I would like to express my appreciation for the invitation to appear before this distinguished group and I hope that this material will be of interest to you despite the relatively elementary nature of the subject matter.

I have been asked to discuss with you the present status of the application of statistical quality control techniques in the meat industry, with particular emphasis on the relationship of these applications to production, packaging, merchandising, and regulatory activities. This is a very broad subject and you will be relieved to know that the presentation is to be limited to 20 minutes. Therefore, it is my intention to present a brief discussion of the various statistical quality control applications in the meat industry of which I am aware, and if additional information regarding any particular application is desired, I will be happy to discuss these with you in greater detail during the question and answer period.

In order to define the scope of the problem I thought you might be interested in some yearly industry production figures for the meat industry. I should add that the figures that I will give represent only the federally inspected production. The percentages of the various types of meat product which are produced under federal inspection vary from an estimated 85% to 90% for fresh meat to 60% to 65% for sausage products.

During 1964, there were 25 million head of cattle and 72 million head of hogs slaughtered in federally inspected establishments. These animals produced 15 billion pounds of beef and 10½ billion pounds of pork, 3 billion pounds of lard and rendered pork fat, ½ billion pounds of tallow and 1 billion pounds of margarine and cooking compounds.

The processed meat industry used these raw materials to produce:

- 2,577,000,000 lbs. of Smoked Cured Pork
- 1,152,000,000 lbs. of Sliced Bacon
- 2,698,000,000 lbs. of Sausage
- 2,037,000,000 lbs. of Canned Meats

As a matter of additional interest the total sausage category breaks down to 295,000,000 lbs. of fresh sausage, 149,000,000 lbs. of dried and semi-dried sausage, 774,000,000 lbs. of wiener and frankfurters, 776,000,000 lbs. of other cooked sausage, 234,000,000 lbs. of loaves and 470,000,000 lbs. of sliced and packaged sausage and loaves.

As you can see from the foregoing data the meat industry produces a tremendous volume of inherently variable, extremely perishable and
relatively expensive products. In addition, there is a vast array of variations, types, classifications and qualities of meat products. It is not unusual for a large meat processor to produce several hundred or more different meat products.

It is obvious from the above that anyone so foolish as to get into the meat processing in the first place must have control of his operations if he is to have a successful business. It is equally apparent that the combination of large volume and small package sizes provides a ready application for statistical sampling and control principles. Fortunately, the statistical principles and techniques used need not be complicated. Only an understanding of control chart theory and familiarity with the meaning of simple such terms as normal curve, variance, standard deviation, probability and the like is necessary. Actually, a thorough understanding of the characteristics of the normal curve is all that is required to make many profitable applications in the meat industry.

The most common application of statistical quality control techniques in the meat processing industry is their use in quantity control of packaged products. In this connection it may again be of interest to note the vast quantity of these types of products produced. From the information presented earlier I have estimated that the federally inspected packers produce in excess of three billion consumer size packages yearly.

These packages must comply with the various state and federal regulations. For example, M.I.D. requires:

(1) The average net weight of the product checked should equal at least the stated net weight.

(2) There should be as many overweight packages as underweight packages.

In addition, M.I.D. instructions to their inspectors state, "systematic controls shall be maintained at all times to check the quantity of contents. It is not practical to state definitely how many units per hour or per carton should be weighed or measured, owing to many variable factors. Inspectors, however, must assume the responsibility of this labeling to the fullest extent, making such tests as are necessary." M.I.D. is interested only in assuring that the product is at marked weight at the time it leaves a federally inspected establishment.

Of greater concern to an interstate packer are the state weights and measures laws. Fortunately, the National Conference of Weights and Measures is making considerable progress in obtaining uniformity among the various states both in their statutes and in the regulations promulgated to implement these statutes.

A typical state law would read in part as follows:

"It is unlawful to keep for the purpose of sale, offer or expose for sale, or sell, any commodity in package form unless the net quantity of the contents be plainly and conspicuously marked on the outside of the package,
in terms of weight, measure or numerical count; provided, however, that reasonable variations or tolerances shall be permitted, and that these reasonable variations or tolerances and exemptions shall be established by rules and regulations made and promulgated by the Department of Agriculture."

The National Bureau of Standards has developed model regulations for checking pre-packaged commodities which define the method by which packaged products are to be checked to determine compliance with the law. Again, many states have adopted these model regulations and it is hoped that all will do so in the near future. The model regulation presents a method of control of pre-packaged commodities for use by state and local weights and measures officials which is based on two concepts:

"(1) Variations in quantities of packages are not permitted to such extent that the averages of the quantities in the packages comprising a lot shipment or delivery is below the quantity stated and an unreasonable shortage in any individual package is not acceptable even though overages in other packages in the same lot shipment or delivery compensate for such shortages."

"(2) Perfection in either mechanical devices or human beings has not yet been attained; thus the existence of imperfection must be recognized and allowances for such imperfection must be made. These allowances are recognized in the average concept."

