MEASUREMENT CHARACTERISTICS OF THE FARM MILK TANK [1]

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For the purpose of this discussion, farm milk tanks will be considered only as measuring devices. The operational elements that affect measurement seem divisible into four principal phases: (*a*) design and construction, (*b*) installation, (*c*) gaging, and (*d*) use. The official test, when it is conducted, is an overall look at all four of these phases. Before exploring measurement in detail, a look at the farm tank's history is revealing.

When the tank first became a factor in the commercial measurement of raw milk, its accuracy was of no more than passing interest, probably because of the other advantages offered, and perhaps even because of the novelty of this method of milk handling.

As time has passed, the measurement function of the tank has received increasing attention, and, as a result, a further look seems now warranted.

The first bulk milk route was established in 1936 in the Oakland, California, milk shed. Growth was quite slow at first; in fact, as late as 1954 there were only 13,000 tanks in the United States, with more than 40% of these located in California, Oregon, and Washington. In the six years between July 1, 1954, and July 1, 1960, more than 139,000 new tanks were installed, an average of 23,000 per year. This rate, according to the National Association of Dairy Equipment Manufacturers, is being maintained.

As routes were established in California, the county weights and measures officials decided that the tank was a commercial measuring device and accepted legal responsibility for accuracy. A practice was founded then that still prevails in a few States—the practice by the weights and measures official of actually gaging (or, as some term it, calibrating) the tanks.

Soon the number of milk tanks in California increased to such an extent as to demand attention from the State Department of Agriculture, and a performance code was written, this code having statewide authority.

By 1952 the use of farm milk tanks had spread east and their accuracy was becoming a matter of concern to regulatory authorities in many States. It was at this time that the attention of the National Bureau of Standards was officially drawn to this new method of milk handling.

In this connection, the role of the Bureau probably should be delineated. As is generally known, the National Bureau of Standards is responsible for the basic units and the national standards of measurement. Among its duties are the refinement of measurement throughout the Nation and the cooperation with the States toward uniformity of weights and measures laws and methods of inspection. Examples of the Bureau's contributions in the weights and measures area are the calibration of State standards, the development of testing equipment and procedures and of specifications and tolerances for devices, the solution of special measurement problems, the preparation of model laws and regulations, and the conduct of technical training for State and local officials. In addition, the Bureau sponsors the National Conference on Weights and Measures—an organization of weights and measures officials that meets annually in Washington to consider model laws and regulations and to hear and participate in discussions on technical matters. The Conference-adopted codes of specifications, tolerances, and regulations for commercial weighing and measuring devices are published by the Bureau as a handbook and recommended to all States for official promulgation.

By the year 1953 a tentative code for farm milk tanks was presented to the Conference, and in June of 1954 the final version of the code was formally adopted. This series of design and performance requirements now has been given legal status in a great majority of the States and thus has provided positive guidelines in measurement characteristics to manufacturers of farm milk tanks. (This is not, of course, to say that all tanks are designed, manufactured, or installed in compliance with code requirements.)

An examination of the tank as a measuring device will point up certain weaknesses. The precision of gaging, testing, and reading is a direct function of the horizontal cross-sectional area of the tank at the point the reading is made. For example, with tanks of current design, the greatest precision one can expect in the measurement of the product is to about 1/3 gal on a 150-gal tank, 2/5 gal on a 300-gal tank, and 1 1/5 gal on a 1,000-gal tank. In the language of the milk processor, with his 8.6 lb-per-gallon conversion factor, this would be about 2.9 lb on the 150-gal tank, 3.4 lbs on the 300-gal tank, and 10.3 lbs on the 1,000-gal tank. Now, when one assumes additionally the inaccuracies introduced by out-of-level, imprecise gaging, cold or unclean rod, and

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careless reading, it is easy to conclude that the modern farm milk tank is a very poor measuring device.

Experience seems to indicate that the contrary is true. One happy trait of uninfluenced errors is their tendency to fall into a random pattern. It is frequently found, for example, that plus errors tend to cancel minus errors. Inventory control records of processing plants seem to reveal that farm-tank measurement is quite good. Tolerances legally established in most States at individual points on the gage rod range from 0.2% to about 0.5%; whereas similarly established tolerances on the milk-intake scale may range from 0.1% on loads over 1,000 lb up to 1% on small loads, depending upon the weight value of the minimum graduated interval on the indicating element of the scale.

Returning now to the four phases that affect measurement, these can be subdivided in an orderly arrangement, and the interrelations then can more clearly be seen.

Design and construction.

Rigidity. Obviously any distortion in the bottom or walls of a tank will adversely affect its measurement characteristics.

Horizontal cross-sectional area. The greater the horizontal section of the tank, the lower the order of precision of measurement.

Design of measurement gage elements. The gage rod must be straight, rigid, and easily readable. It should have a dull surface. The graduations must be straight, clean, and fine. An empirical numbering system is preferred to an inch-and-binary subdivision system. The gage bracket should be rigidly and firmly attached and should provide a positive seat for the gage.

