the coffee tastes like, not simply whether or not it meets a limited set of market specifications (it’s hot, it’s black, it has a characteristic flavor). On the other hand, product parameters can be so specific that it becomes exceptionally difficult to produce the product and next to impossible to deliver the intended sensory experience to the consumer.

The most successful coffee businesses strike a balance between what they as professionals know is ideal and what the consumer is able to perceive, accept, and enjoy, employing resources available (ranging from availability of green coffees with certain flavors to roasting and packaging technology).

©2007 Songer and Associates, Inc.
Goals of a Quality Control Program for Coffee

Quality control programs communicate useful information at the time when it can most effectively be utilized in creating intended coffee. An efficient and complete quality control program design will include the following:

1. A well-defined and achievable set of specifications for the product. These specifications should take into account a realistic level of expected variability but still define aspects (including the flavor attributes) of the coffee that make the product unique. They include a range of allowable variation and standards for rejection of a product. Methods of measuring those specifications, including both instrumental measurements and sensory measurements, are a necessary part of these specifications.

2. Specified levels of sampling. Does one need to cup every roast or several samples within a roast, or will a roast taste as it should if certain physical and process standards are met? The point in the manufacturing process that a sample is taken is also included in the sampling specification (out of the cooling tray, out of a randomly selected package, off the shelf of the retailer).

3. Action to be taken if the specifications are not met or in case of sudden variability, such as change in coffee availability or price. The response time must be taken into account; it is too late if an out-of-spec product is released into the marketplace. If an over roasted batch can be identified before it is packaged, labor and material costs can be saved. The earlier in the process that problems can be detected the more efficient and cost effective a quality control system will be.

4. A system of record keeping, including procedures of regular evaluation of all results over time. A relational database (one where relationships between data can be defined) that can be queried according to user-defined parameters is particularly useful in gathering, storing, and accessing data. This includes reports and communication systems between the green buyers, roasters, and other company departments.

5. A system of reporting so that all concerned will know the status and level of quality within the organization.

Since a primary goal of a quality control program is not only to catch out-of-spec products, but to anticipate problems within the manufacturing process that are likely to cause out-of-spec products, measurements during the manufacturing process itself must be taken as well as measurements of the parameters of the finished product.

In coffee, an example of predictive quality control would be the change in total moisture and water activity in green beans that naturally occurs over time. Since moisture is the main conductor of heat into the bean during roasting, these changes will affect how the bean conducts heat and the flavor changes that happen as a result of roasting. If a quality control program includes regular measurement of moisture and water activity of the green components, the roast parameters can be adjusted to compensate for the changes. Also, these measurements are quick and easy to take.

Defining Achievable Specifications and Methods of Measurement

The determination of specifications is the heart of the quality control program. It is a balancing act between the product ideal and allowable variations, which tests are
performed, what they indicate, and what action can be taken as a result. The costs of performing the tests and how well results are utilized must also be considered.

**Accuracy, precision, and errors:** One major challenge in making a quality control program efficient is to know how much testing is enough and how narrowly measurements must be taken so that effective decision making can take place. Especially important are issues of precision (the closeness of the measurement to the absolute; the range of +/-) and accuracy (how “true” is the measurement). Regardless of the accuracy and precision of the measurement (and the technician doing the measurement or recording the result), there is a chance that an error can occur and that the measurements taken will not be certain. A properly designed quality control program will take this eventuality into account. The usual way is through replicate testing, regular calibration of equipment and cuppers, and systematic evaluation of results.

**Ideal vs. Allowable:** In determining coffee specifications that can be realistically met using currently available supplies and manufacturing processes, there are both targets (the “bull’s eye,” the absolutely perfect product) and the range around the target. It is unrealistic to expect that the coffee will always attain a direct bull’s eye hit. The specified range of the particular standard should not allow the coffee to deviate so far from the intended target that it is no longer recognizable, but a realistic range of specifications should be included in the standard.