The majority of the weights and measures regulations then require that the average weight of a sample of product obtained in the retail store must equal the marked net weight and that there should be no unreasonable underweights. An unreasonable underweight is proportional to package weight as defined in the model regulation. However, for purposes of illustration an unreasonable underweight on a one lb. package is one which is more than 1/4 oz. less than marked weight.

In setting up a statistical quantity control system it is first necessary to determine the inherent variability of the process before establishing the average overfill. However, there are other important factors which must be considered in designing the system. For example, one must know the shrink or loss in weight which the product will experience between the time of packaging and the time of sale, and overfill an additional amount to compensate for it. Since shrink is normally proportional to the age of the product, the shelf-life of the product and the average age at which the product is sold are additional factors to be considered.

Investigation of these factors often leads to the development of improved packages to reduce the quantity of shrink for which it is necessary to overfill. However, package changes may be accompanied by unforeseen results. For example, at Oscar Mayer & Co., we were able over a period of time to reduce the shrink characteristics, and therefore the overfill, of our former "tray style" bacon carton to an acceptable level, but we anticipated a further reduction in overfill upon conversion to the new sarangac
vacuum package. We were surprised to learn that the intimate contact between the film and the bacon, as a result of the vacuum employed, caused a film of bacon fat to cling to the film when the package was opened. The amount of product adhering to the package more than offset the savings in reduced shrink, and we actually had to increase our overfill slightly over our standard for the previous package.

In addition to the moral and legal obligations of providing full stated weight to our customers, there are also important economic considerations. For example, if because of lack of control, the meat processing industry were to include 1/32nd oz. (.06 of a pound) extra in the 3,000,000,000 lbs. of processed meats produced annually, it would cost the industry 24,000,000 lbs. or an estimated $9,500,000 yearly.

In an individual company the installation of a statistical quantity control program invariably provides substantial savings as well as increased protection. In the case of my own company, the savings obtained as the result of the application of S.Q.C. to pre-packaged product weights approximately 15 years ago, were sufficient to pay for the additional help required to perform the statistical quality control, and the entire quality control program as well.

In addition to quantity control, statistical procedures are used in quality control as well. Similar principles apply except in this case we are dealing with techniques which relate to attributes. Attribute systems are very important in the quality control field as they provide the opportunity to express subjective product characteristics in numerical terms. Usually these are in terms of defects, percent defective or demerits. The demerit systems are normally employed when defects of different degrees of seriousness are being considered. For example, the defects which normally occur in a given product are often classified as critical, major or minor, and are assigned appropriate demerit weights.

In setting up a quality control system based on attributes it is necessary for the sales or marketing divisions to interpret the relative seriousness of the known defects in terms of their possible effect on the sale of product. Standard levels are then drawn up with appropriate control limits. These defects are associated with such factors as quality characteristics of the meat product itself, workmanship factors in assembling the package and packaging characteristics.

The following slides illustrate how meat quality, workmanship and packaging defects are defined in cooperation with the sales department. The first slide demonstrates the maximum amount of internal fat which is permissible on the cut surface of a boneless half ham. The next slide shows the maximum amount of smearing of pork sausage which is allowable. The third slide illustrates a workmanship defect - in this case a critical shingling defect on sliced bacon.

In addition to assuring the production of a uniform product at the desired quality level, the employment of statistical quality control techniques can also provide valuable information for in-process control by identifying factors which require corrective action, and by providing a measure of the effectiveness of the action taken. An example of this type of application would be the analysis of packaging rejects to determine the
frequency of the various causes. A standard frequency can then set up on each cause and control limits calculated.

Statistical quality control data often provides a basis for making improvements in the quality of the product when designing new equipment. In my own company, the design of new continuous wiener processing equipment is a case in point. Conventionally produced wiener are subject to an undesirable degree of weight, color, length and diameter variation. Also, a certain number of the wieners have marks where they hang over the smoke sticks and we are not always able to get our production workers to place these wieners in the package with the stick marks down.

In the new continuous processing unit the product uniformity has been much improved to the point that the weight is controlled exclusively by sampling and statistical quality control, and it is not necessary to have a single scale in the production line. Color variation has been eliminated, as has size variation, and there are no stick marks.

Statistical quality control techniques can also be usefully applied in the slaughtering, cutting and boning operations. These systems may be based on either variables or attributes depending on the particular application. All that is required is to first define the factors which are to be measured or compared, and then set up the frequency of the sampling in order to gain the degree of control required.

Typical examples of the application of statistical quality control on the killing floor might include checks for effectiveness of immobilization, accuracy of sticking, splitting of carcasses, head trimming, etc.

On the cutting floor, S.Q.C. techniques have been used to control the point of division of the carcass between the shoulder and the remainder of the carcass, between the ham and the remainder of the carcass and between the belly and loin fatback portion. It is desirable to make cuts accurately, since there is certain latitude in the position at which the cut can be made, and often the difference in value between the primal cuts on either side of the line of division makes it advantageous to favor one portion over another.