Location of gage. The nearer the center of the tank the gage is located, the less the inaccuracy caused by any out-of-level condition of the tank.

Level-indicating means. Farm milk tanks are required to be so designed as to facilitate the reading of the level condition of the tank. This requirement can be met by providing one or more spirit levels or a plumb-bob or by having the top edges of the tank constructed as a level "base." Particularly on a tank with the gage located at the end, this level-indicating means must be sensitive and accurate.

Installation.

Foundation. If a tank is to provide repeatable accuracy, it must be installed on a floor that is firm and that provides proper support.

Level. On a 300-gal tank an out-of-level condition of only 1° may cause an error in reading of as much as 7 gal, or as much as 60 lb. Whether the tank is gaged at the factory or on the farm, the level is critical.

Illumination. Obviously there must be sufficient light to insure accurate reading of the milk level.

Tank gaging.

Standards used. Any liquid measures used in the gaging of farm milk tanks should be of proper design and should be tested and certified. On a 300-gal tank, for example, a 5-gal measure is filled and emptied 60 times. An error in the measure of only 5 cubic inches—less than one-fortieth of a gal—would result in an inaccuracy in the tank chart of approximately 1 1/3 gal at tank capacity.

Procedures. A tank should be gaged according to accepted methods and with extreme care. The surface of the liquid in the tank must be perfectly still when a reading is taken. If two individuals are involved in the gaging process, their readings should be taken independently and any difference reconciled before more liquid is added to or taken from the tank.

The gage rod. During the gaging operation, the rod must be absolutely clean, it must be approximately at the temperature of the surrounding air, and an appropriate dusting powder should be used to ease the reading of the water line. Even this dusting compound must be selected with care, since certain dusting compounds have been found to falsify the liquid level.

The use of the tank as a measuring device.

Level. The tank must be in level when a reading of the liquid level is taken.

The gage rod. For accurate measurement, the gage rod must be clean and dry and must not be colder than the surrounding atmosphere.

The reading. The liquid level line on the gage rod must be read only when the surface of the milk is completely quiet and read with considerable care. The chart should be referred to immediately following the reading and the chart value recorded at that time.

In spite of the advances made in the farm milk tank and its use, several problem areas still exist. Principal among these is the level condition of the tank.

The States have taken two diametrically opposite views in connection with the maintenance of level of a tank. One group, undoubtedly a minority, rules that the tank legs must be firmly and permanently cemented to the milkhouse floor. The second group, accepting the recommendation of the National Conference on Weights and Measures and the National Bureau of Standards, permits the legs of the tank to be free, but requires that the tank be equipped with a sensitive level-indicating means and be maintained in level. With floor-settling and frost-heaving, the latter view seems the sounder, but it does impose

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on the producer and the pickup driver the responsibility of checking the level condition and at times correcting an out-of-level condition.

Of major concern to measurement experts are three matters involving the gage rod and values obtained from it. In the early design of the rod, it was quite reasonable for manufacturers to graduate in inches and binary subdivisions (halves, quarters, eighths, sixteenths, and thirty-seconds), because the rod was considered simply a linear measure. However, since dimensional length in customary units has absolutely no relation to level-of-liquid readings, it was suggested a number of years ago that the evenly spaced graduations on the gage be numbered empirically — 1, 2, 3, etc. — in order to reduce errors in reading and recording the values. (One is less likely to err in reading and recording a whole number as, for example, 285, than a number and fraction such as 17 13/16.) There seems to be little progress along this line.

A serious problem was encountered and identified when a large Chicago processor noted inventory shortages in farm-tank pickups. A study at the National Bureau of Standards determined that condensation on a steel rod, cooled to milk temperature and then exposed to a warmer atmosphere, would cause high liquid-level reading (greater gallonage) in the order of one to two graduations. This is exactly what happens when the air in a milkhouse is humid and is warmer than the milk in the tank. The rod is removed from its bracket, wiped dry, reinserted for a liquid-level determination, and then removed for the reading. Between the time the rod is wiped dry and the time it is reinserted in the milk, the moisture in the air condenses on the steel surface and causes the high reading.

The National Conference Code for Farm Milk Tanks was amended in 1956 to require that a gage rod be stored outside the tank until it is inserted in the milk for a measurement. It appears that, except in the States of Maryland and Pennslyvania, this requirement is being generally ignored for any of a number of reasons. The inevitable result is inaccuracy.

The third problem involving measurement is one that technically is very easily solved, but that is in many States unsolved, apparently because of tradition. Since the farm milk tank is a liquid-measuring device and not a weighing scale, weights and measures officials have generally agreed that it would be inappropriate to certify the accuracy of a tank-gage-chart combination in terms of pounds. On the other hand, milk producers and processors have maintained the position that raw milk has been marketed by weight and that, with an 8.6 lb-per-gal conversion factor, it is quite proper and more convenient to continue to use the pound as the unit of exchange.