**Different products, different standards:** Specialty coffee roasters offer more SKU’s of products to appeal to specific preferences of different customer segments. Each of these coffees has specific roast characteristics and flavor attributes that distinguish it from others. These distinguishing characteristics should be included in the set of physical and sensorial standards.

**When to test?:** If a quality control program is to be effective, it must provide the necessary information in a timely manner to decision makers. The timing of testing and communication of results are also a necessary part of a specification.

Timing is everything. Testing is most useful when the product is changing ownership or when it is changing form (moving to the next stage in the production chain). It is extremely important, for example, to ensure that a received lot of green coffee is of acceptable quality before purchasing or roasting in large production batches. The acceptability of a roasted product must be determined before packaging.

One of the main challenges of dealing with coffee quality is that it is always on the move, in green, roasted, or packaged form. Variations in green physical aspects may cause problems for the roaster. A reasonable response may be narrowing the roast specification ranges.

For example, suppose a range for bean size and moisture for the green bean has been determined. Due to availability, time of year, or other conditions, a lot has been purchased that does not meet the specified range of standards. In this case, a reasonable response would be tighter roasting standards and a higher rate of sampling (testing the product more often).
Process Evaluation: Specifications for the processes that are most likely to produce the desired result are also written. This is especially important with roasting. The time of roast, temperature of the environment, temperature of the bean, and amount of airflow is examples of specifications that can be written for processing. A typical roasting log is shown in Figure 1.

<table>
<thead>
<tr>
<th>Roaster Log</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change</td>
</tr>
<tr>
<td>Ideal</td>
</tr>
</tbody>
</table>

Figure 1: A typical roaster’s log showing relevant temperatures and timings of the roast.

Coffee is at its most stable in the green stage, but changes can occur at this level. Most important among these are moisture and water activity. Depending upon storage conditions and the coffee itself, moisture and color parameters will change over time. As coffee loses its moisture, water activity decreases (indicating that free moisture is less available to conduct heat during roasting), and its color changes from green or blue-green to yellow. In the presence of high humidity, water activity increases and an increase in moisture will eventually be noticed. For long-term storage, one may want to measure water activity every 30-90 days, especially in conditions of high humidity or seasonal changes. A difference of 0.05 over 30 days has been shown to predict significant past crop/woody flavor.

Going back further in the production chain, roasting companies, especially those in the specialty segment, are also becoming more directly involved in how coffee products are produced at origin. Though roasters have no direct control, process specifications suggested include agricultural, harvesting, and processing, with inducements of higher prices and long term contracts. Unfortunately, one of the main determinants of coffee flavor, climate, is out of everyone’s control.

Measurable and replicable product specifications, especially when reinforced with examples of “gold standards” (samples that absolutely meet the standard criteria), are useful in communicating desired standards to those at origin. ISO certifications, which are becoming more common especially in Central America, require extensive record keeping and chain-of-custody labeling. Examination of these records can not only assist the roasting company in determining quality and origin of greens, but may also reveal important quality issues, such as how quickly a sample was dried or the method used.

Sampling

The goal of an efficient quality control program is to minimize the amount of testing necessary while ensuring a coffee that has the necessary flavor attributes as originally defined. This partially depends upon the variability of the individual product.
Since coffee is a natural product, not everything that is produced will be exactly as intended. However, one must be reasonably certain that coffees are within the target range. The more testing performed the more certain one can be about the state of that coffee. For example, if one tests one cup of coffee from a 32,000 pound container of green coffee, it may or may not reflect the actual quality of the entire quantity. If one samples from several bags in the container, mixes it all together, and tastes numerous individual cups (as in the New York board of Trade procedure), one will get a better idea of the quality of the whole batch. If all cups tested are virtually the same, one can state with reasonable certainty that the product is within intended specifications. Statistics (discussed later) quantify the chances that the quality is as intended based upon the size of the lot and the sampling procedures.

If there are slight variations, it must be determined if these are acceptable within the context of that product. If there are obvious problems, it may be necessary to do further sampling to see how wide spread the problem is. There are even cases where several cups are superior to the others, which is not usually considered a problem, but it does reflect inconsistency.

