EXAMINATION OF OFFICIAL MEASUREMENT TOLERANCES FOR ONTARIO'S FARM MILK TANKS

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ABSTRACT

A random sample of 72 farm milk tanks was check-calibrated to determine whether official tolerances for estimates of milk weights were realistic. The overall calibration error for 859 calibration check values was + 3.12 lb. Sixty-nine percent of all values exceeded the official tolerances and this was reduced to 23% when the calibration check values for each tank were reduced by an amount equal to the mean calibration check error for the tank. Under these circumstances the official tolerances were approximately equal to one standard deviation of errors. When the tolerances were doubled (approximately two standard deviations), the percentage of the calibration check values which were excessive was reduced to 4.9%. It was concluded that the official tolerances were too small and should be doubled in size, giving a tolerance range of 6 to 16 lb. (0.5 to 0.18%) for a range of tank capacity from 1200 to 9000 lb.

More than 13,000 refrigerated farm milk tanks in Ontario are used for storing about 80% of the 5 billion lb. of milk sold off farms annually. This milk is purchased from producers by the Ontario Milk Marketing Board on the basis of a measurement using a gauge rod. A tank calibration chart is used to convert the measurement to a weight equivalent. The measurement is no more accurate than the accuracy of the manufacturer's calibration of the tank. After the tank is installed other factors may also affect the accuracy of the measurement including levelness of tank and structural defects that allow tank capacity to change with time *(3)*. The purpose of this study was to determine whether estimates of weights of milk in Ontario's farm milk tanks were within limits of official tolerances *(4)*.

MATERIALS AND METHODS

A random sample of 72 farm tanks was selected from the counties of Wellington, Waterloo, Oxford, and Perth in southwestern Ontario. The procedure for checking calibration of a farm tank was to add increments of about 200 lb. of water from a portable delivery container positioned above the farm tank. This container was filled with water from a supply carried in a tank truck. After each addition of water the water temperature was recorded and two separate measurements were made with the gauge rod dusted with Bon Ami powder. The average measurement was converted to pounds of milk and was recorded with the corresponding weight of milk found on the tank calibration chart. This procedure is hereafter referred to as a calibration check. Successive increments of water were added until the tank was filled to capacity. A total of 859 calibration checks were made on the 72 tanks.

The delivery container was previously carefully calibrated by filling and emptying the tank six times with distilled water to determine the net weight of water. The Toledo scale used for these weighings was checked and adjusted with standard 50-lb. weights by the Department of Weights and Measures just before use. Weighings were done at five different water temperatures ranging from 38 to 57 F. The range of net weight of water for the 30 determinations was 200.0 to 200.2 lb. Variations at the various temperatures were not significantly different so an overall average weight of 200.068 lb. was used as weight of water delivered.

To convert weight of water to volume the following conversion factors were used: 1 lb. = 0.45359 kg; volume in liters = kg ÷ apparent wt. 1 liter distilled water in kg; Imperial gallon = liters ÷ 4.54596 *(1)*; Imperial gallons per delivery =

$$\frac{200.068 \times 0.45359}{4.54596 \times \text{apparent wt.}}$$

A table of apparent weights of water at 0.9° intervals from 32 to 68 F was used in making the conversions. The table was calculated by the formula:

$$\text{Apparent weight} = \frac{D}{1 + 0.00106 + 0.0012\ (1\text{-}D)}$$

where D is the absolute density in grams per milliliter. This was derived from a table for reductions of weighings in air to vacuo *(2)*.

The estimated volume of water added was converted after each addition to pounds of milk using the official conversion factor 10.32 × Imperial gallons *(4)*.

The random sample included tanks of 17 manufacturers that were arranged in six groups. Groups A, B, C, and D each contained tanks of a single manufacturer and numbered 18, 13, 7, and 6 tanks, respectively. Of the remaining 28 tanks, 13 had a capacity of 1800 lb. or less and were placed in Group E. The remainder were placed in Group F. "Over-calibration" means tanks containing less milk than the calibration chart indicated. "Under-calibration" means the opposite.

RESULTS AND DISCUSSION

A summary of check calibration data is presented in Table 1. The individual calibration check error range and the tank average error range indicated that there were considerable differences between actual amounts of milk in some tanks and amounts being determined by the gauge rods. The overall average error for the tanks in each group indicates that producers in Group A were paid for an average of 8.9 lb. of milk less than was in the tanks. In all other groups the average error was positive indicating that producers were being over-paid. Forty-six tanks were over-calibrated and 26 were under-calibrated. The overall calibration error for all

TABLE 1. SUMMARY OF CHECK-CALIBRATION DATA INDICATING INDIVIDUAL CHECK POINT AND TANK AVERAGE ERROR RANGES, AND OVERALL AVERAGE ERROR

Tank group	Tank capacity range (00's lb.)	No. of tanks	Individual check-point error range (lb.)	Tank average error range (lb.)	Overall average error (lb.)	Tanks check calibrated	
						Over	Under
A	12 – 38	18	–53 to 19	–42 to 9	–8.9	3	15
B	18 – 52	13	– 6 to 30	– 2 to 20	9.0	11	2
C	15 – 30	7	–18 to 42	– 6 to 31	10.9	5	2
D	16 – 30	6	– 7 to 22	0.2 to 12	6.9	6	0
E	12 – 18	13	–16 to 21	–11 to 17	2.6	8	5
F	20 – 52	15	–13 to 37	– 2 to 31	7.8	13	2

