In setting up any control system, it is first necessary to define exactly what is to be controlled; find a precise, accurate, and rapid testing procedure; set up control stations where the tests are to be taken and post results so that action can be taken promptly when needed.

Definition.

In this discussion our problem may be defined as the detection and prevention of bacterial build-up anywhere in the processing line that may result in the production of an unwholesome, spoiled product. Although bacterial spoilage may be eliminated by the application of excessive heat or acidification, such excessive treatments may play havoc with flavor, color, texture, and other quality attributes of the food. The ultimate goal of providing a good quality end product may, therefore, be accomplished only by the use of sanitary materials and by maintaining sanitary manufacturing conditions. These may be controlled by routine testing for bacterial build-up.

Testing Procedures.

The absolute test of the effectiveness of the process is the quality and performance of the finished product. If no cans of product have swelled, or found to be off-flavor, or otherwise adversely affected by unsanitary conditions, then it can be said that the process is under control; however, if some of the cans are lost as a result of swelling or other detrimental changes, the damage will have already been done irretrievably. Thus, the test must be one that will predict rather than measure the final quality and performance of the finished product.

In selecting an appropriate test procedure we must consider not only precision, that is, whether duplicates check out closely; but also accuracy, that is, whether the test does in fact predict the ultimate quality and performance of the finished product. The time required to complete the test is also of major importance. If a test can be performed within fifteen minutes of the time the sample is obtained and the results indicate that some difficulty may be encountered, there may yet be time to change the process to maintain the quality of the finished product. However, if a time lapse of days is required before test results are obtained, large quantities of product may have been manufactured during this incubation period, which may end up in a hazardous, perhaps unsalable condition.

When comparing the plate count method to the direct microscopic method in terms of these three criteria, we find that the plate count method is perhaps more precise, undoubtedly more accurate since it counts only live bacteria, but much slower; the results becoming available generally in no less than 24, usually 48, hours after sampling, whereas, there is no time required for incubation when the direct microscopic method is used.

It should be pointed out that all bacteriological tests, and other microanalytical tests such as mold or insect fragment counts, appear to suffer from lack of precision; that is, reproducibility, when in fact they may be quite precise, but duplicates may vary widely because of the inadequacy of the sample. It should be recognized that the occurrence of such things as bacterial spores or mold filaments in foods is in the nature of a rare accident. Under such conditions the characteristic frequency distribution is the Poison. The standard deviation of the Poison distribution is the square root of the mean occurrence. Thus, for example, a sample having a true average count of 4 would have a standard deviation of the square root of 4 or 2. This means that if one determination were made there would be about 2 chances out of 3 that the actual count would be 4 ± 2, and about 1 chance in 3 that the count would be less than 2 or more than 6. There would even be a remote chance (about 1/100) of the count exceeding 10 or being 0. This chance for error has nothing to do with the precision or the accuracy of the test method itself. It is simply due to the nature of the material which is being examined which no improvement in the method will alleviate. The only opportunity for reducing this error is by increasing the number and frequency of sampling. The more tests that are made, the more closely will the average value of such tests approach the true value for the lot.

In view of the urgency of obtaining results while the product is still in the production line, it is suggested that the plate count methods be reserved for survey types of investigations, such as those conducted by the National Canners Association in order to detect specific sources and locations of contamination. Such investigations may indicate the appropriate place where further routine quality control type testing is to be made, preferably by the direct microscopic method, for no other reason but that the results will be immediately available.
Control Station.

The tests should be made and the results posted as closely as possible to the location in the production line where the problem may exist, and where corrective action can be taken, rather than in a central laboratory which may be far removed from the line.

The complete survey should reveal whether the contamination is introduced with the raw material or other ingredients, whether bacteria grow on surfaces of equipment or are built-up as a result of accumulation of product or water. Surveys most frequently indicate the following equipment as sources of bacteriological contamination: washers, pumps, flumes, pipes, tanks, dewatering screens, conveyor belts, picking tables, quality graders, blanchers, filler hoppers, filler spouts, mixing tanks, blending tanks, boning tables, dicers, closing machines, blanching or cooling water.