The level of sampling is determined by whether or not the system is in statistical control, involving a measured certainty that a product is within a certain acceptable range. This is easier with a sample of high quality; if the tests (cups on the cupping table or physical measurements) are within a reasonable precision, it demonstrates that less testing is necessary for that product. A more variable sample may require more testing to determine the range of flavor attributes and overall consistency of the particular batch.

![Figure 2: Process control chart for Agtron measurements. (Agtron is a widely used scale for degree of roast.)](image)

©2007 Songer and Associates, Inc.
In this example, there are obviously some out-of-spec products being produced, but the counts indicate that the process is in statistical control, since it follows the normal distribution curve. It is reasonable to assume that this testing reflects the overall state of manufacturing quality. The next decisions are what changes need to be made or if the standards are not achievable. (In most cases, this would not be considered adequate quality control for the product, with 17.5% out-of-spec.) One can also observe that the roaster is having more trouble with roasting too dark (the lower the Agtron number, the darker the roast).

Determining adequate levels of statistical control requires different amounts of testing for different products. When one initiates a quality control program, it may not be known which products are most variable or at what level of production the variations are most likely to exist. This initially requires a dedicated program with much replication of measurements.

However, even if a formal quality assurance program has never been put into place, those who are directly involved with the products, like roasters and cuppers, have a sense of where problems are most likely to arise. When setting up a program, these areas must receive special attention and more testing. In getting at this valuable experiential knowledge, have the individuals consider the following.

**Timing:** Do certain problems happen at a certain time of day or during a certain season?

**Conditions present:** Are there certain environmental conditions that indicate more potential problems?

**Technical considerations:** Are some problems caused by a certain piece of equipment or as the result of adjusting it a certain way?

**Action to be taken if specifications are not met**

Unfortunately, even in the best roasting operations some out-of-spec products are produced. The first thing is to consider if the problem is an isolated case, such as an obvious mistake, or indicative of system wide problems. If it is a roasting problem, was it simply an oversight or problems with equipment or training of the technician? Is the ferment just a single bean or cup or is there a significant problem with the lot itself? The other question is what to do with the product. Some products are slightly off and could be mixed with an in-spec product and still meet specifications. It may be possible to put the product into another blend. However, some out-of-spec products will not be salvageable and may need to be donated.

This level of decision making will directly affect profitability and the reputation of the company. As a result, management must be involved in making this level of decision. In the reporting system, there should be a management level individual responsible for determining the final disposition of out-of-spec samples and this should be a formal part of their job description.

©2007 Songer and Associates, Inc.
The timing of this determination is also important. The management person so charged needs to know as soon as possible so that a timely decision can be made.

The hardest part of this whole process is for the company to admit a mistake has occurred. The usual tendency is to sweep it under the rug, especially if the person in charge of the cause (such as the roaster) is also in charge of the quality control measurement (the roast degree). This relates to the larger problems of corporate culture and labor/supervisor relations, beyond the scope of this article. The most positive outcome of the production of an out-of-spec product is to create a learning experience so that the problem will not re-occur, perhaps by investigating the conditions that led to the problem. Did the roast take too long because the roaster was not hot enough? Was the coffee dryer than anticipated?

**Recording Results**

Quality control is an investment in time, resources, and manpower. If the results are used only once, to determine if a product is in or out-of-spec, the best use is not being made of the information developed. This information developed over time can be used to identify sources of problems, improve the efficiency of the program by applying QC resources where they are most needed, and evaluate skills and consistency of technicians and cuppers.

The relational database is the most convenient way to do this. It is referred to as “relational” because it contains tables (similar to a column in a spreadsheet) containing individual fields (similar to the individual cells) and records (rows) that relate to a single entity or test. These are designed to relate to each other according to the rules set in the database. For example, each sample can be related to a specific series of tests and any number of iterations of those tests (like each roast batch).

