SYMPOSIUM ON SAMPLING OF BULK MATERIALS

INTRODUCTION

By W. Edwards Deming[1]

This symposium has been arranged by Task Group No. 7 on Bulk Sampling of ASTM Committee E-11 on Quality Control of Materials. The assignment of this task group is to study the sampling of bulk materials. Specifically the assignment reads as follows:

"To study and report on the problems of sampling materials that occur in bulk form or in packages, with the aim of estimating, at minimum cost, measurable characteristics of a quantity of material in order to get some prescribed limit of error with an assigned probability. Special attention should be given to the three problems:

1. To describe a method whereby bulk materials can be sampled to produce knowledge of average with measurable error.
2. To describe a method of sampling whereby constancy of property within the bulk can be determined.
3. To describe a method of handling bulk materials whereby the desired constancy between incremental portions at the point of consumption can be maintained."

The sampling of bulk materials is one of the most important technical problems in industry. Vast sums of money change hands every day on the basis of samples. A tremendous amount of ingenuity has been put into the problems of sampling, for many years. As a student in mechanical engineering I used a shovel to mix a large pile of coal, put it into the form of a cone, flatten it, quarter it, and repeated the process, finally using a spatula to produce a sample of a few ounces which supposedly represented the original pile of coal. It is amusing to reflect back 35 years to see how little sampling has changed in some respects, and yet how much progress it has made in other respects.

The sampling of any material is partly statistical theory and partly manipulation or engineering. Some people think that the manipulation of a material is the really difficult part, whereas others are inclined to think that the theory is the more difficult. The boundary of any science is, of course, the basic theory, and practice is oftentimes a long way behind the boundary.

Probably no branch of science has expanded so rapidly and outgrown its shell so many times in the past 10 years as the science of sampling. In the theory of quality control, in manufacturing, and in acceptance sampling, great growth and progress is obvious. In the sampling of human populations probably even greater progress has been made. Indeed the sampling of human populations (by which I mean the collection of census information, so vital for the defense, expansion of industry and marketing, market research, monthly indexes of prices, agricultural estimates, monthly wage rates, monthly turn-over, condition of crops, etc.) has reached the stage where the procedures and the language

[1] Co-Chairman Symposium Committee; Office of the President, Bureau of the Budget, Washington, D. C.

for describing these procedures have become pretty well standardized worldwide: such samples are expected today to meet certain levels of performance in order to be acceptable for decisions in commerce and government.

People who are working in social and economic surveys often remark that the sampling of physical materials must be a much easier job because a particle of material must come to you to be tested when you call it, whereas with people and farms and banks you have to find them and persuade them to give you the information that is wanted. Likewise, people who deal with the sampling of physical materials imagine that the sampling of human populations must be a great deal easier because the units are individual people, farms, banks, manufacturing plants, and are easily definable—at least that is the way they argue. But did you ever try to define a farm? Did you ever try to figure out how to define the units of a big manufacturing concern for the purposes of getting census information?

In my own experience I seldom see any sampling problem that is easy. I should say that sampling problems are as difficult in human populations as they are in the sampling of physical materials. They are both pretty nasty problems sometimes. It must be admitted, though, that from the standpoint of manipulation or engineering, the sampling of human populations has gone a long way. I would not agree that this is because such problems are more difficult. Such progress merely represents more effort, and a fundamental desire to improve practice.

Take the problem of acceptance sampling. The theory of acceptance sampling is based on the assumption that random samples of items are drawn from a lot. Yet I wonder how much attention has been paid to the actual random sampling of items from a lot, in the use of single, double, and sequential sampling plans.

In almost every problem that I meet in sampling, whether it be in the sampling of human populations or in the sampling of physical materials, I am appalled by the difficulties and restrictions. I also always develop a sincere and deep-rooted reverence for the men who have devoted years to the engineering aspects of the problem, and a deep respect for the progress that they have made ofttimes without the use of statistical theory.

The statistical method has arisen quite naturally from the increasingly exacting demands of industry and government for reliability, economy, and speed. The fundamental quality of a statistical method is reliability, although economy and speed are usually important by-products. A statistical sampling plan is one which delivers an unbiased result with a controllable and demonstrable index of precision, usually expressed as a standard error. Statistical calculations cannot be used, and are not used by statistical experts, unless the material can be so manipulated that the theory is applicable and so that the result is statistically unbiased.

It is recognized now that the dangers, the risks of biases, and the lack of a controllable and demonstrable index of precision in a judgment sample are too great to be faced without a struggle. The use of statistical techniques offers more reliability, speed, and economy, and above all, a result whose quality is known. We should remember that the cost of a sampling plan cannot be discussed without reference to the quality of the result.

The consideration of cost is the prime problem for the statistician. Through the use of theory the statistician is always able to devise several plans of sampling, all of them unbiased, or at least with

negligible biases, and all of them with controllable and demonstrable precision. The cost of the various possible methods, however, will usually be greatly different, and he will choose that one which shows promise of delivering the precision that is wanted, at the lowest cost. If the lowest cost is still more than the material is worth, or is more than someone is willing to pay, then some other type of sampling must be used. In the case of a pile of coal, the cost of an adequate unbiased sample would be so great that we might as well forget about it. Anyone can take an unbiased sample by a statistical sample if he has enough time and money.

In many cases it may pay to spend a bit more money in the handling of a material in order to save many times this added cost later on in the sampling of the material. Real effort in this direction will yield results, as it has with other types of problems.

This symposium was organized by Mr. Charles A. Bicking who, up until today, has been quality control engineer with Hercules Powder Co. Within a few days he will begin an assignment with Brigadier General Leslie E. Simon, Chief of Research and Development, Office of the Chief of Ordnance, in Washington. He has arranged the discussion on each paper so that criticisms and comments will come from both engineers and statisticians.

This task group has been in existence for about 3 years and during that time has held several meetings to which anyone interested in the subject has been most welcome. Much of our inspiration has come from visitors. The ground plans for this symposium were laid a year ago when this task group met in an all-day session at the Westinghouse Company in Pittsburgh. During the three years since this task group commenced to work, several papers have appeared in journals from its members. Some of these papers have affected very profitably certain engineering practices in the sampling of materials.