The location of the control station can then be established intelligently on the basis of the information provided by the survey. This may consist of one particular spot where the sample is taken, which the survey indicated is a particularly troublesome point in the line or several spots may be indicated, where samples may be removed or material collected in any other manner would be utilized for a direct microscopic count.

How many tests should be made and how frequently they should be made will depend entirely on the precision required, and the probability of a change in the situation. For example, if it is found that a count of less than 6 is satisfactory, and the typical count is ordinarily a value greater than 6 too frequently by chance alone to rely on a single count. In such a situation it would be advisable to make perhaps four or five counts at one time and report average values. All the information available on the characteristics of the process should be utilized to make the counts where and when they will be most useful. For example, if it is known that counts are generally high at the beginning of an operation, or immediately following a meal break, testing should be concentrated at such times. If the use of a new lot of raw material may cause a shift in count levels, testing should be increased at such times.

Reporting.

Results obtained at the control stations should be posted immediately on the control charts so that action may be taken promptly whenever counts go out of control. For the greatest usefulness and likelihood of success, the results should not go into a laboratory notebook only, but should be posted prominently at or near the location where action if needed would be taken. Posting the data in the form of a control chart makes it possible to view the progress of the production operation on a continuous basis, indicating clearly and promptly when action should or should not be taken, and also indicating developing trends which may point to action even before the situation has gone out of control. In Figure 1 is an example of a P chart which would apply to such counts. We assume that the counts on the average are about 5 and in order to obtain the desired precision, we average 5 counts. We set our upper and lower control limits as follows:

\[ 3\sqrt{\frac{c}{n}} \]

where \( c \) is the average count, and \( n \) is the number of tests averaged. Thus in our example:

\[ 3\sqrt{\frac{5}{5}} = 3 \]

Thus, the upper control limit is \( 5 + 3 = 8 \) and the lower control limit is \( 5 - 3 = 2 \). We decide that these five tests should be done at hourly intervals, and come up with the results shown in Figure 1.

Thus in practice we decide to take five samples within an hour period, and post these individual results in the lower part of the Figure, opposite the spaces filled under "Samples", 1...5, for "Time" 8.

We then sum these five counts as shown in the Figure in the row starting with the symbol "x". Next the mean of this sum is obtained by dividing the sum (x) by the number of individual tests (5), and this is recorded in the next line starting with the symbol "\( \bar{P} \)". This mean value is then located on the control chart shown as the upper part of Figure 1, where the vertical axis is the scale of counts, and the horizontal axis is time in hours.

Note that the first set of five tests taken at 8 a.m. averaged 11, indicating an out of control situation which apparently was corrected by 9 a.m. Although the remaining averages shown did not exceed the upper control limit of 8, the trend is unmistakable, thus it would be well worthwhile to take further action by 2 or 3 p.m., without necessarily waiting for a given average to again exceed the count of 8.

Action.

The control chart will indicate when action should be taken. It may or may not point directly to the specific action to be taken. If, for example, the results are taken from a test of a conveyor belt which is continuously dipped in a sanitizing solution, it may be obvious that the solution should be changed or more material added. In other instances the cause of the build-up may not be obvious, so that something of an investigation may be required before the cause of the build-up is found and corrected. The following are some suggestions given by G. A. Vacha,

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Minnesota Department of Agriculture for action which may minimize contamination:

1. Before cleaning dismantle or open the equipment as far as possible.
2. Disconnect lines where possible or open cut-outs to avoid washing debris from one piece of equipment to the next.
3. Remove as much waste as possible with brush, shovel, broom or other appropriate tool.
4. Rinse surfaces to be cleaned with water to remove food residues.
5. Clean surfaces with hot water with an added detergent specifically formulated for the removal of a particular type of soil. Use cleaning aids such as high pressure or brushes to remove tenacious deposits.
6. Complete the cleaning by thoroughly flushing with hot water to remove detergent residues, and finally rinse with cold water to cool equipment below 80°F. 
7. Allow equipment to drain and air-dry.
8. Do not depend on high pressure steam to sterilize equipment; in many instances the steam spreads contamination by blowing it from crevices and cracks onto equipment which has been cleaned.
9. Before resuming operations, sanitize equipment by rinsing or spraying the equipment with a chlorine solution which contains 100 to 200 parts per million.
10. Sanitize in same manner water pipes used for recirculating wash water and for pumping peas, corn, etc., as well as brines and syrup.

11. Avoid contamination of equipment by spatter from floors or from contaminated equipment.
12. Keep hoses used for rinsing equipment off the floor.
13. Make sure that water used for brine, syrups and for cleaning is free from contamination. Water storage tanks must be frequently drained, cleaned and sanitized so as to eliminate bacterial build-up.
14. Thoroughly back-wash and sanitize regularly water filters and water softeners. Bacterial build-up by accumulation and actual growth is very common in such equipment.
15. Eliminate dead ends in water pipes, brine and syrup pipes and pipes used for transferring foods from one place or equipment to another.
17. Provide in-plant chlorination and maintain a chlorine residual of 1 ppm in the plant water supply. Provide controls so the chlorine content can be increased to 25 ppm or higher during cleaning operations.
18. Eliminate scale from the surfaces of pipeline blanchers, water pipes and equipment surface. Such deposits may harbor thermophiles and other types of microorganisms.
19. Keep viners clean so as to reduce the contamination of peas and lima beans.
20. Pea boxes, bins, etc. must be in good repair and washed after each trip to the plant. Rinsing the boxes and bins with a chlorinated final rinse is recommended.
21. Clean daily and sanitize corn huskers and cutters.
22. Replace wooden husker and cutter bins with metal ones, and clean and sanitize daily.
23. Keep cooling tanks clean and chlorinate cooling tanks or canals. Satisfactory chlorine residual is 2 to 5 ppm.
24. During canning and freezing operations periodically rinse equipment, conveyor belts, picking tables with water to prevent accumulation of debris, thereby physically removing large numbers of microorganisms.
25. During a breakdown, rinse off equipment and cool it down below 90°F so as to arrest bacterial growth.
26. During short period shutdowns keep washers, dewatering screens, blanchers and similar equipment running, and cool down to below 90°F.
27. Use only sugar, starch, salt, spices which have been tested and approved by a reliable laboratory.

NEWS AND EVENTS

"AND THIS IS PORTLAND!"
SITE OF IAMFES 51ST ANNUAL MEETING

Portland, Oregon, located near the head of the river navigation for deep-sea vessels, is the Columbia Empire's gateway to the seven seas of the world. It is a thriving industrial and seaport city of some 402,300 people, a transportation hub of rails, steamship and airplane routes. Majestic Mt. Hood, 62 miles distant, 11,245 feet high, snow covered the year round is clearly visible from the city.

A CITY is a horde of natives in an orderly jungle, its air heady with the pungent perfume of industry and raucous with the cry of the untamed taxicab.

It is a seat of government, a hub of commerce, a center of entertainment and learning, and a rainbow terminus where some find a pot of gold and some find a pot of free mission stew.

It is churches and theaters, parks and parking lots, freeways and alleys, hotels and suburban Edens. It is a potpourri, spiced by variety.

To the dweller in this concrete honeycomb it's a place to take a vacation from (but to return to inevitably with fascination), and to the country dweller the city is a mecca to visit as often as an excuse can be found.

All of these things are of a metropolitan atmosphere. But a city can have something else — undefinable but perhaps best called personality. It is this intangible attribute that inspires people to refer to a population center as "The City," with the capital letters apparent even in their speech.

Every state has at least one such metropolis. In