The power of this system becomes apparent when one uses “queries” to make reports. A query is a user determined set of parameters. For example, one can get a report on all French Roast samples produced between certain dates, or the entire production from one date, or from one roasting technician. Data mining techniques can also be employed to search for patterns that may not be readily apparent.

Queries can also be used to make spreadsheets, which can then be used to make charts. Relevant information is sometimes more apparent when illustrated in chart form.

Spreadsheets can also be useful in recording data, especially in smaller operations. One can use various sorting tools in the same way that a query is used in the relational database. Design of a spreadsheet system is often simpler and more straightforward. A spreadsheet application can eventually be expanded into a database if necessary since it may become cumbersome with large amounts of data.

**Reporting Results**

The main way information developed from quality control programs is used is the issuance of regular reports. One can compile reports using customized queries and forms developed through the database or use the filtering tools on a spreadsheet. Three issues are to be
considered: (1) what information should be included in the report, (2) how often the reports should be issued, and (3) who should receive the reports.

Information to include: The amount of information to be included in a report should be decided on the basis of its usefulness. Not everyone receiving a report will be interested in the technical details of each sample and the tests they undergo and few are prepared to go through pages of individual results.

A good procedure to summarize totals and give an “Executive Summary” on the first page that can be glanced at and understood. Use of charts as well as tables of results can make the information more accessible. Ideally, the first page of a quality control report should give all readers a good general understanding of the status of the program. Comparisons can be usefully included in reports. Is the quality control improving or are there certain areas that consistently need attention? All information provided should have direct relevance to the quality of products being produced. An executive summary should not be more than 3 pages long, including charts.

However, some departments will want more details. For example, the floor foreman may be interested in the time and place at which certain problems occurred so they can examine potential causes. This information may be made selectively to each department or may be included in a larger report with appropriate references made in the executive summary.

Timing: Certain departments may require more regular reporting so that adjustments can be made, while upper management may be more interested in an occasional (perhaps monthly) analysis. The key is to run a report when actions are most likely to be taken. Issuing reports before company or department meetings can be used to set some agenda items. If a sudden drop in quality is noted, a special report may be needed. When a new piece of equipment is put into service or a different roasting technician is hired, it makes sense to monitor the quality being produced more often.

Who should get the reports: One of the goals of a quality control program is to get everyone in the company involved in quality improvement. As a result, most individuals should get some version (however general) of quality control reports. Floor workers may only need to see a few general charts projected at company meetings, but all those in management, especially those directly involved in supervision of quality aspects, should receive a report, not only because they need the information but they need to know what information is being disseminated. However, one should beware of giving out too much information, especially that of a personal nature that reflects upon individual job performance (except to their supervisor), since this can de-motivate and polarize individuals.
Designing the Q.C. Program

The following is a step-by-step approach to establishing a quality control system in a roasting plant.

1. Determine which tests would be most likely to address anticipated or actual known problems in consistency of product.
2. Determine the points at which testing should occur such that appropriate responses can be made.
3. Determine who should be responsible for sampling and testing. Invite their feedback and observations.
4. Build a database or spreadsheet that will accommodate all necessary tests and products.
5. Put the program into place.
6. Evaluate the resulting data to see if the testing program is in a state of statistical control (i.e., if problems are being caught and handled).
7. Re-design system with more appropriate levels of testing (higher or lower) if necessary.

In setting up a QC program, one first lists the tests that are going to be most useful in predicting and managing the quality of a coffee. Then one draws a flow-chart showing how the product proceeds through the system and the tests and process records that need to be recorded. Make special notes of any particular problems that are already known. A chart known as the “fish bone” diagram is useful in determining which tests should occur at which stage in production. An example is seen in Figure 3.

There should be one general supervisor of the program whose responsibilities include assuring that equipment is operating properly and regularly calibrated, that written test procedures are followed, and that reports are regularly issued. In smaller operations, this person may need to be performing other duties as well, but adequate time should be allowed so that they are able to supervise the program.