This point is illustrated by the following slide:

Here you see a 200/210 No. 1 hog with a value of $22.50/cwt. live. On the market that was in effect at the time this slide was prepared, the various primal cuts had the values shown. You will note that there is considerable difference between the value of the loin and the ham which lie on either side of the line separating D and G. There is an even greater difference between the value of the Boston butt and the loin which lie on either side of the line separating B and D. The cuts represented by these lines can be varied within certain quality limitations and it is economically desirable to calculate the cutting procedure which will achieve maximum value and then control the division at the desired points. S.Q.C. procedures can be used very nicely to control this sort of operation. In the illustration shown the ham would be favored over the loin inasmuch as the ham section coverts to ham at approximately 50 percent
whereas the yield of loin from the loin section is about 50 percent. Further, the loin would be favored over the Boston butt. Therefore, in this case we would cut a so-called long ham and short shoulder.

Other useful applications of S.Q.C. are in the control of ham trimming, ham shank lengths, loin trimming, belly trimming and weight grading.

Moving through the slaughtering operation to boning and defatting, S.Q.C. principles have been used to control such things as cleaning of bones, presence of small bone fragments or other undesirable materials in sausage trimmings and trimming of primal cuts for such factors as depth of fat, beveling of the fat, percent of collar, etc.

S.Q.C. principles are also used in the meat industry to assist in purchasing decisions and to control processes on the basis of laboratory and analytical results. Applications of this type include control of the composition of trimmings by blending, and periodic sampling and analysis, with the use of appropriate control limits. Analysis of trimmings is also used in checking the purchases of trimmings from other suppliers. In this case random samples are drawn from purchased loads and a statistical acceptance sampling plan employed to determine whether the purchased lot is acceptable or rejectable. Similar plans are in use to control the purchase of non-meat ingredients and supplies such as cans, packaging materials and the like.

The meat inspection division is also increasing their use of analytical controls and they are particularly interested in cases where off-premises analyses can be made to check the effectiveness of their on site inspection. As the M.I.D. moves in this direction, industry is in many cases cooperating to help develop the necessary analytical relationships, but is insisting that M.I.D. take full recognition of the variability of many of the meat products and employ appropriate statistical limits. For example, a system to control added water in sausage products was worked out jointly by industry and M.I.D. several years ago. This control procedure has worked very well with a minimum of difficulty on either side because the statistical limits employed allow for the unavoidable variation inherent in sampling and analysis of the product.

On the other hand, the control procedures in effect for cured and smoked pork products have been in almost a constant state of flux and have been a source of irritation to both the M.I.D. and industry because of dissatisfaction with the system on the part of both groups. Industry's dissatisfaction stems from the fact that M.I.D. was loath to permit the proper statistical limits - mainly because these products vary much more widely than sausage products, and, hence, the limits appeared to be too wide to the M.I.D.

I have a slide which shows the system presently in effect for canned hams and which represents the type of controls employed for all cured and smoked pork products. In this case, a ham analyzing between ±4.0% added substance may move freely whereas results of 4.1 to 5.1 require that the process be immediately corrected to reduce the added substance. If the analysis is over 5.1 added substance the product is
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retained. Similar limits are in effect for a running average of 5 samples. If the average does not exceed 1.8 added substance the product may move freely; if it falls between 1.9 and 2.3 the process must be corrected, and if it exceeds 2.3 the product is retained.

This system is based on a study conducted jointly by industry and the M.I.D. from which a within lot standard deviation of 3.5 was calculated. A comparison of this value with the out-of-control point of 5.1 illustrates the reason for industry's dissatisfaction with this control procedure.

In summary, I would like to emphasize that while statistical quality control procedures are important in controlling the operations to which they are applied, they are perhaps even more valuable because of the information which they provide for management decision. I believe that the word "management" implies control. No manager is truly managing his operation unless he has accurate knowledge of the output of his operation and the ability, by decision, to alter his output by a predetermined amount. Statistical quality control techniques readily provide this type of control at a minimum of expense.

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DR. ROBERT SAPPLE: Thank you, Don, I think that all of us now have a much better understanding of many of the applications of Statistical Control and you have stimulated our thinking along this line into additional areas. I think one of the things that come into statistical control is that we must have means of measuring, which Don has indicated, and our next speaker is to cover some of the methods of measuring the chemical analysis of products considering the variations. Dr. W. A. Landmann was to cover this, he was with the A.M.I.F. and now is Meat Chemist at Texas A & M and, unfortunately, due to a death in the family, could not be here with us. However, Professor Robert Hostetler from Texas A & M is here to give his paper. Robert Hostetler received his M. S. degree at Purdue University and he is now on the staff of Texas A & M. The subject to be covered is "Methods of Sampling Various Meat Ingredients with Respect to Accuracy, Precision and Limitations of Rapid Methods to Determine Moisture, Fat and Protein". Obviously, this is a broad subject and could not be covered fully in the time period. In our correspondence, we agreed to try to cover as much as possible but to only emphasize one or two specific examples. Professor Hostetler.