The Model Code of the National Conference on Weights and Measures provides that the chart "shall show gallonage values only," so, where the code is being enforced, there will be found in the milkhouse two charts—one the official chart with values in gallons, the other the chart that actually is used, with values in pounds. In certain other areas charts will be found with both gallon and pound values. In the third group of States (representing probably the majority), there will be no gallon values at all.

It does seem a bit peculiar that an industry that has accepted an entirely new system of handling its basic raw material refuses to accept a change basic to accuracy in measuring this material. Raw milk does vary in specific gravity and, accordingly, in pounds per gallon. Surely it must be conceded that, if the total transition to volumetric marketing could be accomplished, there would be far less confusion and even greater precision in the measurement and payment for the product.

Another reason that has been given for holding to the marketing by weight is that butterfat determinations and evaluations must be made gravimetrically. This, of course, is not the case, since the butterfat test results in a percentage, and percents of gallons can be taken just as easily as can percents of pounds.

There remains to be explored one other aspect of the measurement picture of farm milk tanks today. This is the control of the devices by the various regulatory officials who enfore weights and measures laws.

In this connection, the States can be divided into four distinct groups: *(a)* those who exercise complete control; *(b)* those who control by a sampling technique; *(c)* those who provide a referee service; and *(d)* those who disregard the farm tank as a measure.

Those States that exercise complete control over farm milk tanks go so far, even, as to gage the tanks and prepare the charts. The weaknesses of this approach are the cost to the public and the unanswered question, "If the official gages the tank, who is going to check his work?"

What seems now to be the most efficient method of official control is exercised by the second group where the tanks are expected to be installed with an accurate chart by the manufacturer or his agent and maintained properly by the owner. The official, on a predetermined, but unannounced, schedule, carefully tests tanks on a sample basis. If trouble is found in tanks from one manufacturer, concentrated effort is directed to his tanks.

The third group operates on the premise that the farm milk tank is a more or less "private" measuring device, involving only one seller and one buyer. The public has no general interest. So long as the pro-

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ducer and the processor to whom the milk is sold are satisfied, no official attention is given. If difficulties arise, the official is available as a referee and may, if the situation so indicates, test a tank. In this case, the code requirements are applied and the tank is approved or rejected on the basis of conformance or nonconformance to code requirements.

In the last group of States, the weights and measures officials say that the farm tank is a device for measurement in fulfillment of the terms of a private contract and thus has no official status and is of no concern to the public. The farm tank is, in effect, ignored officially.

That, briefly, is the situation today. What about the future? Undoubtedly, the most significant advance in farm-tank measurement would be the development of a liquid meter designed for truck mounting and sufficiently accurate to meet legal requirements. The regular, periodic, official testing of such a meter would be a simple matter, and the total costs involved should be substantially less than the cost of the gage, gage bracket, gaging chart preparation, and official testing of the many tanks serviced by one pickup truck.

The engineering problems faced by a meter manufacturer are formidable. In the case of each measurement—that is, milk from each farm tank—the delivery must start with an air-filled line and must remove all the milk from the tank and the line. The positive-displacement liquid meter in use throughout commerce today registers the passage of air just as it registers the passage of liquid. So, one major problem is the separation and elimination of both free air and air that is entrapped in the fluid milk. A second problem relates to sanitary requirements and is outside the purview of this discussion.

One meter manufacturer claims to have overcome the difficulties and is said to be offering a meter for service on farm-tank pickup trucks. This meter, it is believed, has not been submitted for official test to any weights and measures agency.

Whether it is this manufacturer or another who succeeds, it reasonably can be assumed that meters will be developed and will lead to less expensive and probably more accurate measurement of the milk on the farm.

One rather serious problem in farm-tank measurement has recently arisen. Milk processors, in an effort to exercise more precise control over their raw material, have weighed, either over a vehicle scale or through the intake scale, or have measured through an in-line meter, the tank-truck loads of milk picked up from farm tanks and compared these results with the totals derived from gage-rod measurements. Discrepancies thus have been discovered. Too frequently the immediate conclusion has been that the gage-rod measurements on the farms were inaccurate. It is probable that such a conclusion is not warranted.

In the case of actual vehicle-scale or intake-scale weighing versus farm-tank measurement, there must be considered the permitted errors in the tanks and in the scales and, in addition, the fact that a weight-per-gal of the milk is being assumed. The total possibility of legitimate difference here is quite large.

Even in meter versus farm-tank measurements, permissible errors can accumulate to a substantial total difference.

Legally and philosophically, it is generally agreed that, so long as the measurement at the farm is the last point at which individual milk can be identified, the transaction must be concluded on the basis of that measurement.

The farm milk tank has brought about an almost complete transition in handling, measuring, and merchandising a very vital farm product. Its progress has been remarkable. That there have not been many more serious measurement problems is surprising and is complimentary to milk producers, milk processors, equipment manufacturers, educators, and public officials.

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