The database is designed to reflect the fishbone diagram or other flow chart. One decides at which points in the process that information would be most valuable and designs useful queries and reports.
Figure 3: Fishbone diagram showing progression of testing
Once one has a general idea of what testing needs to occur, how much needs to occur, and how it will be recorded and reported, the individual tests must be considered. The following needs to be considered and written down in specifying individual tests:

1. Who is responsible for performing the test? What training do they need in order to minimize error?
2. What equipment is needed to perform the test? How often does it need calibrated? How easy is it to operate? How expensive is it? When will it need replaced?
3. What facilities and infrastructure (counter space, lighting, electricity, and plumbing) is necessary to perform the test?
4. What are the procedures for performing the test? These should be written out and accessible to all who need the information. Step-by-step procedures can be posted above the station where testing is to be done.
5. When should the test be performed in order that information is received by necessary parties in a timely manner?
6. How, when, and by whom should results be recorded? A roaster asked to fill out process results of their own roasts will always tend to err on the side of “in spec”. The independence and validation of results is important.
7. What are the costs of performing each test, including personnel? What interruptions in production flow occur as a result of testing?

Special Considerations for Sensory Analysis Testing (cupping)

More objective measurements such as roast color or moisture are fairly consistent and dependable as long as the equipment is well calibrated and test procedures are followed. Sensory tests are more subjective due to the variability of cupper sensitivity, experience, and preferences as well as potential variability of products. For this reason, cuppers, samples, and their interactions must be regularly evaluated. Scoring habits and tendencies of cuppers to prefer certain coffees or degrees of roasts should be regularly assessed. This sort of variability does not necessarily mean a cupper is “good” or “bad”, but that their habits should be taken into account or brought to their attention during training. The use of a panel is always recommended in sensory testing because different individuals have different sensitivities to various stimuli. If a panel of different cuppers all give high ratings to a sample, chances are that the coffee will have broad appeal in the marketplace. However, some profitable specialty coffee products appeal to a limited number of consumers and it is possible that these should be tasted only by those who understand and have a liking for these products. In any case, one must know the sensitivities, habits, and preferences of panelists in order to best make use of them on the panel.

Putting the Program into Place

Once one has determined the types of tests to be done and the level testing required for the subject coffee to be in statistical control, the quality control system can be designed. The first decision that must be made is what tests are going to be applied. Physical standards are more directly measurable than sensory standards and, as a result, are more emphasized. However, the initial investment is often greater due to capital investment in testing machinery. Sensory tests, on the other hand, require less investment in machinery,
but take more time and training. A well-trained sensory panel may yield other benefits as well, such as ideas for development of other products or insights into roast techniques being employed. In looking at the initial study, examine which tests reveal the most about a product, which are easiest to perform and incorporate on a day-to-day basis, and their precision and accuracy.

*Involve everyone:* The most effective quality control programs involve all individuals that have a stake in the success of the product. Measurements taken, trends, and analysis of results can be useful to all departments so that variations of product quality and control of the manufacturing process is observed and taken into account at all levels, including management, production, marketing, and sales. Continual up to date information leads to greater comprehension of the problems and opportunities involved in the coffee business and more informed decision making at all levels. Improved product knowledge, wherever it occurs in the company, usually results in better products and greater sales.

*Changes and stages, circles and cycles:* While most roasters and mills agree that quality control is necessary, such programs are often neglected. A common cycle is that a quality control system is put into place, but observed less and less over time until a major problem occurs. The program is again put into place, perhaps with some additional procedures, and the cycle begins again.

Quality control is often perceived as an interruption and a hassle. When initiating a quality control program, it must be presented to the different departments involved as a means of solving their problems as well as increasing the company’s wealth. One way of doing this is to invite their feedback. What information would help them perform their job more effectively? Do they get what they need to know in a timely manner? Is there obvious duplication of effort or other time wasted?

Introducing a new system of any sort will be threatening to some employees, including supervisors on various levels. They may be intimidated by the thought of a new organizational structure, different aspects to consider, more intense supervision, or new procedures. Perceptions of the individuals who actually do the work (roasters, cuppers, salespeople, marketers) should be taken into account in designing a program. It may not be possible to incorporate all suggestions, but if employees have an impression that they have been heard and their suggestions considered it is more likely that they will work to make the program more effective.