TABLE 2. ERRORS IN BULK TANK CALIBRATION AFTER ADJUSTMENT OF CALIBRATION CHECK VALUES TO ZERO AVERAGE ERROR

Tank capacity (lb.)	Number of tanks	Total No. check points	Max. error (lb.)	Min. error (lb.)	Standard deviation of errors	Official tolerance (lb.)
1200	4	24	1	–2	0.9	3
1400	5	35	7	–7	3.3	3
1600	9	72	8	–10	3.7	4
1800	5	45	6	–15	3.4	4
2000	12	120	9	–13	3.0	4
2200	7	77	17	–13	5.1	4
2400	2	24	11	–7	3.8	4
2600	11	143	18	–21	5.3	4
3000	4	60	19	–15	5.7	5
3200	3	48	11	–9	4.5	5
3400	1	17	6	–13	5.0	5
3600	1	18	10	–13	6.5	5
3800	3	57	11	–16	5.0	5
4200	2	42	10	–8	4.1	5
5000	1	25	8	–11	5.9	6
5200	2	52	11	–23	5.8	6

calibration checks for all tanks was +3.12 lb. Sixty-nine percent of all calibration check values exceeded tolerances allowed by the Regulations of the Milk Act *(4)*. Reasons for this unsatisfactory situation were not clear. Even though no attempt was made during the survey to ascertain condition of the tanks in respect to levelness or structural defects, it was assumed that these were reasons for some of the errors. Also, methods of calibrating tanks might introduce serious errors. There is no common method of calibration used by manufacturers of tanks sold in Ontario. If methods are such that the gauge rod reading for a given volume of water does not duplicate the reading for a similar volume of milk, then an error is introduced. In addition, it is believed by the authors that the gauge rod reading for a given volume of milk may vary depending upon such factors as temperatures of gauge rod and milk, humidity of air, condition of gauge rod surface, composition of milk at liquid-metal interface as well as human error in reading the gauge rod. Therefore, it was considered possible that the large percentage of calibration check values which exceeded the official tolerances was not only due to condition and levelness of the tank but also due to official tolerances being too small to be practical under field conditions.

To estimate the magnitude of tolerances that might be practical, each calibration check value for a given tank was reduced by an amount equal to the mean calibration check error for that tank. This resulted in 23% of the calibration checks still exceeding the official tolerance. It is worth noting (Table 2) that official tolerances for tanks were approximately equal to one standard deviation of errors. When the tolerances were doubled (approximately two standard deviations), the percentage of the calibration check values that were excessive was reduced from 23% to 4.9%. The statistics describing the distribution of errors are presented in Table 2 where tanks have been rearranged into groups according to capacity. Official tolerances are also included.

It is apparent that the condition of Ontario farm tanks is such that most of them cannot meet the standards, in respect to estimation of milk contained therein, as required by the Regulations made under the Milk Act *(4)*. Some portion of the measurement errors can probably be overcome by periodic re-calibration of the farm tanks. However, it is also apparent that the official tolerances are too restrictive and are not realistic for practical operations. A doubling of the tolerances seems to be reasonable and would mean a range of 6 to 16 lb. (0.5 to 0.18%) for a range in tank capacity from 1200 to 9000 lb.

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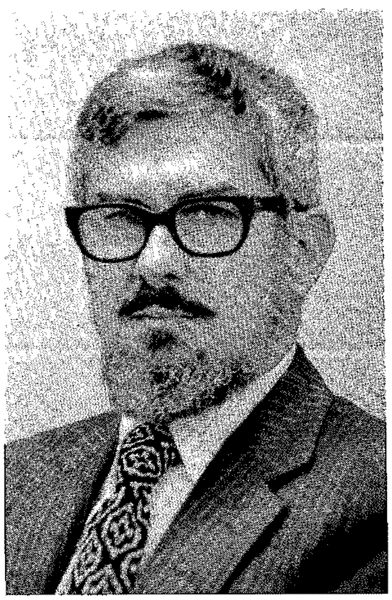

HOWARD HUTCHINGS

Howard Hutchings is director of Sanitation and Safety for the South Dakota State Health Department. In this position, he supervises the inspection and licensing of all food, lodging and campground establishments in the State. The safety program includes radiation safety and mine inspection.

Howard considers himself a grass roots food sanitarian. He has a B.S. in Food Technology and a M.S. in Public Health, both from the University of Missouri at Columbia. He started his public health career as a part-time health inspector at Boonville, Missouri. Three years later he became a full-time inspector for the Columbia City Health Department.

While working as food sanitarian for the City of Columbia he started a weekly health department radio show, created a grocery store-church inspection program and began enforcement of a previously dormant city food code.

In 1960 he established the first campus sanitation program at the University of Missouri and spent seven years as their sanitarian. His M.S. thesis was based on his food handler educational programs at the University in which he documented the importance of proper training.

He has held his current position since 1967. In South Dakota, he has established a public school food service inspection program, plan review for all new or remodeled establishments, developed a campground law and regulation and a recent food salvage law. While practicing a fair, but firm, enforcement program he feels training and cooperation is still the key to functional public health. He lectures widely at high schools, colleges and training workshops.

He is an active member of I.A.M.F.E.S., serving on the Food Protection Committee, Food Equipment Committee and is currently secretary of the Affiliate Council. He has served as secretary-treasurer of the