The quality control person is rarely the most popular individual with production, since they generally only communicate when there are problems. This can be partially overcome by including their feedback whenever possible and making it as easy as possible for them to conform to the program by scheduling testing so that their work flow experiences a minimum of interruption. It is also necessary to give positive feedback when warranted, especially in more public forums such as company meetings.
Evaluating the program

As noted at the start of this article, most quality control systems are put into place solely to reject products that do not meet set specifications. An equally important function of a well-designed quality control program is to anticipate conditions that will cause rejection. Taking a broad overview at regular intervals can reveal what those conditions are and how they result in out-of-spec products.

The other reason for regular evaluation is simply to see if the program is working as intended. In review, an effective quality control program:

• Can be continually observed
• Is efficient and cost-effective
• Is able to isolate and measure the level of variability of quality perceptible to the consumer
• Produces actionable information that can be easily communicated

In evaluating a quality control program, there are these considerations

1. Is the program cost efficient?
2. What does the program reveal about the quality being produced?

Program Costs

A paradox about quality control programs is that the more effective they are in controlling quality, the less necessary they appear to be. Once one has a sufficient amount of data to analyze, it may make sense to perform fewer tests or to streamline the testing procedure. For instance, if a green coffee was found to be reasonably consistent, the roast times and temperatures were followed, and the roast degree within specifications, it is not necessary to cup the roasted coffee as much. Some occasional testing will still need to be done, however.

Keeping in mind the goals of a quality control program listed above, the following are some of the pitfalls:

1. Too much testing. If one product is able to be produced fairly consistently it is a waste of time and money to test each and every batch. There is also the danger that those responsible for testing may see the program as overly intrusive and their motivation for following it reduced.
2. Testing at the wrong time. For example, if a batch of coffee is over roasted and is already packaged, all of the packaging costs are wasted if the product is rejected.
3. Too little testing. If one only tests one or two cups of a container of coffee, it is not a true indication of the quality of that container. It does not represent a significant cost savings either, since the main cost of sensory testing is the actual convening of the panel, not the amount of time they spend on a single sample.
4. Having one set of standard tests for all products. Some products are simply more variable than others in different ways. Green beans that are not as well prepared may not hold up as well in storage. Natural process coffees are innately more variable than wet process coffees and therefore require more testing.
5. Standards being too tight. It may not be realistic for a roaster to hit +/- 1 Agtron
point of the specified roast or for an importer to always supply green coffee at 11.5% moisture. This is one of the primary reasons that so many quality control programs go by the wayside. If one is finding that the process is in statistical control but that a high percentage of tests are out-of-spec, the standards should possibly be broadened. On the other hand, if it is currently not technically possible to meet standards due to equipment, available precision of testing, or lack of technical training, the situation should be addressed.

As can be seen, a primary issue in efficiently managing a program is the amount of testing that needs to be performed, a function of the level of sampling and scale of the operation. There are two considerations in determining a level of sampling: (1) the actual quality of the product (how closely it meets ideal specifications) and (2) measurement of the variability of the product. This reflects two statistical concepts, the statistical significance of the measurement itself and the certainty of the measurement. The danger is that either a product will be rejected even though it is in spec (Type I error) or that an out-of-spec product will make it through the quality control system (Type II error).

In making the determination if a product is in or out of specifications, one must be sure that the measurements taken are significant, as opposed to random. “Looks brown to me” is not a significant measurement of roast degree. Statistically speaking, “significance” is how sure one is that the individual measurement taken is accurate. If approximately the same results are consistently obtained, then one can be reasonably sure that the test results are accurate. “Significance” is the probability that a wrong measurement will be taken.

The “confidence level” in statistics has more to do with the variability of the measurements, the chance that an out-of-spec coffee will make it through. For example, referring back to the data illustrated in Figure 1, despite the fact that a considerable number of samples were out-of-spec (and it is arguable that these should not go into the marketplace), since 80 measurements were taken and most were within specifications, it can be said with 95% certainty that the Agtron measurement will be between 44.6 and 44.5. As we can see from Figure 1, however, we cannot make this blanket assumption. There is a 5% chance that the coffee will be outside of those parameters. This is revealed only as the result of repeated testing of several iterations of the particular product.

If the operation has been established for some time, there may already be some indications of where problems are most likely to occur. Those who are directly involved with the products, like roasters and cuppers, have a sense of where problems are most likely to arise. In other cases, initial over-testing may be needed to develop enough valid data to make a judgment.

Another source of potential savings can be the point in the production line at which the testing occurs. It may make sense to have an oxygen meter near the packaging line not only so that testing can be done quickly, but problems spotted sooner.
Where are the Problems?

After a certain amount of testing is done, one can use the developed data to see where and when problems are most likely to occur. For a smaller roaster, the patterns may be easy to see by simply examining the data itself. Charts can help understand and illustrate developed data for suppliers, production department personnel, green coffee buyers, and managers at various levels.

Evaluation of Individual Samples

The first step is data exploration on a test-by-test basis to examine the data from several different viewpoints to see if there are any obvious patterns. This can be done either in discrete groups (for instance, over a certain time period) or as a whole. Examples of useful discrete groups are individual coffees, coffees produced during certain shifts, or coffees produced by a certain roaster. An example is shown in Figure 4.

![Figure 4: Roasting problems within a given time period](image)

One can see that the natural process coffees are out-of-spec more often than the wet process coffees. It would make sense to apply more testing resources to the examination of these products.

This is likely to give a good idea of the results of individual tests. By looking at each set of tests, patterns can emerge. Perhaps one particular lot of green appears to be more inconsistent than originally anticipated, resulting in other test failures.

Besides observing individual tests, one also wants to see the “big picture”, especially for making reports that will go to management. One method for doing this is called “Pareto Analysis”.

©2007 Songer and Associates, Inc.
Pareto Analysis and Diagrams

Pareto analysis is based on the 80/20 assumption: that 80% of out-of-spec samples result from 20% of the potential causes. To examine this, first one makes a list of all the out-of-spec samples that were found and why they were out-of-spec. Then a count is done of each cause. It usually makes sense to only include those aspects that have a certain level of observed variability. Finally, a diagram is made of all the out-of-spec causes and the amount that each contributed to the overall quality picture. A typical result can be seen in Figure 5.

![Pareto Diagram](image)

**Figure 5: Pareto analysis of out-of-spec samples**

In this diagram, one observes that two factors relating to shelf life account for the largest number of out-of-spec samples. More testing, machine maintenance, and/or operator training are indicated.

Data Mining

When one has a great deal of information in the database, data mining techniques can be applied. These are special statistical techniques that search large amounts of data for problems that are not immediately obvious. For instance, do roast problems occur at a particular time of year? If a natural processed coffee achieves first crack in only five minutes, is it more likely to roast darker? To what extent does bean size affect roast parameters, or is moisture a more important indicator? It may take a few years of data to see significant results.
Summary

Quality control programs are considered to be “necessary evils” in the manufacturing process. However, properly applied, they can contribute to a company’s ability to compete in the marketplace by having consistent products of known quality. It is especially important in a coffee operation since the coffee itself is highly variable.

The keys to an effective and efficient quality control program are:

- Effective program design that is regularly evaluated and changed as necessary due to changes in raw materials, technical ability of the company, and changes in the marketplace. An important part of this is setting standards for the products being produced.
- Effective execution, doing an appropriate amount of testing and conducting tests according to set standards.
- Including the entire company in the effort. This is partially a function of reports and other feedback.
- Accurate record keeping of test results and regular analysis of data gathered.
- Communication in the form of regular reports to all involved.

This is an outline of some of the general concepts in dealing with quality control. Each business will need to determine what is practical and necessary for individual situations. However, virtually every business that aspires to success will need to apply quality control at some level.